SUPPLY RESPONSE AND WELFARE ANALYSIS OF PRICE POLICY FOR COTTON IN COLOMBIA

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CHAPTER I

INTRODUCTION

Colombia has an agricultural oriented economy. The agricultural sector has been a major source of growth. The agricultural sector accounts for 70 percent of the Colombia's foreign exchange, 35 percent of the labor employed, and 25 percent of the Gross Domestic Product. Deficiencies of raw materials for industry has forced the government to increase imports. Part of the inflation in Colombia can be explained by the high prices of agricultural products, especially food, since most of the families spend more than 40 percent of their incomes on it. The country has lost competitiveness in the international markets because Colombian products are more costly to produce now.

A variety of policy alternatives in the areas of coffee diversification, price supports, price stabilization, input subsidies, export subsidies and investment strategies have been applied by the government to stimulate the agricultural sector. Macroeconomic policies, such as the exchange rate, interest rate, import controls, fiscal and monetary measures, have substantially affected progress in agriculture, both directly and indirectly. To increase the availability of food and fiber, to generate more employment, to recover the comparative advantage in commodities that are exportable and to reduce the instability of the agricultural sector are some of the most important challenges that the Colombian government has to face.

For several years the domestic price has been significantly less than the international price. Cotton appears to be competitive, but historically it has been indirectly taxed because of the overvaluation of the Colombian peso and subject to export controls. Given the overvaluation of the peso, Colombian cotton has lost market share in the external markets.

Recently the government has increased the value of the CERT (Tax Credit Certificate), and has used variable subsidies to offset the lack of incentive from an overvalued exchange rate. International conditions have undoubtedly contributed to the problems of cotton; however, the country could have maintained greater competitiveness abroad with more adequate macroeconomic policies.

The technology recommended for cotton is highly dependent on chemicals. In addition to the situation of lower real domestic and international prices, input costs have increased continuously. This has caused a deterioration in the terms of trade, since most of the raw materials required in the manufacture of pesticides and fertilizers are imported. Increases in the prices of machinery, labor and land have also contributed to increases in production costs. Therefore, cotton producers have been facing a profit squeeze for several years. High levels of instability in prices of cotton and in farm income have been recognized by policy makers in general. Reduction of risk is expected to promote investment, expand production, and stabilize prices significantly.

Agronomic and Production Aspects of Cotton in Colombia

The ideal conditions for cotton production in Colombia are given by an altitude of 100-400 meters above the sea level, a temperature of 27-30 degrees Centigrade, and annual precipitation of 1100-1400 m.m. The pattern of rain seasons has served as an indicator for ICA to establish specific planting periods to obtain a higher level of pest control. The cotton areas in the country are divided in two large zones: 1) the Costa-Meta, which covers the departments of Atlantico, Bolivar, Cesar, Cordoba, Guajira, Magdalena, Sucre, and Meta, and, 2) the Interior zone, which covers the departments of Cundinamarca, Tolima, Huila and Valle del Cauca. (Figure 1 and Appendix A).

The interior zone is characterized by two rainy seasons which alternates with two dry seasons, which allows two cotton harvests by year. However, cotton is planted only between January-March to break down the biological cycle of many plagues. Cotton is harvested from June to August. On the coast there is only a rainy season followed by a dry season each year; cotton is planted between July and September and it is harvested between December and January. ICA sets a limit on the acreage to be planted, and also sets a maximum time for the destruction of the plant residue once the cotton has been harvested. This is done in an effort to control pests (insects and diseases).

Since 1970 STONVILLE 7A has been the seed most commonly used in the country reaching 77% of the area planted in the Valle del Cauca. Weeds compete with cotton for light, water, and nutrients of the soil. Therefore control of weeds is very important. The most common weeds for cotton are gramines, cyperaceas, and dicotyledons (coquito and argentine grass). According to ICA, there are 92 species of insects and 6 diseases which attack cotton. The most common is Agrotis Spodoptera.

Most of the harvesting of cotton is done by hand. Approximately 300 thousand families work on it. The harvesting is done in three steps: in the first one 60 percent of the cotton is picked up; 30 percent in the second one; and 10 percent in the third one. Cotton is separated into several products: between 56 percent and 59 percent to cotton seed, 33 percent to 38 percent is cotton fiber,

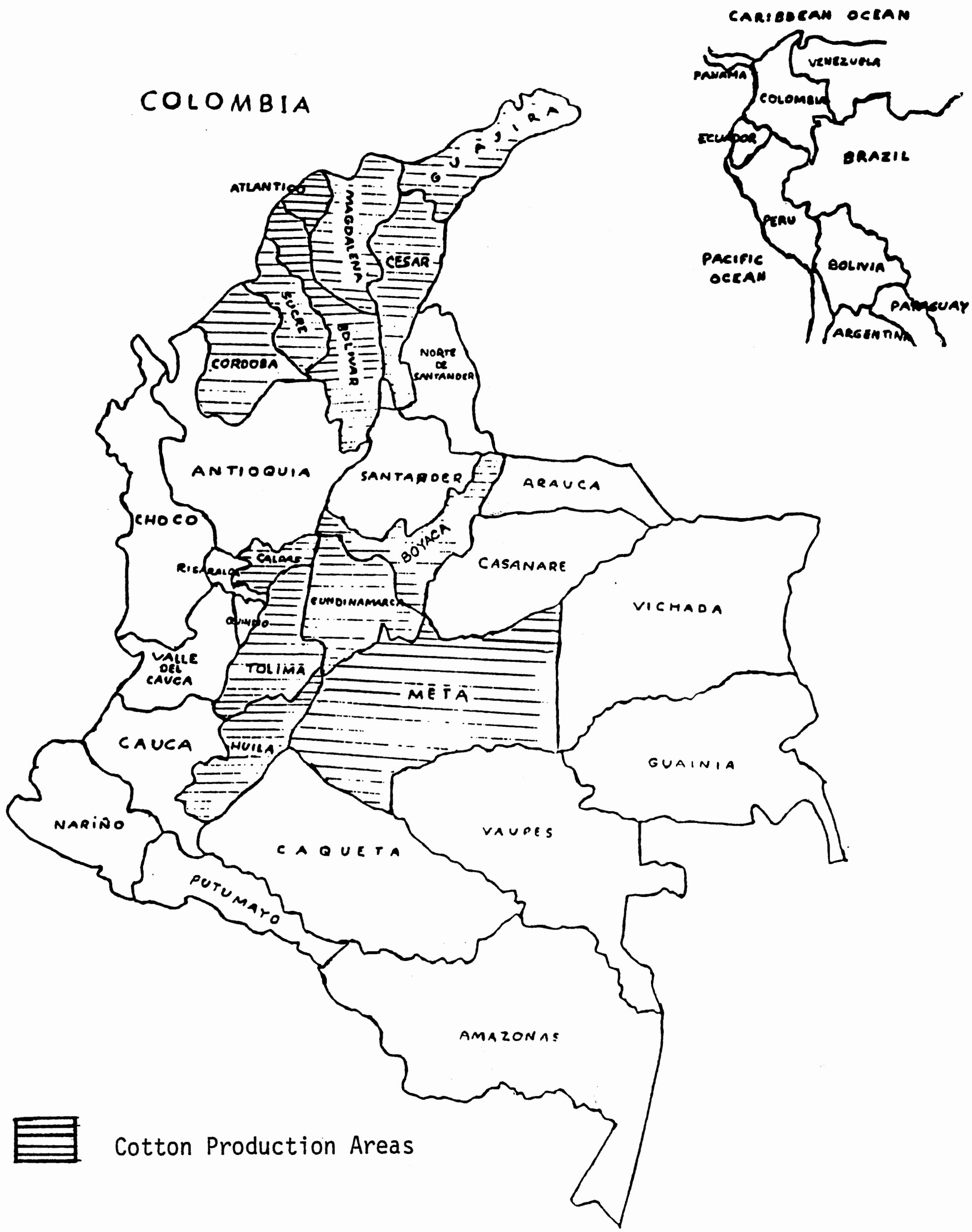


Figure 1. Cotton Production Areas in Colombia

and 2 percent to 4 percent represents impurities. Cotton seed is processed to obtain between 33 percent and 43 percent cotton cake, and between 15 percent and 16 percent oil. Cotton fiber is analyzed according to its length, finer, and resistance.

The distribution of area and production of cotton by department in the 1983-84 cotton harvest are shown in Appendix A. Cesar is the department which provides most of the acreage and the production of cotton in the Costa-Meta zone, while Tolima is the most important department in this aspect in the interior zone.

Production costs are also shown in Appendix A. Control of pests, harvesting and land rent are the items which have the larger values in the production costs of cotton. The variation indexes for financing and production costs of cotton per hectare for the period 1970-1986 by zone (with respect to 1970 period) are presented in Appendix A.

In 1950, 42,000 hectares were planted to cotton in Colombia for a production of 21,000 tons of cotton seed and 8,500 tons of cotton fiber. The number of hectares harvested and the production of cotton showed a upward trend until 1977 when they reached their maximum. Hectares harvested were 377,200; the production of cotton seed was 475,000 tons; and cotton fiber was 161,600 tons (Figure 2 and Appendix C). Low international prices of cotton fiber caused by the record yields of cotton obtained in China and the release of cotton stocks by the United States was the principal reason for the reduction in area and production of cotton in Colombia, in the last half of the 1970's and first half of the 1980's.

Overvaluation of the peso has made Colombian cotton less competitive in the international market. 1983 was a bad year for the Colombian cotton sector. In that year only 80,332 hectares were harvested, producing 152,400

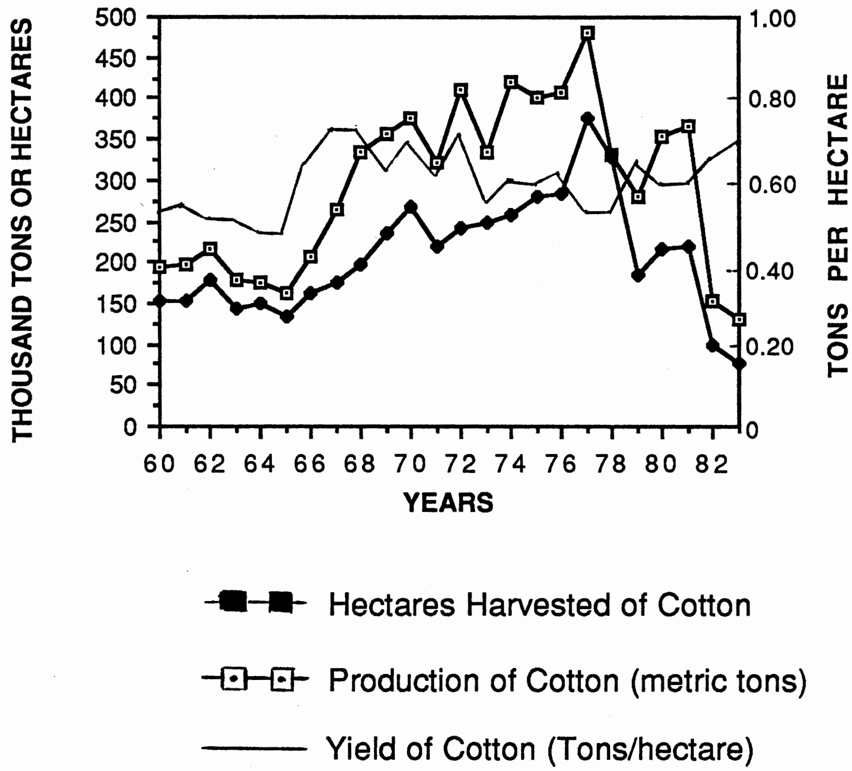


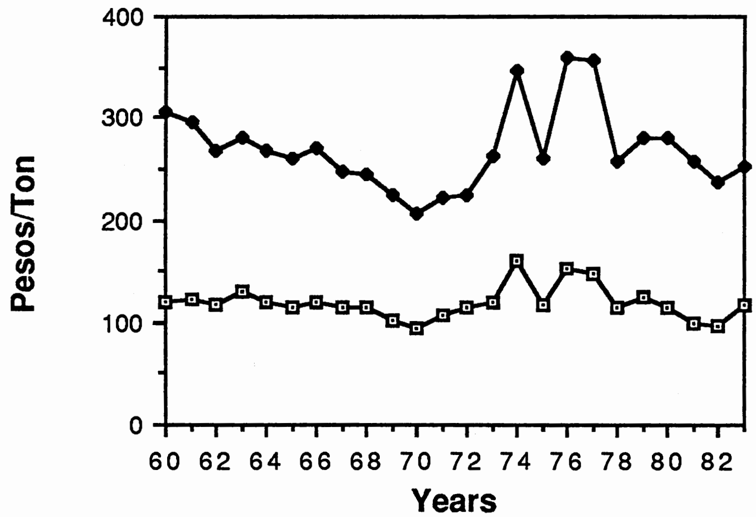
Figure 2. Production and Hectares Harvested of Cotton in Colombia (1960-1990)

tons of cotton seed and 54,100 tons of cotton fiber. The importance of Colombian cotton in the international markets is insignificant. According to the magazine "El Algodonero" (July-August, 1986), from the Colombian federation of cotton growers, Colombian cotton fiber exports in the international market are less than one percent. Colombia is the eighteenth largest producer of cotton fiber in the world, and is the fourth largest producer of cotton fiber in Latin America.

Although Colombia has to be considered as a small country case for purpose of analysis of cotton policy in international markets, cotton is one of the crops which demands large amounts of human, economic and technical resources in the country. Almost 60 percent of the production of cotton fiber obtained in the Costa-Meta zone is exported, and 90 percent of the production of cotton fiber obtained in the interior zone is consumed domestically. The total amount of cotton seed obtained is commercialized in the country. The domestic price of cotton fiber in Colombia is reached by an agreement between the FEDERACIONES (which represent the cotton growers) and DIAGONAL (which represent the textile producers). The domestic price of cotton seed is also reached by agreement between the FEDERACIONES and the producers of oils and fats. These agreements are approved by the government.

The real prices paid by DIAGONAL and the producers of oil and fats (deflated with the index of prices of the nonagricultural sector, 1975=100) do not show a sustained trend through the years (Figure 3).

In summary, raw cotton output declined 70 percent from 1977 to 1982, caused by low international prices and by lack of incentives in the cotton sector. The cotton crisis has particularly hurt the Coastal Region where there are fewer alternative crops, and the total labor force employed depends heavily on cotton. Production declines have resulted in unemployment and economic recession in



Price of cotton seed paid by oil and fat producers (Deflated with the index of prices of the nonagricultural sector (1975=100)

Price of cotton fiber paid by DIAGONAL (Deflated with the index of prices of the nonagricultural sector (1975=100)

Figure 3. Prices of Cotton Fiber Paid by DIAGONAL and of Cotton Seed Paid by Oil and Fat Producers in Colombia (1960-1983)

that region. In 1977, the national area planted to cotton was 377,000 hectares with 17,069 cotton growers; in 1983, the country area planted to cotton was 75,000 hectares with 5,661 cotton growers. The share of cotton in the value of agricultural production, in the value of production of oil seeds, and in the value of total agricultural exports decreased by 20 percent in 1983 compared to 1960 (based on 1970 constant prices).

Cotton Price Policy in Colombia

Garcia and Montes (1986) distinguished two fundamental goals of agricultural policy during the twenty century: (1) to solve the balance of payments problem, to become self-sufficient in food and raw materials, and to increase agricultural output; and, (2) to maintain price stability, initially to hold wages for coffee and the infant industrial sector low, and later when the urban population increases to maintain political stability. Sectoral policies that are intended to directly increase agricultural production and income include price supports, import protection and export subsidies, and nonprice inducements such as agricultural investments of government, input supply, research, extension, and transfer technology.

The Government's objectives for cotton have been: (1) to increase domestic price stability, and (2) to increase cotton farmers' income. The policies implemented by the government to achieve these objectives have been based on: (1) domestic market intervention; (2) export and credit subsidies; and, (3) a cotton production program to increase yields. The principal constraints confronting the government in reaching these goals have been: (1) unanticipated shocks of international prices which have increased domestic instability; (2) financial deficits due to low government revenues, that has affected the magnitude and timely payment of the export subsidy; (3) difficulties in the management of macroeconomic policies, basically the exchange rate policy, given the effects on the economy of changes in the world coffee price; (4) structural parameters of domestic cotton supply and demand; and, (5) the role of special political and economic interests.

Price policy in the cotton sector has been characterized by an active intervention of the government for most of the period 1960-83. OPSA (Oficina de Planeacion del Sector Agropecuario), the Planning Office of the Ministry of Agriculture, intervenes in the marketing of cotton. The agency may not be an effective price stabilizer, since it does not actually buy or sell cotton. However, it approves the agreement reached between the cotton growers (represented by the FEDERACIONES) and the textile producers (represented by DIAGONAL) about the price of the fiber to be sold in the domestic market, and with cotton growers and oil producers about the cotton seed price in the country. Cotton exports have been subject to an export quota. For most of the years of the period under study, 1960-1983, the external cotton price has been higher than the domestic cotton price. Cotton fiber exports received a subsidy that was fairly constant between 1967-74 and then suffered variations over the years (Garcia and Montes, 1986).

Thomas (1985) mentions that crops which can compete successfully in international markets have not been stimulated, but have been implicitly taxed because of the overvaluation of the Colombian peso. Only when export crops develop problems in external markets, have support measures been devised and implemented, as in the case of cotton. Colombia's export crops such as cotton, cannot be exported before significant processing costs have been incurred. The loss of international competitiveness of cotton was so great that the area planted and the output declined by two thirds after 1975.

Unsound Colombian macroeconomic policies, the erratic performance of the international cotton sector, and lack of incentives by the Colombian government for the agricultural sector have led to a recession in the Colombian cotton sector. However, these effects have not been measured yet. Models that allow the study of the relationships between the production of cotton and changes in macroeconomic and international trade policies need to be developed.

Cotton policy goals, or at least the importance of some of these objectives have changed through the years; the environment in which cotton growers perform has varied. A recession in the Colombian agricultural sector has occurred since the middle 1970's. New models have to be developed to improve the accuracy of the parameters and the forecasts of policy alternatives. For cotton this necessity is critical, since the number of studies realized are few, and the problems associated with this commodity are very complex.

Estimates of supply response for cotton that take into account risk, and the effects of policy variables in the formation of prices are important to be obtained not only for the development of cotton policy alternatives, but also for welfare analysis. The effects of government intervention and their distribution should be analyzed. The values gained or lost by producers, consumers and taxpayers associated with agricultural policies for cotton also must be determined.

Objectives of the Study

This study has three main objectives: (1) to estimate the supply function for cotton in Colombia; (2) to apply classical welfare analysis to estimate the distribution of gains and losses among consumers, producers, and taxpayers of the actual price agreement, export subsidy policy, as well as the effects of a devaluation of the exchange rate; and, (3) to simulate the effects of variations in cotton and related crop policy alternatives on the production of cotton fiber.

Organization of the Remainder of the Study

The remainder of this study is organized in five chapters. Chapter II covers the review of literature for supply response and welfare analysis. Chapter III describes the methodology, estimation methods and data sources. Chapter IV presents and discusses the results and the welfare measures of the analysis of the current cotton policy in Colombia. Chapter V presents the main conclusions and limitations of the study and makes suggestions for future research.

CHAPTER II

REVIEW OF LITERATURE

Supply response analysis aims at quantifying the change in output caused by a change in price and other economic factors. Accurate estimation of supply response models is very important. Government policy negotiations are based on supply estimates in predicting both commodity and intercommodity effects of changing programs and in anticipating their consequent social benefits and costs. Not only the government but also agribusiness firms and individual farmers need accurate estimates of elasticities of supply and associated price predictions in making investments and production decisions.

Since the study of Bean (1929), much research has been done in agricultural supply response. Several studies have done a complete review of methods, estimates and comparisons of estimates among regions and countries, as well as pointing out areas in which further investigation is needed. (Tweeten and Quance, 1969; Askari and Cummings, 1977; Colman, 1983; Henneberry, 1986; and Shumway, 1986). Shumway (1986) concluded that although many studies have been done on this topic, agricultural economists have not been nearly as comprehensive as one might expect. There remains much room for innovative and substantive research on this important subject.

There are various methods for estimating the own price supply elasticity. They can be classified as direct and indirect methods of estimation of the supply function. Models classified as direct methods include the cobweb, partial adjustment, adaptive expectation, Nerlove's, weighted average of input demand elasticities, aggregation of area and yield elasticities, mathematical programming, multicommodity and simulation. The duality model is considered the indirect method of estimation.

Dynamic Formulation in Econometrics Models of Supply

Marc Nerlove has made a significant contribution in the area of dynamic supply analysis. He developed a model that explains price expectations and supply responses. There were several studies formulating price expectations before Nerlove's approach. The earliest and simplest explanation of agricultural price expectation was the development of the cobweb model in the 1930's. Later Koyck, in 1954, based on a geometric lag model, developed a more sophisticated approach. Modifications of Koyck's model have been the adaptive expectation and partial adjustment models. The adaptive expectation, the partial adjustment, and Nerlove's model have been used extensively in the studies of dynamic supply analysis (Henneberry, 1986).

Gichuhi and Dunn (1984) applied the partial adjustment model to analyze the acreage response of several crops in Kenya. They used the asymmetric supply response hypothesis established in the fixed asset theory, which suggests that it is easier for farmers to increase than to decrease production. For many of the same reasons that adjustment is not instantaneous, farmers find that it is not economically viable to back down the supply curve they just came up. Therefore, farmers will be less responsive to price decrease than to price increases. In this study price variances were included in the acreage response functional relationship as a crude representation of the risk variable. A dummy variable and a trend variable were included to represent weather and technological change. The acreage elasticities suggest that commercial wheat farmers in Kenya respond rationally and substantially to economic incentives. They did not find statistical support in the results for the asymmetric hypothesis.

The more formal statistical analysis of supply response appearing since the late 1950's has been largely influenced by Nerlove's work (1956, 1958). Askari and Cummings (1976, 1977) surveyed 190 supply studies that were in part influenced by the Nerlove formulation and made an analysis about their price formulation and estimation methods. Most of the cited studies used post-World War II data. The models were of the single equation, single price form, and were based on econometric estimations. Few models included alternative product prices, variable input prices, or fixed output or input quantities. Thus, the elasticities were generally of the total elasticity form where other price adjustments would be expected to occur as they have historically in response to a change in the price variable of direct concern. Extreme variability was found in signs and magnitudes of the elasticities due at least in part to differences in estimation methods, geographic areas, and data periods.

The major criticism to the Nerlove's model is that farmers' expectations of prices do not necessarily change with observed price changes if the farmers view these changes to be temporary. Therefore, the formation of price expectations may overestimate real expected price changes and as a result underestimate the true aggregate supply elasticity (Henneberry 1986).

Askari and Cummings (1976, 1977) mention that one particular notable deficiency in most of the studies was that no attempt has been made to evaluate farmers reaction to risk. In this regard they recommended that the effects of such factors as crop diversification need to be clearly examined, as well as changes in indicators of risk, such as standard deviation of price. The relative risk involved in crops grown for different purposes, such as family use, domestic market, or export sale also seems relevant, as does the question as to whether any form of government control over prices is exerted. In relation to the problems of estimation in Nerlove's model, if Ordinary Least Squares (OLS) techniques are utilized, the estimation will be inefficient and inconsistent. The residuals in the estimating equation are serially correlated because of the inclusion of lagged values of the dependent variable on the right hand side of the estimating equation. One way to approach the problem of efficiency and consistency in the parameter estimates is to employ nonlinear maximum likelihood estimating techniques. Problems arising from serial correlation and lagged dependent variables can be handled by using autocorrelation estimation methods like Hildreth-Lu and Cochrane-Orcutt.

Aggregation of Area and Yield Elasticity Model

Supply response can be disaggregate into area and yield components, (Tweeten and Quance, 1969; Evans and Bell, 1978). Given the elasticity of acreage A with respect to price P: E_{ap}, the elasticity of yield Y with respect to acreage: E_{ya}; and the elasticity of yield with respect to price: E_{yp}. The elasticity of crop production C with respect to farm price P: E_{cp} can be calculated:

$$E_{cp} = E_{yp} + E_{ap} (1 + E_{ya}) \tag{2.1}$$

The area elasticity of yield is supposed to capture the negative effect of a higher acreage on yield.

Pomareda and Samayoa (1979) implemented this approach for a regional linear programming model to estimate supply responsive for the South Pacific region of Guatemala. The model incorporated the most important actual constraints and took into account that farmers are risk-averter individuals. At the given levels of resource use and risk parameters, the model reflected satisfactorily the behavior of farmers. Area planted, technology mix, crop yields, total production, resource use, and shadow prices fell close to the actually observed levels in the base period. The approach was found to be particularly relevant in areas of developing agriculture, where land and family labor are extremely scarce. Hence, any increase in food production would have to take place through increases in yields, intensifying the use of inputs, such as fertilizers, improved seeds and technology.

√ Bogahawatte (1982) did an analysis of government policies on rice in Sri Lanka. He estimated the elasticity of production of rice with respect to price as the sum of the elasticity of area planted and the elasticity of yield with respect to price. The parameters of the structural models of the supply and demand models were estimated using two methods, namely generalized least squares (GLS) and two stages least square (TSLS). For the supply system: area under irrigation, rainfall, area under crop insurance, ratio of guaranteed price of paddy rice, lagged guaranteed price of paddy and lagged area were considered like independent variables in the area and yield models. He found an inelastic price supply response for rice in Sri Lanka. The yield and area elasticities were low.

Multi-Commodity Models

Most of the agricultural supply response studies are of a single commodity type. One of the deficiencies of this class of models where agriculture is typified by multiple outputs is that they are of partial nature. This severely limits the role which the theory of the firm can play in the specification and estimation of the models (Colman, 1982).

Models in which several supply functions for some subset of all commodities which are simultaneously estimated provide better estimates than single commodity models. Coyler (1969) pointed out that although the single equation approach is less complicated, current knowledge allows relatively easy computations of systems of equations, and improved data sources offer considerable promise in the study of supply.

It is conceivable that the objective might be to assess the consequences of a hypothetical policy change upon a number of variables and/or groups of economic factors. It is also likely to be very important in these circumstances that the different variables projected should be consistent with one another, and this may need the use of a jointly determined consistent system of equations.

While it may be obvious that the objective of empirical supply response models is to assist in making projections and forecasts, there are variations in the way they are employed. In some cases the estimated form of the model is transformed directly into a projection tool, possibly through the addition of some identify and definitional equations. In other cases, however, summary measures of the estimated response parameters are extracted from the model, e.g., in the form of elasticities, and these may be used in some other ad hoc structure to produce projections of supply. Where the objective is sector-wide agricultural policy impact analysis, one of the three following approaches should be used: (1) a programming model, (2) a directly estimated supply system and, (3) a two-stage profit or cost function system (Colman, 1982).

A simultaneous equation system was specified and estimated for the Delta production region by Penn and Irwin (1971) in an attempt to measure the extent of interdependence among crops and the associated commodity policies. The interdependence of the soybeans economy and those of corn, cotton, and rice means that the policy changes directed toward one crop can have very decided effects upon the others. The model was expressed in four equations with planted acreage response for soybeans, cotton, rice, and corn assumed to be jointly determined. The simultaneity occurs among acreage allocated to competing crops, given a fixed total acreage in any one year but not perfectly invariable among years. This contrasts with the usual market applications, where prices and quantities are assumed to be jointly determined. The pre-estimation identification properties of the model were examined and the system was found to be overidentified. The system was estimated by two stage least squares (TSLS). They found that the interdependence among crops tends to be reflected reasonably well by the simultaneous system; therefore, there appears to be considerable promise in the simultaneous approach.

Risk in Supply Response Models

Agricultural producers operate in an environment where both their yields and their output and input prices are uncertain. Farmers typically make most of their production decisions at the beginning of the season, knowing neither the market price for their products at harvest time nor the weather conditions during the season that will determine their yields, (Bigman, 1985). The analysis of risk on positivistic supply models is recent, as exemplified by the work of Just, 1975. Just argued the need for quantitative knowledge on how farmers actually respond to risk if one wishes to assess effects of alternative agricultural policies.

A measure of risk within positivistic supply response models has been shown to be a significant explanatory variable for specific commodities (Just, 1974). From a policy standpoint, failure to account for risk-response in a positivistic model ignores the effects of government policies on relative risk structures. Newbery and Stigletz (1981) argued that producers' attitudes to risk are important in their decision making, especially in less developed countries, where income is lower and risk spreading options fewer.

From a methodological standpoint, the relevant issue in attempting to include risk in a positivistic model is identifying the appropriate risk measure. This matter has been widely discussed, with several alternative risk variables found within the literature. Price risk is the variability associated with an estimate of the expected price. Such unobservable variability has to be represented by some approximation, and observation of risk in a particular period has been estimated in various ways in econometric models. The means by which an observation in price risk has been represented can be categorized broadly into: (a) the recorded variability or instability over recent periods; and, (b) the extent to which this variability was not expected.

The first category is based on the assertion that risk is directly related to the recorded instability or variability of prices in recent periods. The use of moving variance, a moving standard deviation or a moving weighted standard deviation are all means of trying to capture aspects of this recent variability in a "more appropriate" manner. The second category of measure of risk is based on the assertion that risk is some function of the difference between the expected price and the actual price.

Adams et. al. (1981) incorporated risk variables into the structure of two basic supply response models, the Nerlove and Ryan-Goodwin, for selected U.S. crops. The specific objectives of the analysis were to: (1) evaluate the effect of the specified risk variables on the supply response equation for each commodity as well as the effect on underlying supply elasticities, and (2) evaluate the effect of the form of a basic model on the estimated supply response equation of the selected crop. Acreage instead of production was considered as the dependent variable; the expected price variables were not deflated, input prices were not included, and only one competing crop for each commodity was considered to avoid multicollinearity and to focus on the effect of the risk variables. The first risk variable was the weighted standard deviation of crop gross revenue per harvested acre in year t.

The second risk variable was the square of the weighted covariance between the crop gross revenue per harvested acre and the competing crop gross revenue per harvested acre. It was calculated over the three years preceding year t divided by the weighted variance of the competing crop gross revenue per harvested acre over the year preceding year t.

This second risk variable permited an interaction between the covariance of the crop and the competing crop gross revenues per harvested acre, the level of the crop gross revenue per harvested acre, and the variability of competing crop gross revenue per harvested acre. The results showed that the Ryan-Goodwin models had greater supply response elasticities than the Nerlove models. The Nerlove models had a better fit, perhaps indicating that the acreage harvested in the previous year is a more important variable than price measures. The effect of the addition of the risk variables on the R^2 value of the base equation of the particular model was marginal in most cases, however they were statistically significant in several cases.

There are three major drawbacks with the approach which defines risk in terms of the difference between the expected price and the actual price. First, the results depends critically on the formulation of the expected price. This involves the question of whether price expectations are formed from past prices and, if so, what length and shape of lag is appropriate. Second, the approach requires a more complex estimation procedure where the expected price is formed from a distributed lag on past prices, and third, problems can arise when price variables enter the model as a ratio (Traill, 1978).

Traill (1978) compared a number of different variables representing risk, including some which defined risk as the difference between the expected price and the actual price, and some which are based simply on recent variability of prices. Although the former group of variables have greater theoretical appeal, neither had any superiority in terms of explanatory power for the more complex variables. Based on these findings, perhaps little if anything would be lost in terms of accuracy by using the simpler approach, but much can be gained through the simplicity and ease of the approach.

The manner in which risk is included in relation to the risk of competing products also has differed among the various studies. The competition between products is often incorporated into models by the use of relative prices. However, it is inappropriate to use measures of the variability of the relative price as measure of the relative risk. The variability in the relative price may result equally from fluctuations in either price, and would not reflect the relative variability of the price of one product in relation to the price of the other. Brennan (1982) mentioned that measures to represent the relative variability has been the standard deviation of one product's price divided by the standard deviation of the prices of the competing product, as in Behrman (1968), and the ratio of the covariance to variance as in Ryan (1977).

Brennan (1982) demonstrated that a simple measure of risk (the moving range) can be used by those constructing econometric models to represent risk. This variable is easy to calculate and does not require any complex estimation procedure. The measures of risk for the annual price of wheat for the period of 1948-49 through 1977-78 calculated by Brennan were: (a) moving range (3 periods); (b) moving standard deviation (3 periods); (c) moving range (4 periods); (d) moving standard deviation (4 periods); (e) magnitude of difference between expected and actual prices (naive expectations); (f) magnitude of difference between expected and actual prices (adaptive expectations); and (g) magnitude of difference between expected and actual prices (Almong lags). The results showed high correlation between these measures. Therefore, Brennan mentioned that there is little to be lost in testing for the presence of risk if the simple measures are used.

An appropriate measure for researchers to use to test for the presence of risk would be the moving range over three or four periods. It is easy to calculate and easy to manipulate in the context of model experimentation. Where a measure of relative risk is required, the relative range would be an appropriate measure. Where it is desirable to test whether farmers react more to risk at lower prices than at higher prices, the range divided by the price can be used.

Policy Variables and Expected Price Formulations in Supply Models

Most of the studies in supply response that take into account variables other than price have included use of observed farmer response to policy programs as exogenous variables (Ray, 1978). Some authors have considered the use of weighted support prices and diversion payments, and the use of dummy variables to represent the occurence of particular program provisions (Langley, 1985).

Reed and Higgins (1981) postulated the following supply equation in a study of a disaggregated analysis of corn acreage response in Kentucky:

$$AC_{it} = f\,(PC_{it-1}, PS_{it-1}, AC_{it-1}, GP_t) \qquad (2.2)$$

where AC_{it} was acres of corn planted in area i in year t; PC_{it-1} was the relative price of corn in area i in year t-1; PS_{it-1} was the relative price of soybeans in area i in year t-1; and GP_t was a variable to measure government programs in year t. The price support, the set-aside payment, and the target rate were used to measure the government program. Relative prices were output prices divided by fertilizer price. Fertilizer prices were used as measure of input prices because they were readily available and account for a large proportion of production costs.

✓ Tweeten (1985), in the analysis of supply response in Pakistan, specified the supply function as follows:

$$O_i = f\,(P_i/PP,\ P_j/PP,\ I,\ T,\ G,\ W) \tag{2.3}$$

where O_i was output of commodity i, P_i was price of i, P_j was the price of related commodities, and PP was prices paid by farmers for variable inputs. I referred to infrastructrure and relatively fixed farm inputs, T represented technology, G was government policy (not working through other variables in the equation), and W was weather. He estimated elasticities of area, yield, and production for several crops. Only the area equation was a Nerlove-type formulation. OLS estimation techniques were applied. He found that the total commodity agricultural output and the agricultural production by commodity in Pakistan were responsive to price.

In dynamic supply response models, policy variables can be included in the formulation of the expected prices the most important of which are likely to be the past prices. The role of price expectations is a vital aspect to consider. The difficulties associated with incorporating price expectations into models of agricultural supply response have been the center of analysis (Taylor and Shonkwiler, 1985).

Common approaches to the measurement of expected commodity prices have been the use of various lagged price structrures (Nerlove, 1956; Ray, 1971; Penn and Irwin, 1971), the weighted support price technique (Houch and Ryan 1972), or the use of future market prices (Gardner, 1976). A methodological question which has arisen in recent studies is whether acreage response should be specified on the basis of net returns or price (Bancroft, 1981; Salathe, Price, and Gadson, 1982). It has been argued that, with limited acreage, producers wishing to optimize farm income must allocate acreage to alternative crops on the basis of per acre returns and not price alone (Collins, 1980). A measure of returns per acre also allows the inclusion of expected crop yields or program yields into the decision process (Langley, 1985).

Houck Subotnik (1969) considered the following basic model for acreage supply response of soybean in U.S.:

$$A_t = b_0 + b_1 A_{t-1} + b_2 P^*_{1t} + b_3 P^*_{2t} + U_t \tag{2.4}$$

where A was acreage harvested, P^*_{1t} was the expected price for the crop in question, P^*_{2t} was the expected price crop for a competing commodity, and U_t was a random, mean-zero disturbance with finite variance. Although the expected price for only one competing commodity was included in the model, the method can easily be extended to incorporate others. The model was of the lagged adjustment type developed by Nerlove. The authors hypothesized that the expected price of various crops which affect the soybean acreage supply in year t were

$$P^*_{1t} = W_{i1} P_{i\,t-1} + W_{i2} P^f_{it} \tag{2.5}$$

where P^*_{1t} was the expected price in year t for crop i; $P_{i\,t-1}$ was the farm price in year t-1 for crop i, and P^f_{it} is the efective support price in year t for crop i. The effective support rate was equal to the announced support rate when no acreage compliance was required to obtain the announced rate. This formulation of price expectations also was assumed to be appropriate for both mandatory and voluntary acreage control programs.

Gallagher (1978) investigated the role of government support and market phenomena in the formation of the producer's price expectations. The expectations formation relation was a function of current year support price (PS_t) and previous crop year market price (PM_{t-1}):

$$PE_t = PS_t + \tau [(D_t + 1) \ln (D_t + 1) - D_t], \tau > 0 \qquad (2.6)$$

where

$$D_t = PM_{t-1} - PS_t \qquad (2.7)$$

In this expected price formulation the response of expected price to changes in market or support price was expressed as a simple function of the difference (D_t) between market and support price.

Rosales (1981) in the analysis of supply response for soybeans, cotton, wheat and carthamus in Mexico employed a system of seemingly related supply equations, given that these crops competed for the same land:

$$Q_{it} = f(EP_{it}, Q_{i\,t-1}, [EPR_{it}], PF_t), i = 1......4 \qquad (2.8)$$

where Q_{it} represented the quantity produced of the crop i in the year t; EP_{it} was the expected price of the crop i in year t, [EPR_{it}] was a row vector formed by the expected prices of the other crops, and PF_t was the fertilizer price in year t. Five expected price formulations were considered:

$$EP_{it} = PR_{it-1} \qquad (2.9)$$

Equation (2.9) expressed that the expected price of the crop i in the year t is equal to the rural price of crop i in the last year. The second formulation was:

$$EP_{it} = \{[(PG_{it} - PG_{it-1})\, CONASUPO_{it-1} / Q_{it-1}] + PR_{it-1}\} \qquad (2.10)$$

where PG_{it} represented the guarantee price of the crop i in year t; $CONASUPO_{it-1}$ represented the quantity of the crop i bought by the Mexican Marketing Institution in the year before; Q_{it-1} was the quantity produced of the crop i in the last year, and PR_{it-1} was the rural price of the crop i in the last year.

Equation (2.10) included policy variables in the formulation of the expected price.

The third expected price formulation (EPSOY) included the effect the probability of water (P) in the expected rural price of soybeans:

$$EPSOY_t = EPS_t \times P_t \tag{2.11}$$

and

$$P_t = \sum_j W_{jt-1} / C \tag{2.12}$$

where the probability of water (P) was calculated by the ratio of the amount of water in the lake j in the last year (W_{jt-1}) and the maximum amount of water (C) found in the lake during the period of study (1960-1978).

A strong relationship existed between soybeans and wheat given the pattern of rotation crops. The expected price under this assumption was:

$$EPSW_t = \{[(PS_{t-1} \times RS_{t-1}) + (PW_{t-1} \times RW_{t-1})] / (RS_{t-1} + RW_{t-1})\} \tag{2.13}$$

where EPSW represented the joint soybeans-wheat price, PRS and PRW were the rural price of soybeans and wheat respectively; and RS and RW were the yields of soybeans and wheat.

The last expected price formulation (EPSWP) was the inclusion of the probability of water (P) in the joint soybeans-wheat expected price (EPSW):

$$EPSWP_t = EPSW_t \times P_t \tag{2.14}$$

The system of Nerlove supply functions were estimated using the seemingly unrelated regression method, also different alternatives of price policy effects on production of the crops considered were analyzed. Prices with policy variables in the expected price formulation were more significant.

Bailey and Womack (1985) in a regional econometric investigation of the wheat acreage response in the U.S. calculated the expected prices used in the model as:

$$EP_{ij} = (PRI_{ij} \times PF_{ij}) + (PRO_{ij} \times PM_{ij}) \quad (2.15)$$

where:

PR_{ij} = percent of acreage complying with the farm program for commodity i in region j,

PRO_{ij} = percent of acreage not complying with the farm program for commodity i in region j,

PF_{ij} = effective support price for commodity i in region j,

PM_{ij} = lagged season average price received by farmers for commodity i in region j, and

i = 1, 2; j = 1......5

It was assumed that if a farmer participated in the farm program, PF, reflecting government support variables, would be the relevant acreage inducing price. On the other hand, if a farmer decided not to follow the farm program, then PM, an expected market price, will be the relevant acreage inducing price. Hence, the variable EP had the advantage of representing both farmers in and outside the farm programs.

Estimates of Cotton Supply Elasticities in Colombia and Various Countries

There are few estimates of cotton supply elasticities in Colombia. Junguito (1980) reported the values of the elasticities found by Palma (1975) and FEDESARROLLO-PROEXPO (1975). In the study by Palma, the short and long-run elasticities were 0.7 and 14.8, while the same elasticities for the FEDESARROLLO-PROEXPO study were 0.7 and 19.4 respectively (Table I).

Norton (1985) tested the price responsiveness hypothesis for several agricultural products in Colombia. The analyzed commodities were: cotton,

TABLE I

COTTON OWN PRICE SUPPLY ELASTICITIES (VARIOUS COUNTRIES) [1]

Country Region	Period	Author	Short-run Elasticity	Long-run Elasticity
Colombia	< 1978	Palma	0.7	14.8
Colombia	< 1978	Fedesarrollo-Proexpo	0.7	19.4
Colombia	1960-1983	Garcia & Montes	0.68	7.49
Colombia	1962-1983	Garcia & Montes	1.0	3.7
Colombia/Costa	1962-1983	Garcia & Montes	1.06	24.76
Brazil[2]	< 1974	Pastore	0.19	0.63
Brazil/Sao Paulo	< 1974	Pastore	1.22	2.03
Brazil/Sao Paulo	< 1974	Brandt	0.69	1.57
Brazil/Sao Paulo	< 1974	Ayer & Schuch		0.94
Egypt	1920-1940	Askari & Cummings	-3.36	-5.18
India	1948-1961	Raj-Krishna	0.59	1.08
Indonesia	1960-1980	Liu & Roningen		0.25
Nigeria	1948-1967	Olayide	0.03	
Nigeria	1948-1967	Oni	0.38	0.28
Pakistan	1933-1959	Falcon	0.41	
Pakistan	1950-1967	Cummings	0.41	0.28
Pakistan	1962-1982	Tweeten	0.30 to 0.44	0.28 to 1.03
Punjab	1922-1943	Raj-Krishna	0.59	1.08
Punjab	1950-1968	Cummings	0.37	0.56
Syria	1948-1960	Harik	1.12	0.83
Syria	1961-1972	Harik	1.49	1.09
Sudan	1951-1965	Medani	0.39	0.50
USA/Delta	1905-1932	Brennan	0.33	
USA/Delta	1947-1969	Penn & Irwin	0.36	0.41
USA/Delta	1960-1980	Langley	0.69	0.79
USA/Southeast	1909-1932	Nerlove	0.20 to 0.67	
USA/Southeast	1905-1932	Brennan	0.33	
USA/Southeast	1960-1980	Langley	0.29	1.0
USA/Southern Plains	1960-1980	Langley	0.46	0.74
USA/Southwest	1960-1980	Langley	0.05	0.14
USA/Texas	1946-1976	Shumway & Powell	0.15	
USA (10 states)	1883-1914	Decanio	0.13 to 0.34	0.33 to 0.85
Uganda	1945-1966	Alibaruho	0.50	0.63

[1] Most of the estimates come from direct estimation method.

[2] Estimates of cotton supply elasticities for Brazil were taken from: De Castro, Jose. "An Economic Model for Establishing Priorities for Agricultural Research for the Brazilian Economy." Ph.D. Dissertation, Purdue University, 1974. Several estimates were taken from Askari and Cummings (1976), p. 273 and Henneberry, Shida (1986), p. 187.

corn, sorghum, barley and rice. The results of this study suggest that the production of most of the examined crops (except for rice) were price-responsive (Norton, p. 52). The most important variables in the area planted for cotton were: lagged cotton price, the price of cotton relative to the price of rice, and the price of cotton relative to the rural wage rate. He did not report values of short and long-run elasticities.

Garcia and Montes (1986) estimated the elasticities of supply of cotton, rice, wheat, and coffee. The basic model used for the four commodities were:

$$X_t = aC + abP_{t-1} + (1-a)X_{t-1} + zss_{t-1} \qquad (2.16)$$

where:

ab = short-term elasticity of supply

ab/(1-b) = long-term elasticity of supply, and

ss = supply shifters

Cotton in Colombia is produced principally in: Meta, Tolima, Valle and in the Costa region, which in turn are classified in Costa-Meta and in the interior (Tolima and Valle). The reason for this classification is that the cropping season for Costa and Meta, and Tolima and Valle is the same (Garcia and Montes, 1986).

For the whole country and for each region, Garcia and Montes represented the dependent variable X_t by the number of hectares harvested. The supply shifter used for each region and for the country was the deviation of yield in terms of raw cotton with respect to its trend value for each region and for the country as a whole. For Costa-Meta two prices were used, both measured with respect to the price of nonagricultural output. These prices were the price of raw cotton and the average price of fiber received by the domestic producer for his sales of fiber to the domestic and foreign markets. For Tolima the price of raw cotton and cotton fiber relative to the price of non-agricultural output, plus other prices (sorghum, rice, and cattle) was considered. For Valle the price of soybeans relative to the price of cotton fiber was used; other prices (rice, sugar, beef cattle and milk) relative to the price of fiber were used but these turned to be insignificant.

The estimated coefficients showed short-run elasticity of supply between 0.68 and 1.10. The long-run price elasticity was very high, particularly for the Costa-Meta region, reaching in some cases values close to 25. For the country as a whole the long-run estimated price elasticity was also high, 7.49, but lower than the estimated by Palma and FEDESARROLLO-PROEXPO which was close to 20 (Table I).

A wide range of reported estimate elasticities for cotton supply of several countries was found. A strong difference exists for the long-run supply elasticities reported for Colombia compared to the other countries, including Latin American countries such as Brazil (Table I).

Peterson (1979) and Henneberry (1986) mentioned several reasons for the differences of the estimates of the studies of supply response. The most important are: the estimation method, type of data used, nonprice variables, and government intervention. It is said that the Nerlove models are likely to underestimate the own-price short-run and long-run supply elasticities. Errors in the independent variables, misspecification errors (e.g. exclusion of the technology variable from the supply equation), and failure to include all relevant past prices in the price expectation variable are some of the reasons for this downward bias.

Estimates based on cross-sectional data overestimate the true supply elasticities if there are differences in technological and economical development stages across regions. Time series data are subject to transient fluctuations to which farmers may not respond so much as they would to permanent price changes (Chibber, 1982). It is also expected that individual crops have a higher own-price supply response than aggregate farm output; that commercial crops have larger own-price supply elasticities than subsistence crops; and that supply elasticities estimates for larger commercial farms will be higher than the estimates for relative small farms.

Consumer's and Producer's Surplus

The concept of consumer's surplus dates back to Dupuit who in 1844 defined this surplus as "the difference between the sacrifice which the purchaser will be willing to make to get it and the purchase price he has to pay in exchange." He proposed that this surplus can be measured by the triangle-like area below the demand curve and above the price line. The concept of consumer's surplus was popularized by Marshall.

Hicks (1943) introduced several methods of measuring the consumer's surplus; among them compensating variation and equivalent variation have been extensively used in welfare economics. For a normal good the Hicksian demand curve must be steeper than the Marshallian demand curve (Figure 4). Willig (1976) has argued that, provided that the income effect is relatively small, the Hicksian and Marshallian consumer surpluses are approximately equal. This argument can be used to justify the use of Marshallian or "ordinary" demand curves in welfare analysis of consumers.

Marshall introduced the concept of producer's surplus to formalize the notion that a seller as well as buyer may receive some sort of surplus from a transaction. The supply curve shows the minimum price at which producers are willing to supply the various quantities of commodity. They will tend to supply additional output if incremental variable costs are covered. The opportunity cost

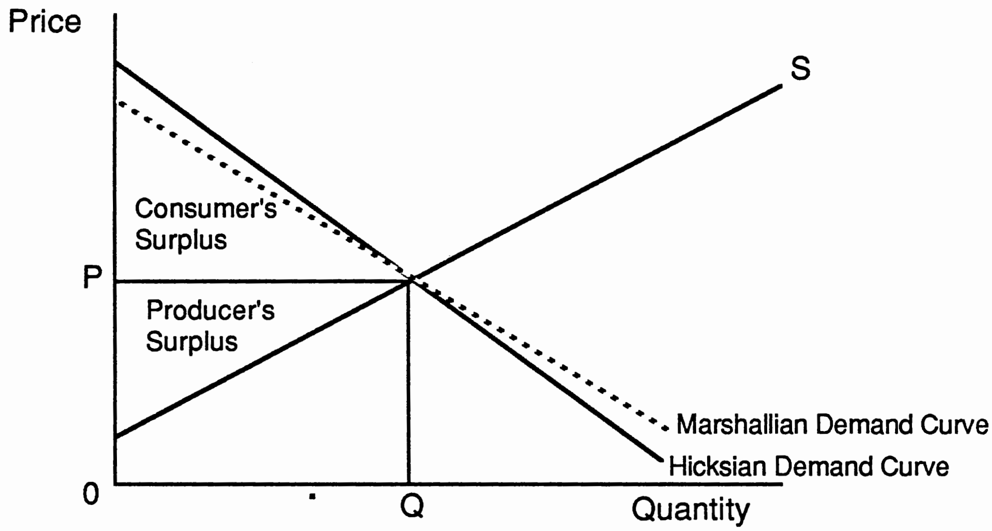


Figure 4. Producer's and Consumer's Surplus

(benefit foregone by not consuming other goods and services) of an incremental unit of output to a competitive supply is measured by the supply price. If the minimum price were paid for each possible quantity, it follows that the total variable cost (benefit foregone of other goods and services) of producing any given quantity is the area beneath the supply curve. Consumer and producer's surplus under free market and a partial equilibrium framework are illustrated in Figure 4.

Application of Classical Welfare Anaysis to Cotton Policy Analysis in Colombia

Classical welfare analysis is another important role for supply and demand elasticities, since the magnitude of the gain or loss in the surplus of each group depends on demand and supply elasticities. The analyst is rarely if ever in a position to designate one best policy because decision makers' objectives tend to be numerous and sometimes obscure. Classical welfare analysis helps to identify the effects on national income of agricultural policies and the distribution of that income among producers, consumers, taxpayers, and society (Tweeten, 1986).

There is only one estimate of the welfare measurement approach to the cotton price policy analysis in Colombia. John Nash (1985) measured the welfare cost of price stabilization for several crops. To illustrate the methodology used, Nash explained it in terms of a simple model of an export good, whose price in the world market assumes only two values, P_1 or P_2 ($P_1 > P_2$), each with probatility 0.5, and whose domestic producer price is stabilized at the mean value, $\bar{P}$, by means of a tax-subsidy scheme devised so that the average protection is 0; that is, when the world price is P_1 there is a tax of $P_1 - \bar{P}$ on the export; when world price is P_2, there is a subsidy of $\bar{P}$-P_2 (Figure 5).

With a price stabilization scheme producers receive price $\bar{P}$, and produce quantity $\bar{Q}$. When the world price is P_1, the government receives area A in export taxes; when the world price is P_2, the government gives subsidies equal to C+D. When the world price is P_1, exporters forego a producer surplus increase of A+B by selling only quantity $\bar{Q}$ at price $\bar{P}$. But area A is not a welfare loss to the country because it goes to the government in taxes. The welfare loss from maintaining the producer price at $\bar{P}$ is area B. Area B is a triangle whose area is $1/2(P_1-\bar{P})(Q_1-\bar{Q})$. The quantity $Q_1-\bar{Q}$ can be expressed as $dQ/dP(P_1 - \bar{P})$ so area B = $1/2 (P_1- \bar{P})^2 (\bar{Q}/\bar{P})E$, where E is the export supply elasticity. By the same kind of logic, the welfare loss to the economy from maintaining an internal price of $\bar{P}$ when the world price is P_2 is area D, which is $1/2 (P_2 - \bar{P})^2 (\bar{Q}/\bar{P})E$. So, the average yearly loss is $1/2E(\bar{Q}/\bar{P})$ Var(P), where Var(P) is the variance of the world price. By definition, the variance is the average of $(P_1 - \bar{P})$ and $(\bar{P} - P_2)^2$.

Also, by similar logic, the consumer welfare loss from stabilization of the price of an imported good can be shown to be $1/2 |N| (\bar{Q}/\bar{P})$ Var(P), where $|N|$ is the absolute value of import demand elasticity. The values of these variables are presented in Table II. The import and export elasticities were computed from estimates of domestic elasticities of demand and short-run supply and are thus the elasticities that would prevail in a market with no governmental interference in free trade. Nash took the estimates elasticities from the results of the background study for an article on nutrition in Colombia realized by Pinstrup-Andersen, Ruiz and Hoover in 1976.

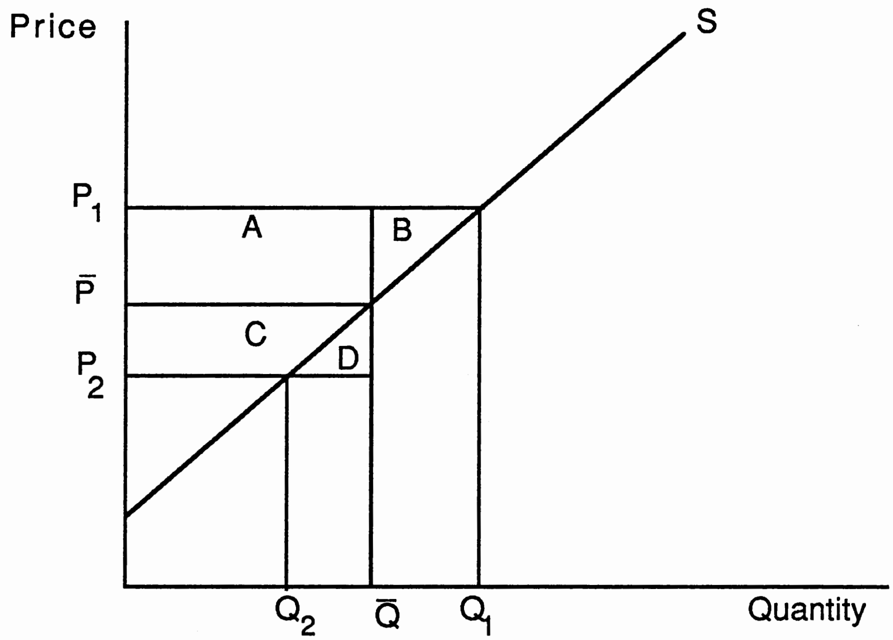


Figure 5. Annual Welfare Losses from Price Stabilization in Colombia

TABLE II

ANNUAL WELFARE LOSSES FROM PRICE STABILIZATION IN COLOMBIA
(1975 PESOS)

Crop	Q (MT)	P ($/MT)	Var(P)	N	1/2|N|(Q/P)Var(P)	E	1/2 E (Q/P) Var(P) (000's Pesos)
Import Crops							
Wheat	364,167	3,471	1,642,000	-0.69	59,434,446	NA	NA
Corn	57,125	3,072	541,900	-12.08	60,864,084	NA	NA
Barley	50,125	3,898	710,200	-0.19	867,595	NA	NA
Export Crops							
Rice	22,467	7,660	4,093,000	NA	NA	38.60	231,694
Cotton	50,317	32,961	26,950,000	NA	NA	5.28	108,611
Potatoes	6,708	4,571	2,299,000	NA	NA	74.87	126,298

NA = Not Applicable
Q = Quantity
P = Price
N = Absolute value of import demand elasticity
E = Export supply elasticity

SOURCE: NASH, JOHN (1985), p. 202.

CHAPTER III

MODEL SPECIFICATION AND ESTIMATION METHODS

Partial Adjustment Model

In economics the dependence of the explained variable on the explanatory variables is rarely instantaneous. Very often, Y responds to X with a lapse of time. Such a lapse of time is called a lag. Koyck and Nerlove have suggested three general reasons for the existence of distributed lags: (1) technical reasons; (2) institutional reasons; and, (3) subjective or psychological reasons.

Partial adjustment occurs when various factors prevent a complete response to change in conditions. This model gives an alternative rationalization of the geometric lag model. Mathematically the model can be illustrated as follows:

$$Q_t^* = \beta_0 + \beta_1 P_{t-1} + U_t \qquad (3.1)$$

where:

Q_t^* = the desired output in time t

β_0 = constant or intercept term

β_1 = slope term

P_{t-1} = the price of the crop in time t-1, and

U_t = unobserved factors affecting output in time t.

Since the desired level of output (Q_t^*) in equation (3.1) is not directly observable, Nerlove postulated the following hypothesis, known as the partial adjustment, or stock adjustment hypothesis:

$$Q_t - Q_{t-1} = \delta (Q_t^* - Q_{t-1}) \quad (3.2)$$

where:

Q_t = the actual output in time t

Q_t^* = the desired or equilibrium output in time t

δ = the coefficient of adjustment reflecting the response of observed output to changes in equilibrium output and where $0 < \delta < 1$; $Q_t - Q_{t-1}$ = actual change; and $Q_t^* - Q_{t-1}$ = the desired change.

Equation (3.2) assumes that the actual change in output in any given time period t is some fraction δ of the desired change for that period. If $\delta = 1$, the actual output is equal to the desired output; that is, all adjustments occur in the same time period. However, if $\delta = 0$, no adjustment occurs and actual output at time t is the same as in the previous period.

Equation (3.2) can be written as

$$Q_t = \delta Q_t^* + (1-\delta) Q_{t-1} \quad (3.3)$$

Substitution of equation (3.1) into equation (3.3) gives

$$Q_t = \delta (\beta_0 + \beta_1 P_{t-1} + U_t) + (1-\delta) Q_{t-1} \quad (3.4)$$

$$Q_t = \delta\beta_0 + \delta\beta_1 P_{t-1} + (1-\delta) Q_{t-1} + \delta U_t \quad (3.5)$$

Estimation of the equation (3.5) yields:

$$Q_t = \hat{\beta}_0 + \hat{\beta}_1 P_{t-1} + \hat{\beta}_2 Q_{t-1} + V_t \quad (3.6)$$

where:

$$\hat{\beta}_0 = \delta\beta_o \quad (3.7)$$

$$\hat{\beta}_1 = \delta\beta_1 \quad (3.8)$$

$$\hat{\beta}_2 = (1-\delta), \text{ and} \quad (3.9)$$

$$V_t = \delta U_t \tag{3.10}$$

From equations (3.7) to (3.9) we can obtain:

$$\delta = 1 - \hat{\beta}_2 \tag{3.11}$$

$$\beta_0 = \hat{\beta}_0 / \delta \tag{3.12}$$

$$\beta_0 = \hat{\beta}_1 / \delta \tag{3.13}$$

The short-run elasticity E_{sr} (elasticity with respect to the price of the year before) is computed: $E_{sr} = \hat{\beta}_1$ P/Q. The long-run elasticity E_{lr} (elasticity with respect to the price of the past years) is calculated: $E_{lr} = E_{sr} / \delta$).

Additional variables such as risk, price of competing crops, policy variables, weather risk etc., can be considered in equation (3.6). Ordinary Least Squares (OLS) estimation of the partial adjustment model will yield consistent estimates although they tend to be biased in finite or small samples (Gujarati, 1978).

Adaptive Expectation Model

In this model, the farmer makes decisions on the basis of expected price, and the farmer's expected price changes according to the accuracy of last year's forecast.

Suppose,

$$Q_t = \beta_0 + \beta_1 P_t^* + U_t \tag{3.14}$$

where

Q_t = actual output in t

P_t^* = the expected price in time t

β_0 = constant or intercept term

β_1 = slope term

U_t = unobserved factors affecting output in time t.

√ Since the expected price P_t^* is not directly observable, the following hypothesis about how expectations are formed is proposed:

$$P_t^* - P_{t-1}^* = \tau \ (P_{t-1} - P_{t-1}^*) \tag{3.15}$$

where τ, such that $0 < \tau < 1$, is known as the coefficient of expectation. Hypothesis (3.15) is known as the adaptive expectation, progressive expectation, or error learning hypothesis, publicized by Cagan and Friedman (Gujarati, 1978). In (3.15), expectations are revised each period by a fraction τ of the gap between the current value of the price and its previous expected value, i.e., that this year's forecast is different from last year's forecast by a fraction τ of the error in last year's forecast. In t-1, (3.14) becomes

$$Q_{t-1} = ß_0 + ß_1 P_{t-1}^* + U_{t-1} \tag{3.16}$$

Multiplying (3.16) by $(1-\tau)$ and substracting from (3.14) provides

$$Q_t - (1-\tau)\, Q_{t-1} = ß_0 \,(1-[1-\tau]) + ß_1 \,(P_t^* - [1-\tau]-P_{t-1}^*) + U_t - (1-\tau)\, U_{t-1} \tag{3.17}$$

(3.15) may be rearranged to obtain

$$P_t^* - (1-\tau)\, P_{t-1}^* = \tau P_{t-1} \tag{3.18}$$

Substitution of (3.18) into (3.17) and rearranging terms provides,

$$Q_t = \tau ß_0 + \tau ß_1 P_{t-1} + (1-\tau)\, Q_{t-1} + V_t \tag{3.19}$$

where $V_t = U_t - (1-\tau)\, U_{t-1}$. Estimation of equation (3.19) gives,

$$\hat{ß}_0 = \tau ß_0 \tag{3.20}$$

$$\hat{ß}_1 = \tau ß_1 \tag{3.21}$$

$$\hat{ß}_2 = 1-\tau \tag{3.22}$$

From equations (3.20) to (3.22) the following parameters are derived:

$$\tau = 1-\hat{ß}_2 \tag{3.23}$$

$$ß_0 = \hat{ß}_0 / \tau \tag{3.24}$$

$$ß_1 = \hat{ß}_1 / \tau \tag{3.25}$$

✓The short-run elasticity $E_{sr} = \hat{\beta}_1 P/Q$. The long-run elasticity $E_{lr} = E_{sr} / \tau$.

The estimates obtained from the adaptive expectation model using OLS will be biased, consistent and inefficient. According to Gujarati (1978), the partial adjustment model resembles both the Koyck and adaptive expectation models in that it is autoregressive, but it has a much simpler disturbance term.

Although similar in appearance, the adaptive expectation and partial adjustment models are conceptually different. The former is based on uncertainty about future course of prices, whereas the latter is due to technical or institutional rigidities, inertia, cost of change, etc. However, both these models are theoretically much sounder than the Koyck model.

✓ Nerlove's Model

Following Henneberry (1986), by combining the partial adjustment and adaptive expectation model we obtain a compound geometric lag model:

$$Q_t^* = \beta_0 + \beta_1 P_t^* + U_t \qquad (3.26)$$

where Q_t^* is the optimal level of output in period t, and P_t^* is the expected price in time t. Nerlove's model is a compound geometric lag model.

Nerlove's model is based on the concept that the expected "normal" price for producers is equal to last period's expected "normal" price plus or minus some degree of adjustment depending last period's actual price. Rewriting equation (3.15):

$$P_t^* - P_{t-1}^* = \tau (P_{t-1} - P_{t-1}^*), \quad 0 < \tau < 1 \qquad (3.27)$$

In Nerlove's model of adaptive expectations, farmers adapt their expectations of price according to past mistakes, in that the change in expected price is proportional to the deviation between actual and expected prices in the last period. Equation (3.27) can be written:

$$P_t^* = P_{t-1}^* + \tau (P_{t-1} - P_{t-1}^*), 0 < \tau < 1 \qquad (3.28)$$

The value of zero for τ implies that the actual prices are totally independent from expectations. The value of one for τ implies a cobweb type model where expected prices are identical with last year's realized price.

Rewriting equation (3.28):

$$P_t^* = \tau P_{t-1} + (1-\tau) P_{t-1}^* \qquad (3.29)$$

Lagging (3.29) in a year,

$$P_{t-1}^* = \tau P_{t-2} + (1-\tau) P_{t-2}^* \qquad (3.30)$$

Substitution of (3.30) into (3.29) becomes,

$$P_t^* = \tau P_{t-1} + (1-\tau) \tau P_{t-2} + (1-\tau)^2 P_{t-2}^* \qquad (3.31)$$

but

$$P_{t-2}^* = \tau P_{t-3} + (1-\tau) P_{t-3}^* \qquad (3.32)$$

thus,

$$P_t^* = \tau P_{t-1} + (1-\tau) \tau P_{t-2} + (1-\tau)^2 \tau P_{t-3} + (1-\tau)^3 P_{t-3}^* + \ldots \qquad (3.33)$$

From equation (3.33) if $\tau = 1$ then $P_t^* = P_{t-1}$; if $\tau = 0$ then $P_t^* = P_{t-1}^*$.

Nerlove's model dynamically describes a supply response model for which distinct estimates of all the parameters can be obtained using either a maximum likelihood technique or a least squares technique. In Nerlove's model, optimal output Q_t^* is a function of expected prices P_t^*, and a vector of non-price shifters Z_t, like price of related commodities, policy variables, risk, a trend term, weather, etc.:

$$Q_t^* = \beta_0 + \beta_1 P_t^* + \beta_2 Z_t + U_t \qquad (3.34)$$

Equation (3.34) together with equation (3.2) of the partial adjustment model:

$$Q_t - Q_{t-1} = \delta (Q_t^* - Q_{t-1}),\ 0 < \delta < 1 \qquad (3.35)$$

and equation (3.15) of the adaptive expectation model:

$$P_t^* - P_{t-1}^* = \tau (P_{t-1} - P_{t-1}^*),\ 0 < \tau < 1 \qquad (3.36)$$

yields a structure that describes dynamically a supply response model. Equation 3.37 is derived by first substituting equation 3.33 in equation 3.34 for P*. Equation 3.34 is then substituted in equation 3.35 and the resulting terms rearranged to derive in equation 3.37.

$$Q_t = \beta_0\, \delta + \beta_1\, \delta \sum_{i=1}^{n} \tau (1-\tau)^{i-1} P_{t-i} + \beta_2 \delta Z_t + (1-\delta) Q_{t-1} + V_t \qquad (3.37)$$

If $\delta = 1$, Nerlove's model reduces to a pure adaptive expectation model. If τ=1, Nerlove's model reduces to a pure partial adjustment model; and, to a simple regression model if $\delta = 1$ and $\tau = 1$.

If i = 1, estimation of the Nerlove's model will give,

$$\hat{\beta}_0 = \beta_0\, \delta \qquad (3.38)$$

$$\hat{\beta}_1 = \beta_1\, \delta, \text{ and } \hat{\beta}_2 = \beta_2\, \delta \qquad (3.39)$$

$$\hat{\beta}_3 = 1 - \delta \qquad (3.40)$$

The short-run elasticity (E_{sr}) = $\hat{\beta}_1$ P/Q. The long-run elasticity (E_{lr}) = E_{sr} / δ.

Once the coefficient of expectation is known, it is possible using the equation (3.33) to compute the weights that farmers give to expected prices for each year. The sum of these weights up to 100% allows us to determine the period of adjustment or numbers of periods required to reach a new equilibrium output given a change in the expected price. The larger the coefficient of the lagged dependent variable ($\hat{\beta}_3$), the lower the adjustment coefficient (δ) will be, which means it takes a longer time for the output to adjust to its long-run value after a price change. In other words, the long-run own price supply elasticity will be much greater than the short-run elasticity. The lower the coefficient of the lagged dependent variable, the quicker output reaches its long run equilibrium value, and therefore short-run elasticity will be closer to its long-run value.

Cotton Supply Model

The law of supply is the relevant economic theory used in the formulation of the economic models in this section. The quantity supplied of a particular commodity by an individual firm is a function of the expected own commodity price, the expected prices of related commodities, the expected price of the inputs used in the production of the product, and other relevant variables.

When there is not an exact "real world" counterpart to a variable suggested by the theory, a proxy variable is typically used. Expected price and risk are subjective measurements which have no exact real world counterparts; therefore, proxy variables must be used. Policy variables are defined them in this study as variables in which the government controls the production or area planted of a commodity by using either incentives or disincentives.

The manner in which policy variables enter in the formulation of expected prices of cotton as well as in the expected prices of related crops, the way in which the risk variables are constructed, the shifter variables of supply that are considered, the expected sign of the variables, and the models of supply that are postulated, are all discussed below.

Policy Variables and Formulation of Expected Price Alternatives

Given the structure of commercial cotton production in Colombia, one might presume that cotton growers simultaneously make resource allocation decisions among soybeans, sorghum, rice, and cotton, crops which are competing for the same land and production resources (Appendix A).

The simplest formulation of expected price considered in this study does not include any policy variable directly. In this case, the expected price of crop i in year t (EPi_i) is formulated as the producer price received of crop i in year t-1 (Pi_{t-1}):

$$EPi_t = Pi_{t-1} \tag{3.41}$$

The exchange rate, export subsidy, and internal price that results from the agreement approved by the government between the FEDERACIONES (which represent cotton growers) and DIAGONAL (unique domestic enterprise which buys cotton and represents the textile producers) are the policy variables considered in the formation of the expected price for cotton:

$$EPC_t = \frac{\{(PD_{t-1} \times QD_{t-1}) + [PX_{t-1} \times (1+(S_t - S_{t-1}))] \times XC_{t-1}\}}{QD_{t-1} + XC_{t-1}} \tag{3.42}$$

where:

$$PX_{t-1} = PI_{t-1} \times NER_{t-1} \tag{3.43}$$

where:

EPC_t = Expected price of cotton in year t

PD_{t-1} = Price paid for cotton by DIAGONAL in year t-1

QD_{t-1} = Quantity bought by DIAGONAL in year t-1

PX_{t-1} = External price of Colombian cotton in year t-1

S_t = Export subsidy (percent of international price) for cotton in year t

S_{t-1} = Export subsidy (percent of international price) for cotton in year t-1

XC_{t-1} = Quantity of cotton exported in year t-1

PI_{t-1} = International price of cotton in year t-1

NER_{t-1} = Nominal exchange rate in year t-1

Prices are deflated with the nominal index of prices of the nonagricultural sector (IPNAS) (1975=100.0). If the export subsidy in year t is larger than the export subsidy in year t-1 ($S_t > S_{t-1}$), the expected price in year t is greater than the expected price in the year t-1. If there is no change in this policy variable in year t, ($S_t = S_{t-1}$), the expected price in year t is the same as the expected price in the year before. A decrease in the export subsidy in year t, ($S_t < S_{t-1}$), implies a lower expected price in year t compared to year t-1. Exchange rate policy is included in the expected price formulation through the external price.

An overvaluation of the Colombian Peso implies a lower nominal exchange rate; therefore, a lower external price. The domestic market quotas and export quotas also are considered in (3.42) since the domestic and external price are weighted by the quantities bought by DIAGONAL and the quantity of Colombian cotton fiber sold of in the international market the year before.

Soybeans, sorghum and rice are considered the related crops of cotton in this study. Therefore, soybeans, sorghum, and rice policies announced by the government affect cotton growers' decisions. One way of introducing in the model these effects is through the formulation of the expected prices of soybeans, sorghum, and rice. These crops also receive support prices; thus, the following expected prices for them are formulated:

$$EPS_t = \{[(PSS_t - PSS_{t-1}) \times IDES_{t-1}] / QS_{t-1}\} + PS_{t-1} \quad (3.44)$$

$$EPR_t = \{[(PSR_t - PSR_{t-1}) \times IDER_{t-1}] / QR_{t-1}\} + PR_{t-1} \quad (3.45)$$

and,

$$EPG_t = \{[(PSG_t - PSG_{t-1}) \times IDEG_{t-1}] / QG_{t-1}\} + PG_{t-1} \quad (3.46)$$

where:

EPS_t = Expected price of soybeans in year t

PSS_t = Price support of soybeans in year t

$IDES_{t-1}$ = Domestic quantity of soybeans bought by the IDEMA (Colombian Market Institution) in year t-1

QS_{t-1} = National Production of soybeans in year t-1

PS_{t-1} = Producer price of soybeans in year t-1

EPR_t = Real expected price of rice in year t

PSR_t = Price support of rice in year t

$IDER_{t-1}$ = Domestic quantity of rice bought by the IDEMA in year t-1

QR_{t-1} = National production of rice in year t-1

PR_{t-1} = Producer price of rice in year t-1

EPG_t = Expected price of sorghum in year t

PSG_t = Price support of sorghum in year t

$IDEG_{t-1}$ = Domestic quantity of sorghum bought by IDEMA in year t-1

QG_{t-1} = National production of sorghum in year t-1.

PG_{t-1} = Producer price of sorghum in year t-1

Prices were deflated with the nominal index of prices of the nonagricultural sector (IPNAS) (1975=100.0). Equations (3.44), (3.45), and (3.46) represent the government's participation in soybeans, rice, and sorghum markets. If there is no difference in the support price of the crop between year t and year t-1, the expected price is equal to producer price of the crop in the year t-1. Support prices for these crops, except for rice, have been lower than the market price in most of the years in the study. Also IDEMA has purchased only a small fraction of these crops. However, the support price and the quantity of the commodity bought by IDEMA the year before are considered as active policy variables for these crops. It is assumed that the presence of IDEMA in the marketing process gives a certain level of security to the producers.

The own expected price for each crop should have a positive sign, indicating that an increase in it, encourages producers to increase production. The expected price of the competing crops should have a negative sign, since an increase in the expected price of a competing crop motivates producers to increase the use of production resources for that crop.

Risk Aversion Variables

Generally farmers are risk-averters. Price, income, and yield fluctuations and climatological variability have substantial implications on responsiveness of farmers and may directly or indirectly affect price expectations, output, and planning decisions. Risk in this study is based on the assertion that risk is directly related to the recorded instability or variability of prices in recent periods. This involves the implicit assumption that perceived risk is equated or directly related to variability, and that present riskiness is related to riskiness in the recent past. The use of a moving range and a moving standard deviation for domestic and external prices are measures of variation postulated in this study. Specifically the construction of risk variables are:

RVC1 = Risk variable for cotton formed by the moving range of cotton domestic price (3 years)

RVC2 = Risk variable for cotton formed by the moving range of cotton external price (3 years)

RVC3 = Risk variable for cotton formed by the moving standard deviation of cotton domestic price (3 years)

RVC4 = Risk variable for cotton formed by the moving standard deviation of cotton external price (3 years)

RVS = Risk variable for soybeans formed by the moving standard deviation of soybeans domestic price (3 years)

RVR = Risk variable for rice formed by the moving standard deviation of rice domestic price (3 years)

RVG = Risk variable for sorghum formed by the moving standard deviation of sorghum domestic price (3 years)

The own crop risk variable should have negative sign, indicating that an increase in variability of prices has a depressing effect on the acreage harvested.

Other Shifters of Cotton Supply

Production costs reported by Garcia and Montes (1986), (in pesos per hectare) formed by the costs of fertilizers, pest control and labor will be included. High levels of production costs discourage production of cotton; therefore a negative sign is expected for this variable.

Most of the cotton planted in Colombia is done with credit. Therefore, it should be relevant in the supply function. Since it is expected that availability of credit increases the area planted to cotton, a positive sign is expected for this variable.

Cotton yields, as reported at the national or aggregate level, have not varied considerably over time. However, expenditures on research for cotton are included in the model to determine the effect of this variable in the supply function. In general a positive relationship between yields and expenditure on research is expected.

Several shifters of the supply function are omitted. Data and time limitations made it difficult to include a weather variable, and other input costs such as price of the land, machinery, seeds, and planting costs.

Econometric Models of Cotton Supply

According to the review of literature a wide range of values of cotton supply elasticities was found, since variation in the elasticity estimates depends on prices formulations, model specification, estimation method, type of data, and the time period considered. Four alternative models are postulated to compare their results.

Model I

The production function of cotton can be expressed as:

$$QC = f\ (HHC, I) \tag{3.47}$$

Equation (3.47) shows cotton production as a function of hectares harvested (HHC) and the quantities of inputs (I), such as fertilizer, pesticides, etc., applied per hectare. The number of hectares planted to cotton are influenced by the expected price of cotton, the expected price of competing crops, and government programs.

Suppose cotton growers decide to harvest Ho hectares of cotton (Harvested HHC_0 hectares). The cotton supply function can be expressed as:

$$QC = g\ (EPC, HHC_0) \tag{3.48}$$

In which cotton output (QC) is a function of the expected price of cotton and the land input (HHC_0). A yield per hectare function can be derived from equation (3.48).

$$Y = QC/HHC_0 = h\ (EPC, HHC_0) \tag{3.49}$$

The relation between Y and EPC is expected to be positive, assuming that producers seek to maximize profits.

To estimate production response to price in this model, a system of two behavioral equations and an identity is used:

$$HHC = a(EPC) \quad (3.50)$$

$$Y = y(EPC, HHC) \quad (3.51)$$

$$QC = HHC \,.\, Y \quad (3.52)$$

The total derivative of the system is:

$$dHHC = a_{EPC} \,.\, dEPC \quad (3.53)$$

$$dY = y \,.\, dEPC + y_{HHC} \,.\, dHHC \quad (3.54)$$

$$dQC = y \,.\, dHHC + HHC \,.\, dY \quad (3.55)$$

Using Cramer's rule to solve for dQC/dEPC:

$$dQC/dEPC = HHC \,.\, y_{EPC} + HHC \,.\, y_{HHC} \,.\, a_{EPC} + Y \,.\, a_{EPC} \quad (3.56)$$

Multiplying through by EPC/QC and with some algebraic manipulations, the production elasticities for expected price are:

$$\epsilon_{QC/EPC} = \epsilon_{Y/EPC} + \epsilon_{Y/HHC} \cdot \epsilon_{HHC/EPC} + \epsilon_{HHC/EPC} \quad (3.57)$$

$$\epsilon_{QC/EPC} = \epsilon_{Y/EPC} + \epsilon_{HHC/EPC} (1 + \epsilon_{y/HHC}) \quad (3.58)$$

$\epsilon_{QC/EPC}$, $\epsilon_{y/EPC}$, and $\epsilon_{HHC/EPC}$ are the elasticities of production, yield, and hectares harvested. The response of production to price, therefore, depends upon the relative responses given in (3.58). It is expected that $\epsilon_{y/EPC}$ and $\epsilon_{HHC/EPC}$ will be positive, and $\epsilon_{y/HHC}$ will be negative. If $\epsilon_{y/EPC} = 0$, $\epsilon_{QC/EPC}$ will always be less than $\epsilon_{HHC/EPC}$. If $\epsilon_{y/EPC} > 0$, $\epsilon_{QC/EPC}$ may be greater or less than $\epsilon_{HHC/EPC}$. The implication is that policy makers, to achieve desired production increases or decreases, must be aware of the relative response contained in equation (3.58).

Based on this approach, the econometric Model I of cotton supply response with the expected sign is expressed as:

$$HHC_t = \beta_0 + \beta_1 EPC_t - \beta_2 EPS_t - \beta_3 EPR_t - \beta_4 EPG_t + \beta_5 + HHC_{t-1} - \beta_6 PPC_{t-1} + \beta_7 CDC_t - \beta_8 RVC_t + U_t \quad (3.59)$$

where:

HHC_t = Hectares harvested of cotton in year t

EPC_t = Expected price of cotton in year t ($/ton)

EPS_t = Expected price of soybeans in year t ($/ton)

EPR_t = Expected price of rice in year t ($/ton)

EPG_t = Expected price of sorghum in year t ($/ton)

PPC_{t-1} = Production costs of cotton in year t-1 ($/hectare)

CDC_t = Approved credit for cotton (in million of $) in year t

RVC_t = Risk variable of cotton in year t

U_t = Error term

t = 1960-1983

Expected prices and production cost of cotton are deflated by the index of prices of the nonagricultural sector (IPNAS) (1975 = 100.0).

Cotton yields are affected by weather, economic, cultural, technological, and environmental factors. Changes in production costs have both positive and negative impacts on cotton yields. For example, if expected prices for cotton are expected to be higher next year, producers could increase the use of non-land inputs, but they could also increase the hectares planted of cotton, which would affect yields adversely as marginal cotton land is incorporated into production. Weather significantly influences cotton yields; they are susceptible to an excessive rain season or to a long period of dry season. Insect damage and weather are also related; for example wet weather increases the likelihood of insect damage. Cultural factors also affect yields significantly. Non-availability of data made it impossible to include several variables in this equation. The cotton yield statistical equation with the expected signs is postulated as:

$$Y_t = \alpha_o + \alpha_1 EPC_t + \alpha_2 HHC_t + \alpha_3 RSC_{t-1} - \alpha_4 PPC_t + \alpha_5 CDC_t - \alpha_6 RVC_t + \alpha_7 T + U_t \quad (3.60)$$

where:

EPC_t, HHC_t, PPC_t , CDC_t and RVC_t were defined before, and

Y_t = Yield of cotton (metric tons/hectare)

HHC_t = Hectares harvested of cotton

RSC_{t-1} = Expenditures on research of cotton (million $/year)

T = Trend variable (1, 2, ...24) representing weather effects

U_t = Error term

t = 1960-1883

The expenditures on research are deflated with the index of prices of the nonagricultural sector (IPNAS) (1975=100).

Model II

This model tries to capture directly the interdependence between the cotton economy and those of soybeans, rice, and sorghum. The assumptions for this model are that a strong interdependence exists between these crops. It means that policy changes directed toward a crop can have very decisive effects upon the others. A simultaneous equation system was specified in an attempt to measure the extent of interdependence among crops and the associated commodity policies. This approach contrasts with the previous studies which have employed single equation techniques on time series to estimate the supply of cotton in Colombia. The statistical equations with the expected signs of the variables for this model are formulated as follows:

$$HHC_t = \beta_o + \beta_1 EPC_t - \beta_2 EPS_t - \beta_3 EPR_t - \beta_4 EPG_t + \beta_5 HHC_{t-1} - \beta_6 PPC_{t-1} + \beta_7 CDC_t + \beta_8 RSC_t - \beta_9 RVC_t$$

$$- \beta_{10}\, HHS_t - \beta_{11}\, HHR_t - \beta_{12}\, HHG_t + U1_t \qquad (3.61)$$

$$HHS_t = \alpha_o - \alpha_1\, EPC_t + \alpha_2\, EPS_t - \alpha_3\, EPR_t - \alpha_4\, EPG_t$$

$$+ \alpha_5\, HHS_{t-1} - \alpha_6\, RVS_t - \alpha_7\, HHC_t - \alpha_8\, HHR_t$$

$$- \alpha_9\, HHG_t + U_{2t} \qquad (3.62)$$

$$HHR_t = \tau_o - \tau_1\, EPC_t - \tau_2\, EPS_t + \tau_3\, EPR_t - \tau_4\, EPG_t$$

$$+ \tau_5\, HHR_{t-1} - \tau_6\, PCR_{t-1} + \tau_7\, CDR_t + \tau_8\, RSR_t + \tau_9\, XSR_t$$

$$- \tau_{10}\, RVR_t - \tau_{11}\, HHC_t - \tau_{12}\, HHS_t - \tau_{13} \cdot HHG_t + U_{3t} \qquad (3.63)$$

$$HHG_t = \theta_o - \theta_1\, EPC_t - \theta_2\, EPS_t - \theta_3\, EPR_t + \theta_4\, EPG_t$$

$$+ \theta_5\, HHG_{t-1} - \theta_6\, RVG_t - \theta_7\, HHC_t - \theta_8\, HHS_t - \theta_9\, HHG_t$$

$$+ U_{4t} \qquad (3.64)$$

where:

HHC_t, EPC_t, EPS_t, EPR_t, EPG_t, PPC_{t-1}, CDC_t, RSC_t, and RVC_t are defined the same as they were defined before, and

HHS_t = Hectares harvested of soybeans in year t

HHR_t = Hectares harvested or rice in year t

HHG_t = Hectares harvested of sorghum in year t

RVS_t = Risk variable for soybeans in year t

RVR_t = Risk variable for rice in year t

RVG_t = Risk variable for sorghum in year t

PCR_t = Production costs of rice in year t-1 ($/hectare)

CDR_t = Approved credit for rice in year t (in millions of $)

RSR_t = Expenditures on research for rice (in millions of $)

XSR_t = Export subsidy for rice (in millions of $)

U_{it} = Error term

Variables in monetary units are deflated with the index of prices of the nonagricultural sector (IPNAS) (1975=100.0).

Model III

This model is based on the same assumptions as those for Model II, and consider the same explanatory variables. However, production instead of hectares harvested is postulated as the dependent variable under the assumption that if interdependence exists within hectares harvested for these crops, this interdependence remains in the production obtained. Therefore, the policy established by the government to increase production of one of these crops affects the production obtained of the other crops. The statistical equations for this Model are:

$$QC_t = \beta_0 + \beta_1 EPC_t - \beta_2 EPS_t - \beta_3 EPR_t - \beta_4 EPG_t + \beta_5 QC_{t-1} - \beta_6 PPC_{t-1} + \beta_7 CDC_t + \beta_8 RSC_t - \beta_9 RVC_t - \beta_{10} QS_t - \beta_{11} QR_t - \beta_{12} QG_t + U_{1t} \quad (3.65)$$

$$QS_t = \alpha_0 - \alpha_1 EPC_t + \alpha_2 EPS_t - \alpha_3 EPR_t - \alpha_4 EPG_t + \alpha_5 QS_{t-1} - \alpha_6 RVS_t - \alpha_7 QC_t - \alpha_8 QR_t - \alpha_9 QG_t + U_{2t} \quad (3.66)$$

$$QR_t = \tau_0 - \tau_1 EPC_t - \tau_2 EPS_t + \tau_3 EPR_t - \tau_4 EPG_t + \tau_5 QR_{t-1} - \tau_6 PCR_{t-1} + \tau_7 CDR_t + \tau_8 RSR_t + \tau_9 XSR_t - \tau_{10} RVR_t - \tau_{11} QC_t - \tau_{12} QS_t - \tau_{13} QG_t + U_{3t} \quad (3.67)$$

$$QG_t = \theta_0 - \theta_1 EPC_t - \theta_2 EPS_t - \theta_3 EPR_t + \theta_4 EPG_t + \theta_5 QG_{t-1} - \theta_6 RVG_t - \theta_7 QC_t - \theta_8 QS_t - \theta_9 QR_t + U_{4t} \quad (3.68)$$

where the independent variables are defined the same as they were in Models I and II, and,

QC_t = National production of cotton in year t (metric tons)

QS_t = National production of soybeans in year t (metric tons)

QR_t = National production of rice in year t (metric tons)

QG_t = National production of sorghum in year t (metric tons)

Model IV

To determine if there is any gain in the results of working with a simultaneous equation model to explain the supply function of cotton, a single equation model for cotton is postulated. It corresponds to the first equation of Model III.

$$QC_t = \beta_0 + \beta_1 EPC_t - \beta_2 EPS_t - \beta_3 EPR_t - \beta_4 EPG_t + \beta_5 QC_{t-1}$$
$$- \beta_6 PPC_{t-1} + \beta_7 CDC_t + \beta_8 RSC_t - \beta_9 RVC_t + U_t \qquad (3.69)$$

where all the variables of this equation have been defined.

Econometric Model of Cotton Demand

Empirical demand estimation is necessary for public policy analysis in two important and related ways. First, estimates of price and income elasticities are useful for determining the direction and magnitude of changes in the quantity and price of commodity that might occur when a particular government policy affects any of the determinants of the demand for that commodity. Second, estimates of the demand parameters can be employed to obtain measures of the gain or loss in consumer welfare as a result of some public policy, as is the purpose in this study.

The demand model for cotton to be postulated in this study consists of two parts: a demand function and adjustment equation. Based on the Nerlove hypothesis, the adjustment equation assumes that the change in consumption of cotton fiber is a function of the difference between the change in "desired" and current use of cotton fiber, the statistical model with the expected signs is expressed as follows:

$$CCF_t = \beta_0 - \beta_1 PD_{t-1} + \beta_2 CCF_{t-1} + \beta_3 YNC_t + \beta_4 POP_t$$

$$+ \beta_5 PX_t + \beta_6 PVFO_t + U_t \quad (3.70)$$

and the adjustment equation is:

$$CCF_t - CCF_{t-1} = \theta (CCF^*_t - CCF_{t-1}) \quad (3.71)$$

Substituting equation (3.70) into (3.71) and solving for CCF_t, the equation for the demand of cotton is obtained:

$$CCF_t = \theta\beta_0 - \theta\beta_1 PD_{t-1} + (1-\theta) CCF_{t-1} + \theta\beta_3 YNC_t + \theta\beta_4 POP_t + \theta\beta_5 PX_t + \theta\beta_6 PVFO_t + \theta U_t \quad (3.72)$$

where:

CCF_t = Consumption of cotton fiber (metric tons)

PD_{t-1} = Price paid by DIAGONAL ($/ton)

YNC_t = National income

POP_t = Population

PX_t = External price of cotton ($/ton)

$PVFO_t$ = Price of fats and vegetable oils ($/ton)

t = 1960-1983

Prices and national income are deflated using the index of prices of the nonagricultural sector (IPNAS, 1975=100). The demand for cotton fiber (equation 3.72) is a derived demand. Cotton fiber is an input in the production of textiles. The demand for a factor of production, like the demand for all goods and services, is a relationship between the quantity of the factor used and prices. Shifters of the derived demand function are also considered in empirical studies. The factor demand function is derived from the first-order condition for maximum profit.

For Colombian cotton fiber, the price paid by DIAGONAL is the own price. An increase in the price paid by DIAGONAL reduces the quantity demanded by textile producers. Data limitation made it difficult to include the product price (clothes) in the equation.

Oil obtained from cotton seed is considered as a joint product of cotton fiber. The share of cotton seed oil in the total production of fats and vegetable oil is less than 15%. An increase in the price of fats and vegetable oils in which cotton participation is insignificant is expected to have a positive effect on the consumption of cotton fiber.

Since it was not possible to get information about the total capital investment in the textile industry, and the number of textile producers, national income and population will be used respectively as a proxy of these two variables. It is expected that an increase in these two variables will have positive effects on the consumption of cotton fiber.

Analytical Framework for the Analysis of the Current Cotton Policy in Colombia

Under partial equilibrium assumptions, classical welfare analysis will be applied to provide some insight into the merits of the current export subsidy, the price agreement policy for cotton fiber, and the exchange rate policy for cotton fiber. These policy effects will be measured by their impacts on producers, consumers, taxpayers, and on national income.

The cotton situation for the 1983 crop year, is presented in Figure 6. For the last four years, the domestic price of cotton fiber has been higher than the external price of cotton fiber. Country supply is represented by the line S, domestic demand and export demands are represented by the lines d and D_2, respectively. The domestic market price (Pd) is set by agreement between DIAGONAL and the cotton farmers, cotton growers sell all the quantity consumed domestically, Qd, at the domestic price paid by DIAGONAL (Pd). Once the domestic market has been satisfied, producers sell the excess supply,

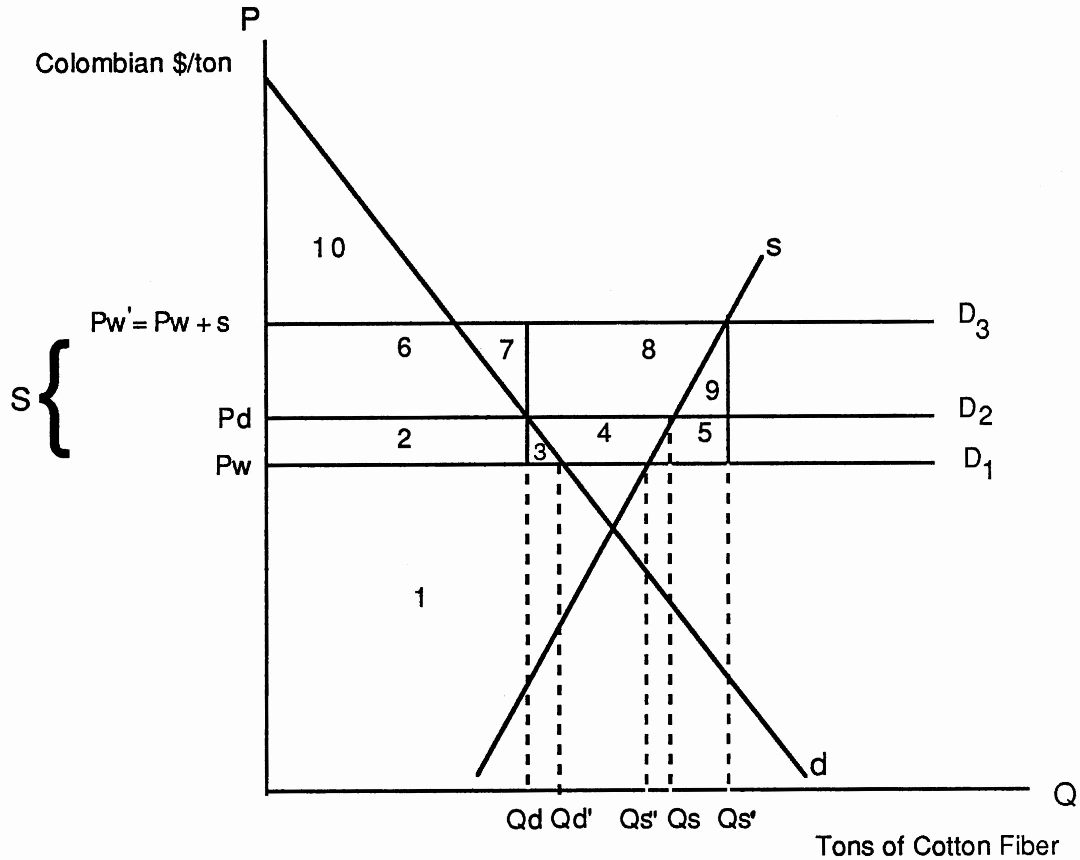


Figure 6. 1983 Price Agreement and Export Subsidy Policy for Cotton Fiber in Colombia

the difference between the total production (Qs), and the quantity consumed domestically, (Qd) at the external price (Pw), which is exogenous given the assumption of a small country case.

Producers receive an export subsidy S, for each unit sold in the international market. This export subsidy is a percentage of the price of the external market for cotton fiber. Pw' results from adding the export subsidy (S) to the external price (Pw). The proportional export subsidy (Pw'-Pw)/Pw is the proportion by which Pw' exceeds Pw.

If the internal price of cotton fiber were the result of market forces between cotton growers and textile producers, and export subsidies are not considered, the consumer and producer surplus in this case would be represented by the following areas of the Figure 6:

Consumer's surplus areas: 2+3+6+10

Producer's surplus area: 1

Given that the agreement between the FEDERACIONES and DIAGONAL, and the export subsidy of cotton fiber is considered (current situation), the domestic demand is the d line until price Pd (Figure 6). The external demand (D_3) for cotton fiber is given by a horizontal line at price Pw' starting from Qd. The export subsidy is represented by the sum of the areas 3, 4, 5, 8 and 9, or simply (Pw' - Pw) x (Qs' - Qd). This export subsidy is paid to cotton fiber producers by the government with funds collected from taxpayers. The effects of the current export subsidy and price agreement policy are given by the following changes in areas with respect to a situation of no government intervention:

Consumer's loss areas: 2+3

Producer's gain areas: 2+3+4+8

Government (taxpayers) loss areas: 3+4+5+8+9

Net Social Loss areas: 3+5+9

For the years in which the internal price of cotton fiber is higher than the external price, the actual cotton policy benefits producers, however, consumers, taxpayers, and the society as a whole lose. Areas 5 and 9 are not transferred from taxpayers to any other group in the country.

Estimation of areas 3, 5, and 9 of Figure 6 can be computed using the following equation:

$$\text{Areas } 3+5+9 = \int_{Pw}^{Pd} D(p)dp + \int_{Pw}^{Pw'} S(p)dp \qquad (3.73)$$

where D(p) and S(p) are the demand and supply functions.

The effects on cotton production of a variation in the exchange rate policy are shown in Figure 7. Overvaluation of the Colombian Peso is said that it has taxed implicitly cotton exports. If the government authorizes a devaluation of the Peso according with the real exchange rate, the new external price (Pw") will be higher than the domestic price.

Given the devaluation of the peso, the price agreement and not export subsidy, the domestic demand is the line d until price level Pd, the external demand of cotton fiber is the line D_4, and the new quantity of cotton fiber produced is Qs'. However,the quantity of cotton fiber consumed domestically does not change because of the price agreement. Qs' could be considered a long-run change in production since it is difficult to increase the total quantity of cotton fiber supplied (Qs) in the short-run.

The changes in the areas of the welfare analysis for this situation (Figure 7) compared with the current cotton policy (Figure 6) are:

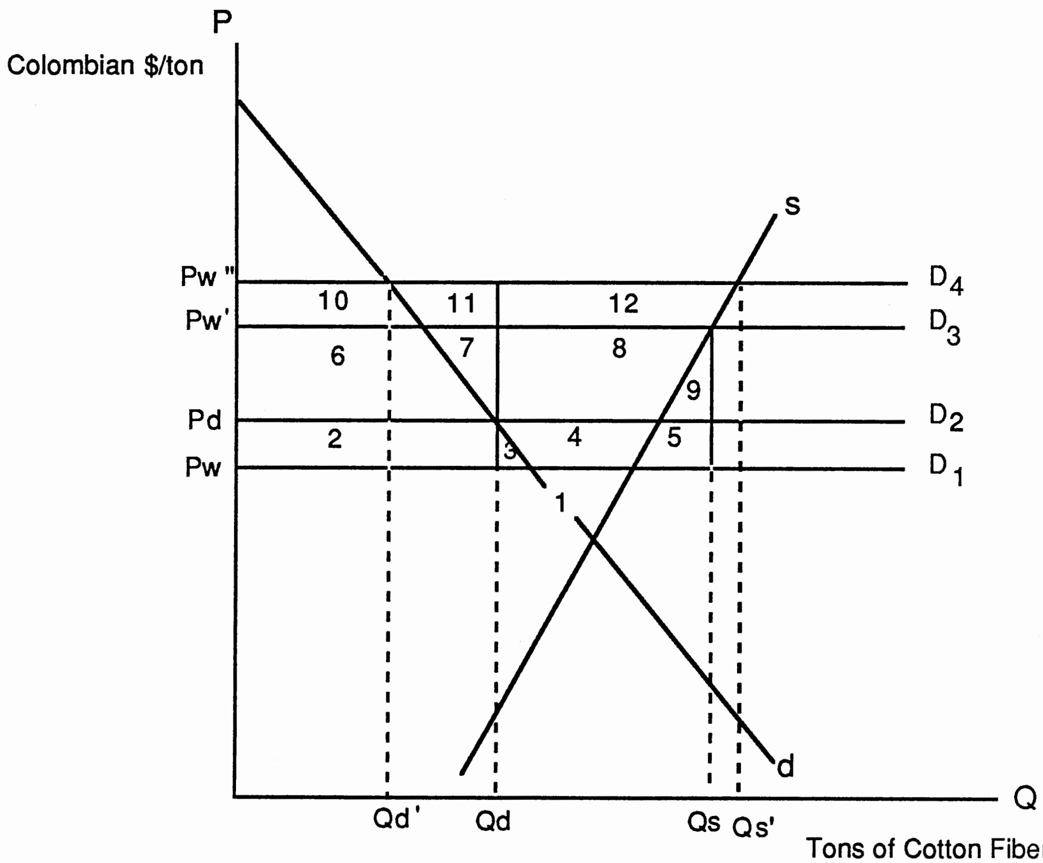


Figure 7. Effects of a Devaluation of the Exchange Rate on the Welfare Analysis of the Actual Cotton Policy in Colombia. 1983

Gain to consumers areas: 6+10

Loss to producers areas: 12-(+6+10)

Gain to taxpayers: 0 payment (3+4+5+8+9)

Gain to society areas: 3+4+5+8+9+12

Society will gain areas represented by the export subsidy of Figure 6 plus the gain to producers given the new increase in external price times the quantity exported (area 12 of Figure 7). Although producers lose in the short-run because of the price agreement, in the long run they will be better than if there were no devaluation of the peso. Effects of the devaluation on inputs utilized in the production of cotton fiber will not be considered in this welfare analysis. However, since it is known that cotton demands large amounts of chemicals and most of them are imported, this study should be complemented in that aspect.

Areas 6+10 of Figure 7 can also be estimated as:

$$\text{Areas } 6+10 = \int_{Pd}^{Pw''} D(p)dp \qquad (3.74)$$

Estimation Methods and Data Sources

The error term of the yield equation in Model I meets all the assumptions of the classical normal linear regression model: (1) the expected value of the population disturbance term Ui is zero; (2) the conditional variance of Ui is constant or homoscedastic; (3) there is no autocorrelation in the disturbances; (4) the explanatory variables are either nonstochastic (i.e. fixed in repeated samples), or if stochastic, distributed independently of the disturbances Ui; (5) there is no multicolinearity among the explanatory variables; (6) the number of observations is greater than the number of parameters to be estimated; and, (7) observations is greater than the number of parameters to be estimated; and, (7) the U's are normally distributed with mean and variance given by assumptions 1 and 2. With the preceding assumptions, application of the ordinary-least-squares (OLS) estimation technique to the regression coefficients of equation (3.60) will give best linear unbiased estimators (BLUE), and with the normality assumption, they will be distributed normally.

The Nerlove supply equations (3.59) and (3.69) of Models I and IV, and the demand equation (3.72) do not meet the assumption of the serially independent errors. Specifically, equations which include the lagged dependent variable as an explanatory variable have serially correlated disturbances and further, the presence of lagged dependent variable biases the Durbin-Watson test for serial correlation in OLS estimation. When successive disturbances are correlated, the parameters estimators are not minimum variance estimators. This results in (1) inefficient estimators; (2) biased "t" values and inaccurate "F" values; and, (3) underestimation of the significance of the explanatory variables.

There are several different techniques to correct for autocorrelation. A technique followed for these equations is to assume serial correlation and automatically adjust for its presence through the use of an appropriate estimation procedure, called Cochrane-Orcutt technique, which consists of regressing the OLS residuals on themselves lagged one period to provide an estimate of the first order autocorrelation parameter (p). Using this estimate, the dependent and independent variables are transformed, and OLS regression on these transformed variables gives the generalized-least-squares estimators (β^{GLS}). New estimates of the disturbances are made, by substituting β^{GLS} into the original (untransformed) relationship, which should be "better" than the OLS estimates. Regressing these new residuals on themselves lagged one period provides a new (and presumably "better") estimate of p. This procedure is parameters through this procedure are biased, consistent and asymptotically efficient.

Models I and II consist of a system of simultaneous Nerlove supply equations. The rules for identification for each model were examined, and they were found to be overidentified (Appendix B). The models will be estimated by two-stage-least-square (TSLS); also the Cochrane-Orcutt technique will be applied to each equation. The TSLS yields second-stage estimators which are biased but consistent and asymptotically efficient, and the usual test of significance on the coefficients are not strictly valid. The coefficient of multiple determination, R^2, and interpretation of the coefficients also are affected since the underlying ceteris paribus conditions are not strictly fulfilled.

The estimation of simulatenous equation models with lagged endogenous variables and first order serially correlated errors was discussed by Amemiya (1966) and Fair (1970). For these models, the coefficients tend to be inconsistent. The methods of estimation for these models to insure consistent estimations differ in the number of instrumental variables used. In models with a large number of independent variables, inclusion of the instrumental variables proposed by Amemiya will result in a larger number of parameters to be estimated compared to the number of observations, (Fair, 1970).

The period under consideration is 1960-1983. Since it was not possible to find information for all the variables, and some values were preliminary, the recent years are not included. Most of the information utilized in this study came from the study realized by Garcia and Montes (1986), and from several reports of the Departamento Nacional de Planeacion-Unidad de Estudios Agrarios and Federacion Nacional de Algodoneros (Appendix C).

CHAPTER IV

RESULTS OF THE SUPPLY AND DEMAND MODELS AND MEASURES OF WELFARE ANALYSIS OF COTTON POLICY IN COLOMBIA

This chapter presents the estimates of the parameters of the structural equations of the supply and demand models, and discusses the economic implications of the results obtained. Measures of welfare analysis of cotton policy, predictions, and results of simulations of policy alternatives are also presented.

Supply Models

Variables in linear and logarithmic terms were considered for every model. According to the coefficients of the correlation matrix the risk variable for cotton formed by the moving range of cotton domestic price (3 years) was selected from the four risk variables measures for cotton.

The levels of significance accepted in the statistical results were 15 percent and 30 percent. Three reasons were considered for the selection of those levels of significance. All the variables included in the models were at the aggregate level; therefore, data manipulation could distort the "true" relation among the variables. For several variables, various "official" sources of data reported different numbers. Consistency with economic theory also was considered to be an important reason for leaving a variable in the model.

Model I

The statistical results for Model I are presented in Tables III and IV. The estimated coefficients in Table III are those without policy variables in the expected price formulation. The expected price for cotton fiber is the price paid by DIAGONAL, while for soybeans, sorghum and rice the expected price is the producer price of each crop. The coefficients of cotton price were positive, although not significant. Sorghum acted as a competitive crop with cotton and its coefficient was highly significant. Rice was a complementary crop for cotton in both linear and logarithmic models. The sign of the coefficient for soybeans changed from positive to negative in the linear model with respect to the logarithmic one. The coefficient of lagged harvested area of cotton was positive and significant.

The coefficient of production costs of cotton presented a positive sign, contrary to what was the expected, but it was not significant. Credit showed a positive and significant effect. An inverse relationship between the hectares harvested of cotton and the risk variable was found, although it was not significant. The R-Square and the adjusted R-Square were between 70% and 79%. The F-test was significant for the supply models. The Durbin-Watson statistic was close to 2, indicating no autocorrelation for the corrected models.

The estimated coefficients of Model I considering policy variables in the expected price formulation are presented in Table IV. For the equation in logarithmic terms based on the sign of the coefficients, soybeans and rice compete with cotton, while sorghum is a complementary crop. The lagged dependent variable was positive and significant. An increase in the availability of credit has a positive effect on the number of cotton hectares harvested

TABLE III

ESTIMATED COEFFICIENTS FOR MODEL I WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR AND LOGARITHMS)

Independent Variables[1]	Dependent Variables (Hectares Harvested and Yield of Cotton)[4]					
	Cotton HHC	Cotton HHC	Cotton Y	Cotton LHHC	Cotton LHHC	Cotton LY
Intercept	6,983.16 (154,392.4)	3,537.50 (176,611.6)	0.90 (0.09	3.86 (5.06)	2.91 (5.02)	0.64 (1.01)
PCR	211.5 (585.5)[2]					
PDR		126.89 (238.08)				0.10 (0.15)
PSRE	1,501.4 (2,787.9	1,165.93 (3,032.29)				
PRR	779.3 (1,416.4)	560.76 (1,491.66)				
PGR	-3,458.3** (0.56)	-3,294.15** (2,789.09)				
HHC			-0.01* (0.01)			
HHC(-1)[3]	0.50** (0.24)	0.50** (0.33)				
PPCR			-0.01** (0.00)			
CDCR	8,211.7** (3,910.2)	8,043.70* (4,106.1)	0.02** (0.00)			
RVC1	-0.59 (1.03)	-0.71 (1.08)	0.01 (0.01)			
RSCR(-1)			0.01 (0.01)			
T			0.003** (0.002)			0.004* (0.004)
LPCR				0.12 (0.45)		

TABLE III (CONT.)

	Dependent Variables (Hectares Harvested and Yield of Cotton)[4]					
Independent Variables[1]	Cotton HHC	Cotton HHC	Cotton Y	Cotton LHHC	Cotton LHHC	Cotton LY
LPDR					0.30 (0.39)	
LPSRE				-0.03 (1.09)	-0.05 (1.06)	
LPRR				0.23 (0.41)	0.18 (0.40)	
LPGR				-(0.49) (0.59)	-0.44 (0.58)	
LHHC						-0.24** (0.08)
LHHC(-1)				0.62** (0.30)	0.64** (0.28)	
LPPCR(-1)				0.22 (0.47)	0.16 (0.43)	-0.28* (0.16)
LCDCR				0.30** (0.13)	0.30** (0.13)	0.20* (0.04)
LRVC1				-0.04 (0.06)	-0.97 (0.34)	-0.01 (0.03)
LRSCR(-1)						0.01 (0.03)
R^2	77%	77%	71%	78%	79%	70%
$\bar{R}^2$	64%	62%	57%	63%	64%	56%
Durbin-Watson	2.29	2.30	1.78	2.44	2.61	1.64
F-Statistic	5.95**	5.09**	5.21*	5.25**	5.46**	5.02*

[1]The L before the name of the variable indicates logarithms.
[2]Standard Error.
[3]The (-1) indicates lagged one period.
[4]Variable definition are in Appendix C.
*Thirty percent (30%) level of significance.
**Fifteen percent (15%) level of significance.

TABLE IV

ESTIMATED COEFFICIENTS FOR MODEL I WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR AND LOGARITHMS)

Independent Variables [1]	Dependent Variables (Hectares Harvested and Yield of Cotton)[4] Cotton HHC	Cotton Y	Cotton LHHC	Cotton LY
Intercept	-1,850.9 (124,690.0)	0.72 (0.14)	-0.14 (3.01)	3.21 (0.99)
EPCR	594.95** (181.53)[2]	0.01 (0.01)		
EPSR	942.70 (2,141.66)			
EPRR	233.31 (1,185.03)			
EPGR	-1,260.72 (3,436.32)			
HHC(-1)[3]	0.36** (0.23)			
PPCR(-1)	706.02** (518.27)			
PPCR		-0.02** (0.00)		
CDCR	7,074.85 (3,258.43)	0.01** (0.00)		
HHC		-0.06** (0.01)		
RVC1	0.43 (0.84)	-0.08 (0.10)		
RSCR(-1)		0.01 (0.01)		
T		0.02 (0.02)		

TABLE IV (CONT.)

Independent Variables [1]	Dependent Variables (Hectares Harvested and Yield of Cotton)[4] Cotton HHC	Cotton Y	Cotton LHHC	Cotton LY
LEPCR			0.91** (0.02)	0.19* (0.16)
LEPSR			-0.02 (0.64)	
LEPRR			-0.15 (0.34)	
LEPGR			0.21 (0.39)	
LHHC(-1)			0.48** (0.20)	
LPPCR(-1)			0.24 (0.28)	
LPPCR				-0.30** (0.15)
LCDCR			0.18** (0.08)	0.21** (0.04)
LRSCR(-1)				0.01 (0.01)
LHHC				-0.31** (0.12)
LRVC1			-0.03 (0.05)	-0.01 (0.03)
R^2	87%	63%	89%	72%
$\bar{R}^2$	79%	46%	81%	58%
Durbin-Watson	2.30	1.58	2.68	1.65
F-Statistic	10.21**	3.76*	11.83**	5.51*

[1]The L before the variable name indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

The risk variable indicated that an increase in the variability of the cotton producer's income reduces the number of hectares harvested of cotton. The R-squared and the F-statistic were higher for the logarithmic equation. The Durbin-Watson statistic was close to 2.

OLS was applied to obtain the estimation of the yield equation of cotton for Model I. For both linear and logarithm equations, the estimated coefficient for hectares harvested was negative and significant. An increase in the number of hectares harvested of cotton implies possibly bringing marginal land into production. The trend variable which represented weather effects into the yield equation was positive and not significant. Risk, and principally production costs of cotton, have a negative effect on yield, while availability of credit has a positive and significant effect.

The coefficient of cotton price with and without policy variables in the expected price formulation presented a positive sign, but it was not significant. Even though the coefficient of expenditures on research was positive, it was not statistically different from zero. Had there been a consistent trend in yields, the problem might be somewhat easier, but over the time period considered in the present study, there was not sustained trend.

Model II

The statistical results for Model II are presented in Tables V to VIII. Variables are in linear and logarithmic terms with and without policy variables in the expected price formulation. Model II is a simultaneous equation model, in which the number of hectares harvested of each crop is the dependent variable. Supply functions of soybeans, rice and sorghum were considered in the Model to explain the cotton supply equation. The cotton supply equation with policy

TABLE V

ESTIMATED COEFFICIENTS FOR MODEL II WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton HHC	Soybeans HHS	Rice HHR	Sorghum HHG
Intercept	38,988.09 (144,637.77)	-58,995.66 (43,569.8)	238,972.76 (64,148.37)	-80,104.89 (64,044.35)
PCR	575.15 (917.77)[2]	-478.54 (199.20)	-625.32* 551.64	-776.87 (516.19)
PSRE	739.63 (2,644.64)	1,446.79** (918.08)	-160.07 (1,540.04)	3,638.45** (1,572.96)
PRR	-1,604.73 (1,727.08)	-1,064.62** (622.60)	3,498.43 (1,073.97)	-2,769.19** (879.16)
PGR	98.17 (2,340.61)	1,547.81** (903.81)	-4,031.14** (1,410.91)	1,328.10 (1,337.25)
HHC(-1)[3]	0.61** (0.23)			
PPCR(-1)	368.83 (0.47)			
CDCR	8,419.28** (3,792.30)			
RVC1	6.36** (2.26)			
HHC		0.11* (0.09)	-0.66** (0.15)	0.07 (0.12)
HHS	0.04 (1.14)		-0.43 (0.58)	-1.06 (0.58)
HHR	-0.13 (0.25)	0.18** (0.08)		0.37* (0.14)
HHG	-1.04 (0.43)	-0.37** (0.17)	2.22** (0.35)	

TABLE V (CONT.)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton HHC	Soybeans HHS	Rice HHR	Sorghum HHG
HHS(-1)		0.28* (0.25)		
RVS		14.28 (9.50)		
HHR(-1)			0.56** (0.13)	
PPRR(-1)			-14.91** (3.92)	
CDRR			-23,377.60 (18,583.66)	
RSRR(-1)			4,059.37* (3,181.57)	
XSRR(-1)			78.79* (22.09)	
RVR			-33.72* (25.25)	
HHG(-1)				0.37** (0.15)
RVG				26.26* (21.13)
R^2	90%	79%	95%	97%
$\bar{R}^2$	78%	61%	88%	94%
Durbin-Watson	2.15	2.17	2.65	2.06
F-Statistic	7.70**	4.51**	13.28**	41.39**

[1]The L before the variable name indicates logarithms.

[2]Standard error.

[3]The (-1) indicates lagged one period.

4Variable definitions are in Appendix C.

*30% level of significance.

**15% level of significance.

TABLE VI

ESTIMATED COEFFICIENTS FOR MODEL II WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LOGARITHMS)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton LHHC	Soybeans LHHS	Rice LHHR	Sorghum LHHG
Intercept	21.57 (13.30)	0.43 (8.40)	11.75 (6.17)	-19.55 (15.96)
LPDR	0.58 (1.79)[2]	-1.14** (0.64)	-0.04 (0.41)	-0.01 (1.47)
LPSRE	-1.22 (1.78)	1.18 (1.39)	-0.18 (0.68)	1.70 (2.35)
LPRR	0.04 (0.58)	0.31 (0.49)	0.25 (0.34)	-1.04* (0.81)
LPGR	-0.55 (0.74)	1.35** (0.96)	0.26 (0.56)	0.65 (1.27)
LHHC(-1)[3]	0.16 (0.19)			
LPPCR(-1)	0.66 (0.54)			
LCDCR	0.40 (0.42)			
LRVC1	0.17 (0.16)			
LHHC		0.31** (0.25)		-0.33 (0.47)
LHHS	0.09 (0.85)			1.01 (0.71)
LHHG	-0.18 (0.24)	-0.11 (0.28)		
LHHR	-0.93* (1.04)	-0.25 (0.61)		1.20 (1.21)

TABLE VI (CONT.)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton LHHC	Soybeans LHHS	Rice LHHR	Sorghum LHHG
LHHS(-1)		0.42** (0.23)		
LRVS		0.17* (0.16)		
LHHR(-1)			0.07 (0.42)	
LPPRR(-1)			-0.41* (0.40)	
LCDRR			0.06 (0.09)	
LRSRR(-1)			0.01* (0.01)	
LXSRR			0.02 (0.03)	
LRVR			0.09* 0.07	
LGGH(-1)				0.29* (0.29)
LRVG				-0.01 (0.22)
R^2	78%	83%	65%	94%
$\bar{R}^2$	52%	70%	30%	89%
Durbin-Watson	1.70	1.79	1.12	2.11
F-Statistic	3.05*	6.24**	11.85	19.46**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

TABLE VII

ESTIMATED COEFFICIENTS FOR MODEL II WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR)

Independent Variables [1]	Dependent Variables (Hectares Harvested of each Crop)[4] Cotton HHC	Soybeans HHS	Rice HHR	Sorghum HHG
Intercept	46,385.53 (147,933.03)	-21,067.40 (64,341.39)	191,844.99 (391,933.47)	-723.86 (81,655.98)
EPCR	150.35 (228.70)[2]	-139.28* (108.73)	-88.71 (652.45)	-351.87** (116.95)
EPSR	2,491.47 (2,579.90)	825.91 (946.78)	3,543.72 (4,696.81)	3,050.66** (1,294.92)
EPRR	-1,028.73 (1,458.52)	-535.49 (644.19)	1,105.51 (4,551.73)	-2,122.21** (592.65)
EPGR	-3,434.09* (3,183.84)	1,191.37* (848.47)	-2,068.37 (7,194.13)	-406.04 (1,276.78)
HHC(-1)[3]	0.46** (0.21)			
PPCR(-1)	460.18 (618.04)			
CDCR	11,712.02** (3,128.86)			
RVC1	4.83** (2.04)			
HHC		0.10 (0.11)	-0.69* (0.65)	0.34** (0.10)
HHS	-0.54 (0.76)		-0.23 (1.08)	-0.51** (0.33)
HHR	-0.12 (0.16)	0.07* (0.06)		0.15** (0.07)
HHG	-0.68* (0.39)	-0.22 (0.23)	1.78* (1.39)	

TABLE VII (CONT.)

Independent Variables [1]	Cotton HHC	Soybeans HHS	Rice HHR	Sorghum HHG
	Dependent Variables (Hectares Harvested of Each Crop)			
HHS(-1)		0.55** (0.21)		
RVS		9.76 (11.37)		
HHR(-1)			0.20 (0.27)	
PPRR(-1)			310.22 (168.27)	
CDRR			-26,656.47 (54,315.40)	
RSRR(-1)			-728,551.58 (391,393.97)	
XSRR(-1)			65.93* (57.34)	
RVR			-87.71 (64.19)	
HHG(-1)				0.11** (0.07)
RVG				78.68** (11.86)
R^2	92%	78%	84%	98%
$\bar{R}^2$	84%	60%	57%	96%
Durbin-Watson	2.42	2.18	1.98	2.39
F-Statistic	10.81**	4.41*	3.14*	63.18**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

TABLE VIII

ESTIMATED COEFFICIENTS FOR MODEL II WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LOGARITHMS)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton LHHC	Soybeans LHHS	Rice LHHR	Sorghum LHHG
Intercept	3.12 (5.88)	8.62 (8.03)	10.42 (24.26)	5.13 (27.29)
LEPCR	0.79** (0.31)[2]	-0.80* (0.67)	0.19 (2.91)	-0.39 (1.52)
LEPSR	0.17 (0.83)	0.26 (1.32)	-1.53 (4.75)	2.88 (2.84)
LEPRR	-0.43 (0.55)	0.73* (0.59)	2.01 (2.95)	-2.03* (2.14)
LEPGR	0.36 (0.41)	0.08 (0.57)	-0.69 (1.54)	0.35 (1.98)
LHHC(-1)[3]	0.42** (0.27)			
LPPCR(-1)	0.28 (0.32)			
LCDCR	0.18* (0.12)			
LRVC1	0.04 (0.50)			
LHHC		0.52* (0.38)	0.35 (0.85)	-0.08 (1.28)
LHHS	0.20 (0.27)		-0.90 (1.34)	-0.33 (0.94)
LHHR	-0.22 (0.40)	-0.54* (0.51)		0.52 (1.96)
LHHG	-0.19* (0.13)	0.23* (0.16)	0.75 (1.10)	

TABLE VIII (CONT.)

Independent Variables [1]	Dependent Variables (Hectares Harvested of Each Crop)[4] Cotton LHHC	Soybeans LHHS	Rice LHHR	Sorghum LHHG
LHHS(-1)		0.19** (0.12)		
LRVS		0.08 (0.12)		
LHHR(-1)			0.08 (1.66)	
LPPRR(-1)			-0.60 (0.99)	
LCDRR			0.07 (0.30)	
LRSRR(-1)			0.01 (0.01)	
LXSRR(-1)			0.07* (0.10)	
LRVR			0.05 (0.27)	
LHHG(-1)				0.10 (0.15)
LRVG				0.07 (0.47)
R^2	91%	87%	16%	85%
$\bar{R}^2$	80%	76%	13%	73%
Durbin-Watson	1.91	2.07	1.95	0.66
F-Statistic	8.61**	8.17**	0.10	7.05**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

variables provided higher coefficients of determination and the regression coefficients were more significant. It means that the policy variables, e.g., export subsidy, external price, the exchange rate, prices paid by DIAGONAL and the quantity bought by DIAGONAL, all are important in the expected price formulation for cotton. The support prices and quantity of the crop bought by IDEMA are also important in the expected price formulation for soybeans, rice, and sorghum, the crops related to cotton.

For the logarithmic model, the estimated coefficients for price of the related crop were as expected. In this model, rice and sorghum were competitive crops, and soybeans were a complementary crop. The sign of the coefficients of the number of hectares harvested of the related crops, which were endogenous variables in the other equations, showed a negative relationship between the number of hectares harvested of rice and sorghum with respect to the number of hectares harvested of cotton. This result indicates competition for the production resources that exist between rice and sorghum with cotton. The coefficient of number of hectares harvested of soybeans presented a positive sign, indicating rotation between cotton and soybeans. A more detailed analysis of crop rotation for the different zones has to be done to determine in a better way the relationship between these two crops.

The lagged dependent variable and credit were positive and significant. The risk variable for this model presented a positive sign, but it was not significant. The R-square and adjusted R-square were high, the F-statistic was significant, and the Durbin-Watson statistic indicated no autocorrelation among the errors for the corrected model.

The results for variables in linear terms were similar to those found for variables in logarithm terms. However, the complementary relationship between soybeans and cotton was not supported because of the negative sign of the coefficient of the number for hectares harvested of soybeans.

Model III

The statistical results for Model III are presented in Table IX to XII. Model III also is a simultaneous equation model similar to Model II. This model assumed that the production of cotton, soybeans, rice and sorghum are jointly determined in the supply sector, which can be described by a four simultaneous supply response equations that involved Nerlove formulations. Inclusion of policy variables in the formulation of the expected price gave better results than when these policy variables were not considered. Therefore, policy variables for cotton and related crops should be included in the expected price of these commodities. An interesting result is that although the signs are maintained in both models, higher coefficient of determination and more significant regression coefficients were found for Model III than for Model II, indicating that actual production of cotton was more responsive than hectares of cotton harvested. Also, for Model III, contrary to the results found in Model II, production costs showed a negative and significant relation with the dependent variable.

Model IV

Model IV is a single equation model, representing only the cotton supply function of Model III. OLS and the Cochrane-Orcutt procedure with first order autocorrelation specification was applied to estimate the parameters. The results obtained are presented in Tables XIII and XIV. For the equation with variables in linear terms, the coefficient of the expected price of cotton was positive and highly significant, it indicated that for each peso increase in the

TABLE IX

ESTIMATED COEFFICIENTS FOR MODEL III WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR)

	Dependent Variables (Production in Tons per Year of Each Crop)[4]			
Independent Variables [1]	Cotton QC	Soybeans QS	Rice QR	Sorghum QG
Intercept	151,950.31	-94,898.52	729,485.04	-58,116.95
	(71,477.19)	(104,274.41)	(311,589.81)	(161,593.48)
PDR	83.94	-855.64**	1,611.75*	-67.36
	(222.50)[2]	(410.75)	(1,235.49)	(434.78)
PSRE	-1,082.09	2,951.27**	-2,039.29	4,503.51**
	(1,135.10)	(1,504.78)	(10,108.86)	(2,586.44)
PRR	-1,274.91**	-669.64	-5,951.54	-3,733.99**
	(709.50)	(1,207.04	(8,261.22)	(2,090.68)
PGR	177.53	1,074.93	2,392.24	-557.55
	(1,153.62)	(1,571.27)	(6,175.99)	(3,003.25)
QC(-1)[3]	0.22			
	(0.24)			
PPCR(-1)	78.50			
	(332.38)			
CDCR	7,006.80			
	(2,246.90)			
RVC1	1.81			
	(0.86)			
QC		0.32	-4.86**	
		(0.35)	(1.50)	
QS	0.02		2.84**	
	(0.32)		(1.27)	
QR	-0.01	0.09**		
	(0.03)	(0.04)		

TABLE IX (CONT.)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton QC	Soybeans QS	Rice QR	Sorghum QG
QG	-0.14	-0.32**	1.58**	
	(0.19)	(0.16)	(0.61)	
QS(-1)		0.28*		
		(0.31)		
RVS		17.62*		
		(15.38)		
QR(-1)			0.03	
			(0.17)	
PPRR(-1)			-174.78	
			(547.37)	
CDRR			2,388,683.84	
			(69,957.54)	
RSRR(-1)			395,758.97**	
			(1,266,091.70)	
XSRR(-1)			113.97	
			(73.76)	
RVR			-242.66**	
			(92.54)	
QG(-1)				0.10*
				(0.06)
RVG				65.03
				(9.67)
R^2	91%	82%	98%	97%
$\bar{R}^2$	80%	68%	96%	94%
Durbin-Watson	2.01	1.87	2.37	1.77
F-Statistic	8.46**	5.80**	50.13**	47.19**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

TABLE X

ESTIMATED COEFFICIENTS FOR MODEL III WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LOGARITHMS)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton LQC	Soybeans LQS	Rice LQR	Sorghum LQG
Intercept	22.93 (7.98)	-4.23 (10.75)	7.10 (5.31)	-17.32 (24.31)
LPDR	0.09 (0.70)[2]	-0.88* (0.93)	-0.54 (1.22)	0.52 (1.69)
LPSRE	-0.24 (0.76)	1.37* (1.47)	0.85 (1.27)	0.18 (2.17)
LPRR	-0.75** (0.35)	0.57 (0.81)	-0.51 (0.62)	0.16 (1.56)
LPGR	-0.26 (0.45)	-0.24 (1.49)	0.63 (1.20)	0.23 (1.14)
LQC(-1)	0.02 (0.06)			
LCDCR	0.62** (0.21)			
LRVC1	0.09 (0.11)			
LQC		-0.01 (0.61)	0.20 (0.55)	-0.46 (0.64)
LQS	-0.20 (0.40)		-0.41 (0.63)	1.00* (0.86)
LQR	-0.42 (0.45)	0.53 (0.81)		1.06 (1.65)
LQG	-0.09 (0.12)	0.12 (0.28)	0.07 (0.13)	

TABLE X (CONT.)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton LQC	Soybeans LQS	Rice LQR	Sorghum LQG
LQS(-1)		0.48* (0.52)		
LRVS		-0.11 (0.27)		
LQR(-1)			0.47* (0.51)	
LPPRR(-1)			0.12 (0.21)	
LQG(-1)				0.33 (0.41)
LRVG				-0.11 (0.30)
R^2	84%	89%	93%	94%
$\bar{R}^2$	69%	81%	88%	89%
Durbin-Watson	2.06	2.07	1.92	2.05
F-Statistic	5.53**	10.69**	18.13**	18.83**

[1]The L before the name of the variable indicates logarithms.

[2]Standard error.

[3]The (-1) indicates lagged one period.

[4]Variable definitions are in Appendix C.

*30% level of significance.

**15% level of significance.

TABLE XI

ESTIMATED COEFFICIENTS FOR MODEL III WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton QS	Soybeans QS	Rice QR	Sorghum QG
Intercept	23,832.72 (46,797.11)	-407.67 (73,568.09)	961,766.96 (614,986.59)	-223,661.97 (99,460.22)
EPCR	151.13** (89.02)[2]	-438.10** (150.43)	187.96 (872.71)	-309.93* (250.29)
EPSR	1,726.15* (1,362.03)	2,981.61** (1,296.48)	-18,192.97* (10,908.11)	9,280.05** (1,714.24)
EPRR	-1,086.77** (662.70)	-1,530.30* (1,480.49)	19,694.81** (10,428.42)	-3,551.44** (1,253.74)
EPGR	-1,140.34 (1,029.95)	610.85 (1,744.03)	-9,521.08 (12,273.70)	20.12 (2,816.18)
QC(-1)[3]	0.15* (0.17)			
PPCR(-1)	-298.69* (235.94)			
CDCR	6,239.03** (1,312.86)			
RVC1	1.25** (0.73)			
QC		0.99** (0.33)	7.30** (2.58)	0.60* (0.54)
QS	0.04 (0.15)		2.42** (0.75)	-0.97** (0.30)
QR	-0.01 (0.02)	0.10** (0.03)		0.08* (0.05)
QG	-0.11* (0.09)	-0.53** (0.18)	4.07** (1.05)	

TABLE XI (CONT.)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton LQC	Soybeans LQS	Rice LQR	Sorghum LQG
QS(-1)		0.28* (0.23)		
RVS		36.57** (15.27)		
QR(-1)			0.02 (0.18	
PPRR(-1)			-758.66** (408.31)	
CDRR			170,681.39** (65,949.74)	
RSRR(-1)			1,753,097.90** (948,305.26)	
XSRR(-1)			348.26** (108.36)	
RVR			-554.99** (136.16)	
QG(-1)				0.42** (0.16)
RVG				82.46** (24.20)
R^2	94%	86%	98%	99%
$\bar{R}^2$	88%	76%	96%	98%
Durbin-Watson	2.06	1.97	2.35	2.08
F-Statistic	15.13**	8.00**	50.97**	130.43**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

TABLE XII

ESTIMATED COEFFICIENTS FOR MODEL III WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LOGARITHMS)

Independent Variables [1]	Dependent Variables (Production in Tons per Year of Each Crop)[4] Cotton LQC	Soybeans LQS	Rice LQR	Sorghum LQG
Intercept	8.41	-6.10	17.37	15.96
	(2.65)	(10.30)	(13.70)	(12.13)
LEPCR	0.66**	-0.84*	0.01	0.44
	(0.18)[2]	(0.86)	(1.58)	(0.89)
LEPSR	0.83**	0.10	1.72	2.35**
	(0.49)	(1.09)	(3.67)	(1.50)
LEPRR	-0.63**	0.98*	-1.53	-2.46**
	(0.23)	(0.68)	(3.12)	(0.84)
LEPGR	-0.02	-0.17	0.33	0.70
	(0.26)	(0.67)	(1.26)	(0.96)
LQC(-1)[3]	0.06*			
	(0.06)			
LPPCR(-1)	-0.18*			
	(0.19)			
LCDCR	0.39**			
	0.07			
LRVC1	0.01			
	(0.04)			
LQC		0.51	-0.61	-0.86*
		(0.68)	(0.88)	(0.60)
LQS	0.03		0.50	0.71**
	(0.13)		(1.16)	(0.38)
LQR	-0.08	0.47		-1.03*
	(0.16)	(0.66)		(0.92)
LQG	-0.14**	0.21*	-0.30	
	(0.06)	(0.15)	(1.21)	

TABLE XII (CONT.)

Indenpendent Variables 1	Dependent Variables (Production in Tons per Year of Each Crop) Cotton LQC	Soybeans LQS	Rice LQR	Sorghum LQG
LQS(-1)		0.38* (0.28)		
LRVS		-0.09 (0.17)		
LQR(-1)			0.01 (0.64)	
LPPRR(-1)			-0.17 (0.82)	
LCDRR			0.27* (0.23)	
LRSRR(-1)			0.01 (0.01)	
LXSRR(-1)			0.02 (0.09)	
LRVR			0.54 (0.26)	
LQG(-1)				0.51** (0.21)
LRVG				0.16 (0.22)
R^2	95%	90%	91%	96%
$\bar{R}^2$	90%	81%	79%	94%
Durbin-Watson	1.99	2.12	1.83	1.95
F-Statistic	18.22**	10.98**	7.55**	35.78**

[1]The L before the name of the variable indicates logarithms.
[2]Standard error.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

TABLE XIII

ESTIMATED COEFFICIENTS FOR MODEL IV WITHOUT POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR AND LOGARITHMS)

Independent Variables[1]	Dependent Variables (Production of Cotton in Tons)[4] Production of Cotton QC (Linear)	Production of Cotton LQC (Logarithms)
Intercept	64,358.56 (65,488.66)	5.17 (3.56)
PDR	124.49* (91.69)[2]	
PSRE	660.49 (1,098.22)	
PRR	-11.95 (525.14)	
PGR	-449.45 (1,020.55)	
QC(-1)[3]	0.61** (0.35)	
PPCR(-1)	-423.26** (278.94)	
CDCR	5,145.23** (1,671.52)	
RVC1	-0.55** (0.34)	
LPDR		0.62** (0.22)
LPSRE		0.31 (0.80)
LPRR		-0.11 (0.26)
LPGR		-0.21 (0.35)

TABLE XIII (CONT.)

Independent Variables[1]	Dependent Variables (Production of Cotton in Tons)[4] Production of Cotton QC (Linear)	Production of Cotton LQC (Logarithms)
LQC(-1)		0.55** (0.25)
LPPCR(-1)		-0.22 (0.24)
LCDCR		0.35** (0.08)
LRVC1		-0.08** (0.03)
R^2	86%	87%
$\bar{R}^2$	76%	79%
Durbin-Watson	2.45	2.41
F-Statistic	8.92**	9.71**

[1]The L before the name of the variable indicates logarithms.

[2]Standard error value.

[3]The (-1) indicates lagged one period.

[4]Variable definitions are in Appendix C.

*30% level of significance.

**15% level of significance.

TABLE XIV

ESTIMATED COEFFICIENTS FOR MODEL IV WITH POLICY VARIABLES IN THE EXPECTED PRICE FORMULATION (LINEAR AND LOGARITHMS)

Independent Variables[1]	Dependent Variables (Production of Cotton in Tons)[4] Production of Cotton QC (Linear)	Production of Cotton LQC (Logarithms)
Intercept	-13,277.26 (37,105.11)	5.84 (1.65)
EPCR	218.51** (66.58)[2]	
EPSR	864.10* (851.95)	
EPRR	-306.36 (477.09)	
EPGR	-677.26 (1,057.24)	
QC(-1)[3]	0.27** (0.17)	
PPCR(-1)	-339.82** (188.04)	
CDCR	5,316.11** (1,023.84)	
RVC1	-0.09 (0.31)	
LEPCR		0.76** (0.14)
LEPSR		0.23 (0.37)
LEPRR		-0.27* (0.20)
LEPGR		-0.12 (0.22)

TABLE XIV (CONT.)

Independent Variables[1]	Dependent Variables (Production of Cotton in Tons)[4] Production of Cotton QC (Linear)	Production of Cotton LQC (Logarithms)
LQC(-1)		0.18** (0.11)
LPPCR(-1)		-0.14 (0.15)
LCDCR		0.34** (0.04)
LRVC1		-0.04* (0.03)
R^2	93%	94%
$\bar{R}^2$	88%	91%
Durbin-Watson	2.16	2.30
F-Statistic	19.07**	28.72**

[1]The L before the name of the variable indicates logarithms.

[2]Standard error value.

[3]The (-1) indicates lagged one period.

[4]Variable definitions are in Appendix C.

*30% level of significance.

**15% level of significance.

expected price of cotton fiber, the national quantity of cotton fiber produced will increase by 218.51 tons. Based on the signs of the coefficients, soybeans are a complementary crop for cotton, while rice and sorghum are competitive crops for cotton.

The lagged dependent variable was positive and significant, and its coefficient was less than one. This tends to support the year to year adjustment hypothesis. The coefficient of production costs had a negative sign and was significant. For each peso that production costs are increased, the national production of cotton fiber will decrease by 339.82 tons. Availability of credit explained directly and significantly the national production of cotton fiber. The risk variable indicated an inverse relationship between the production of cotton fiber and the variability in the income of cotton fiber producers; however, this relation was not significant. The explanatory variables considered in the model explained by 92% of the changes in the production of cotton fiber. The F-test was significant and the Durbin-Watson statistic was close to 2, indicating no presence of autocorrelation for the corrected model.

For Model IV with variables in logarithmic terms, the sign of the coefficients were the same as for the model with variables in linear terms. However, the t values of the expected price of rice and the risk variable were higher, while for the production costs of cotton the t value was lower. The results obtained in Model IV were better than those obtained for the cotton supply equation in the simultaneous equation system of Model III, and better than those obtained in Models I and II. For purposes of prediction and policy analysis of cotton, this model can be considered superior to the others. In the case that not only the supply of cotton, but also the supply of rice, soybeans and sorghum want to be studied, a more detailed analysis such as the magnitude and sign of the coefficients, t-values, coefficient of determination, F-test and alternative models of the supply equations of the related crops presented here should be considered.

In summary, the statistical results for the supply functions were better when policy variables were including in the expected price formulation. Therefore, for the purpose of estimating elasticities, prediction, simulation, and analysis of cotton policy, it is recommended to work with models which include policy variables directly or through the expected price formulation. Even though production was more responsive than number of hectares harvested, results obtained from both can be considered. The single equation Model IV can explain with acceptable accuracy the supply function of cotton.

Demand Model

The demand for cotton was not the principal topic of this study. However, an effort was made to estimate the demand elasticity. The statistical results obtained for the cotton demand model are presented in Table XV. These results were not good, a low R-square resulted for both equations with variables in linear and logarithmic terms. This means that there should be other important variables and/or another type of specification for the demand model that were not considered in this study. As was mentioned in the specification of the cotton demand model in Chapter III, availability of data was difficult to obtain. This could be one of the reasons of not obtaining good results for the demand model.

A negative relation was presented between population and the quantity demanded of cotton fiber. One of the reasons could be that population and national income were used as proxy variables of the number of cotton fiber enterprises and the capital of these enterprises respectively. The coefficient of

TABLE XV

ESTIMATED COEFFICIENTS OF REGRESSION FOR THE COTTON DEMAND MODEL (LINEAR AND LOGARITHMS)

Independent Variables[1]	Dependent Variables (Consumption of Cotton Fiber in Tons)[4] CCF (Linear)	LCCF (Logarithms)
Intercept	68,517 (83,279)	14.17 (11.25)
PDR(-1)[3]	-75.44 (114.99)[2]	
PXR	119.21** (72.00)	
CCF(-1)	0.29* (0.25)	
YNCR	12.70 (16.99)	
POP	-4.03 (5.21)	
PVFOR	35,890.35 (130,941.56)	
LPDR(-1)		-0.25 (0.47)
LPXR		0.51** (0.32)
LCCFR(-1)		0.39** (0.27)
LYNCR		0.66 (0.81)
KPOP		-1.43 (1.55)
LPVFOR		0.01 (0.52)
R^2	0.40	0.41
$\bar{R}^2$	0.12	0.14
Durbin-Watson	2.21	2.18
F-Statistic	1.43	1.51

[1]The L before the name of the variable indicates logarithms.
[2]Standard error value.
[3]The (-1) indicates lagged one period.
[4]Variable definitions are in Appendix C.
*30% level of significance.
**15% level of significance.

the price paid by DIAGONAL was negative, but not significant. The coefficient of external price of cotton fiber was positive and significant, indicating that when the external price of cotton fiber increases, the quantity demanded domestically for cotton fiber increases also. The coefficient of price of fats and vegetable oils was positive, as expected, but not significant.

Elasticities and Adjustment Periods

For cotton, the own-price (short-run), long-run, coefficient of expectations, and adjustment periods; and also the level of significance of the coefficient from which the elasticity was computed are presented in Table XVI.

Elasticities showed that area and production of cotton fiber are high-responsive to cotton fiber price. For hectares harvested of cotton, the range of the own-price elasticity was between 0.16 and 0.91; and the range of the long-run elasticity was between 0.32 and 1.75. For the production of cotton fiber, the range of the own-price elasticity was between 0.12 and 0.76; and the range of long-run elasticity was between 0.21 and 1.37.

The elasticity values presented in this study indicated that hectares harvested and production of cotton fiber is highly responsive to price. The long-run elasticity values found in this study tend to be lower than those reported in past studies.

For Model II, other things equal, an increase of 10% in the expected price of cotton fiber is expected to increase the number of hectares harvested of cotton by 2.0% in the short run and by 3.7% in the long run. For Model IV, an increase of 10% in the price paid by DIAGONAL will increase cotton fiber production by 3.1% in the short run and 7.9% in the long run. Also for this

TABLE XVI

DIRECT PRICE ELASTICITIES AND ADJUSTMENT PERIODS FOR COTTON IN COLOMBIA, 1960-1983

Model	Variables[1]	Short-Run SR	Long-Run LR	Coefficient of Expectation (τ)	Adjustment Period
I (AREA):					
	PDR	0.16	0.32**	0.50	7 years
	LPDR	0.30	0.83**	0.36	8 years
	EPCR	0.76**	1.18**	0.64	5 years
	LEPCR	0.91**	1.75**	0.52	7 years
I (YIELD):					
	PDR	0.01			
	LPDR	0.01			
	EPCR	0.02			
	LEPCR	0.19*			
I (PRODUCTION):					
	HHC	-0.30			
	LHHC	-0.24			
	PDR	0.12			
	LPDR	0.22			
	EPCR	0.55**			
	LEPCR	0.82**			
II (AREA):					
	PDR	0.32	0.82**	0.39	10 years
	LPDR	0.58	0.69	0.84	3 years
	EPCR	0.20	0.37**	0.54	11 years
	LEPCR	0.79**	1.36**	0.58	5 years
III (PRODUCTION):					
	PDR	0.21	0.26	0.78	4 years
	LPDR	0.19	0.21	0.90	2 years
	EPCR	0.41	0.48*	0.85	3 years
	LEPCR	0.66**	0.70*	0.94	2 years

TABLE XVI (CONT.)

Model	Variables[1]	Short-Run SR	Long-Run LR	Coefficient of Expectation (τ)	Adjustment Period
IV (PRODUCTION):					
	PDR	0.31*	0.79**	0.39	10 years
	LPDR	0.62**	1.37**	0.45	9 years
	EPCR	0.60**	0.82**	0.73	4 years
	LEPCR	0.76**	1.04**	0.73	4 years
DEMAND:					
	PDR	-0.29	-0.40	0.71	5 years
	LPDR	-0.25	-0.40	0.61	6 years
	PXR	0.80**			
	LPXR	0.51**			

[1]The L before the name of the variable indicates logarithms. Variable definitions are in Appendix C.

*30% level of significance.

**15% level of significance.

model if the expected price of cotton fiber increases by 10%, production will increase by 6.2% and 13.7%, in the short run and long run, respectively.

Rewriting the equation (3.33),

$$P_t^* = \tau P_{t-1} + (1-\tau)\tau P_{t-2} + (1-\tau)^2\tau P_{t-3} + (1-\tau)^3 P_{t-3}^* + \ldots \quad (4.1)$$

With equation (4.1) and the coefficient of expectations (τ) the adjustment period for cotton in each model was computed. For example in Model IV, cotton fiber producers in the formulation of the expected price for period t give a weight of 73%, (τ), to the price of the period t-1; cotton fiber producers give a weight of 19%, [$(1-\tau)\tau$] to the price of the period t-2; a weight of 5.3%, [$(1-\tau)^2\tau$], to the price of the period t-3; a weight of 1.4%, [$(1-\tau)^3\tau$] to the price of period t-4; and a weight of 0.03%, [$(1-\tau)^4\tau$], to the price of the period t-5; from the sixth year and more the weights that cotton fiber producers give to the past prices are very low. The sum of these weights until the fourth year indicates that the prices of the four last years are explaining 98.7% of the price of the current year. Therefore, the adjustment period to arrive to the new equilibrium production, other things be equal, is 4 years. The shortest periods of adjustment were found in Models III and IV when policy variables are considering in the expected price formulation.

The demand for cotton fiber is inelastic. An increase of 10% in the price of cotton fiber, if other things are equal, will reduce the quantity demanded of cotton fiber by 2.9% in the short-run and in 4.0% in the long-run. An increase of 10% in the international price of cotton fiber is expected to increase the domestic consumption of cotton fiber by 5.0%, other things be equal. The period of adjustment for cotton demand was of five and six years.

For cotton, the cross-price, production costs, credit, research and risk elasticities values for the different models, and the level of significance of the coefficients from which the elasticities were derived are presented in Table XVII. There was not a specific trend for all the models about the relationship between cotton and related crops. Soybeans tend to be a complementary crop. Soybeans are rotated with cotton in some areas, while rice and sorghum showed competitiveness with cotton for the production resources. According to the results found for Model IV, other things been equal, an increase of 10% in the expected price of soybeans is expected to increase the production of cotton by 4.2%. An increase of 10% in the expected price of rice will decrease the production of cotton by 1.1%, and an increase of 10% in the expected price of sorghum will decrease the production of cotton by 2.6%.

Availability of credit showed a positive and a significant effect on area, yield, and production of cotton. An increase of 10% in the availability of credit will increase by 2.5% the number of hectares harvested of cotton, by 0.04% the yields of cotton, and by 3.5% the production of cotton. An increase in 10% in the production costs of cotton will decrease the production of cotton by 2.2%.

The magnitude of the risk elasticity was low. A 10% increase in the variability of income will decrease the production of cotton in 0.10%. This variable did not always present a negative sign and the level of significance expected. Representation of risk in the cotton supply should be an important factor to be considered in future studies. The effects of research on cotton yields found in this study were very low; its elasticity indicated that an increase of 10% spent on research, other things been equal, will increase the cotton yields 0.001%. The effect of research on yields of cotton was difficult to capture. It could be explained because there was not a sustained trend of cotton yields during the whole period of time considered in the present study. Data for cotton yields and for research used in the estimation procedure were at the national level. This level of aggregation could distort the "true" effect of research on

TABLE XVII

CROSS PRICE, PRODUCTION COSTS, CREDIT, RESEARCH AND RISK ELASTICITIES VALUES FOR THE COTTON SUPPLY FUNCTION IN COLOMBIA, 1960-1983

Independent Variable[1]	Model I (AREA)	Model I (YIELD)	Model II (AREA)	Model III (PRODUCTION)	Model IV (PRODUCTION)
PSRE (Soybeans Price)	0.45		0.22	-0.63	0.39
LPSRE (" ")	-0.03		-0.22	-0.24*	0.31
EPSR (" ")	0.24		0.63	0.85*	0.42*
LEPSR (" ")	-0.02		0.17	0.83**	0.23
PRR (Rice Price)	0.16		-0.34*	-0.54**	-0.05
LPRR (" ")	0.23		0.04	-0.75**	-0.11
EPRR (" ")	0.06		-0.20	-0.41**	-0.11
LEPRR (" ")	-0.15		-0.43	-0.63**	-0.27*
PGR (Sorghum Price)	-0.29**		0.01	0.03	-0.07
LPGR (" ")	-0.49		-0.55	-0.26	-0.21
EPGR (" ")	-0.17		-0.46*	-0.29**	-0.17
LEPGR (" ")	0.21		0.36	-0.20*	-0.26
PPCR (Production Costs)	0.28	-0.0040*	0.18	-0.23*	-0.22**
LPPCR (" ")	0.28	-0.2800	0.28	-0.18*	-0.18**
CDCR (Credit)	0.25**	0.0001**	0.43**	0.40**	0.35**
LCDCR (")	0.25**	0.2000**	0.18	0.39**	0.34**
RSCR (Research)	0.0001				
LRSCR (")	0.0100				
RVC1 (Risk)	0.01	-0.0001	0.21	0.10	-0.01**
LRVC1 (Risk)		-0.0100	0.04	0.01	-0.04*

* Computed from coefficients with 30% level of significance.

**Computed from coefficients with 15% level of significance.

[1]Variable definitions are in Appendix C.

yields of cotton fiber. A more detailed analysis of the relation between these two variables is recommended.

Measures of Welfare Analysis of the Cotton Policy

Estimation of the areas shown in Figure 6 are presented in Table XVIII. Based on the cotton export subsidy used in 1983, and given the price agreement, consumers lost 167.9 millions of Colombian Pesos, cotton fiber producers gained 341.1 millions of Colombian Pesos, taxpayers (consumers and producers are also taxpayers) lost 222 millions of Colombian Pesos, and society as a whole lost 81.5 millions of Colombian Pesos. This loss to society is represented by the dead weight loss areas 3+5+9.

The effects of a devaluation of the Colombian peso in the welfare analysis of the current cotton policy is presented in Table XIX. Under this situation consumers gain 1,273.0 million of Colombian Pesos. Producers lost 50.0 millions of Colombian pesos. This lost to producers is because of the price agreement, since under a devaluation, the domestic price to which textile producers buy cotton fiber is lower than the external market price. Therefore, producers lose the difference between the new external and the domestic price times the quantity consumed domestically, areas 6+10.

Taxpayers gain 222 million of Colombian Pesos, represented by the export subsidy that they do not have to pay, since the devaluation of the exchange rate will made more competitive the Colombian cotton fiber. Society as a whole gains 1,445.0 million of Colombian Pesos. As mentioned before, the social costs of these two policies must be balanced against unaccounted for benefits or losses on other sectors, as well as for inefficiency and administrative costs.

TABLE XVIII

WELFARE ANALYSIS EFFECTS OF PRICE AGREEMENT AND EXPORT SUBSIDY POLICY FOR COTTON FIBER IN COLOMBIA, (CURRENT SITUATION) 1983

Factor	Figure 6 Area	Figure 6 Price-Quantity	Units	1983
	CONSUMERS			
(1) Domestic consumption		Qd	Thousands of tons	38.2
(2) Domestic market price		Pd	Thousands of pesos/ton	143.4
(3) External price of cotton fiber without export subsidy		Pw	Thousands of pesos/ton	139.2
(4) External price of cotton fiber with export subsidy		Pw'	Thousands of pesos/ton	149.2
(5) Consumer loss under price agreement	2	(Pd-Pw)xQd	Millions of pesos	163.8
(6) Consumer loss under price agreement	3	0.5 [(Pd-Pw)x(Qd'-Qd)][1]	Millions of pesos	4.1
(7) Total loss to consumers under price agreement (5) and (6)	2+3		Millions of pesos	167.9
	TAXPAYERS			
(8) National production of cotton fiber		Qs'	Thousands of tons	60.4
(9) Export subsidy for cotton fiber		(Pw'-Pw)/Pw	Percent	7.0
(10) Loss to taxpayers (export subsidy policy transfer to producers)	3+4+5+8+9	(Pw'-Pw)x(Qs'-Qd)	Millions of pesos	222.0

TABLE XVIII (CONT.)

Factor	Figure 6 Area	Figure 6 Price-Quantity	Units	1983
(11) Dead weight loss	5	0.5[(Pd-Pw)x(Qs'-Qs")][2]	Millions of pesos	32.4
(12) Dead weight loss	9	0.5[(Pw'-Pd)x(Qs'-Qs")][3]	Millions of pesos	44.9
		-------------------- PRODUCERS --------------------		
(13) Gain to producers from price agreement and export subsidy	2+3+4+8		Millions of pesos	341.1
		-------------------- SOCIETY --------------------		
(14) Net loss to society	3+5+9		Millions of pesos	81.5

[1]Qd' is the quantity consumed of cotton fiber introducing Pw into the estimated demand equation.

[2]Qs" is the quantity supplied of cotton fiber after considering Pw into the estimated supply function.

[3]Qs is the quantity supplied of cotton fiber after considering Pd into the estimated supply function.

TABLE XIX

EFFECTS OF A DEVALUATION OF THE EXCHANGE RATE ON THE WELFARE ANALYSIS OF THE ACTUAL POLICY FOR COTTON FIBER IN COLOMBIA, 1983

	Factor	Figure 7		Units	1983
		Area	Price-Quantity		
			---------- CONSUMERS ----------		
(1)	Nominal exchange rate (E)			Pesos per US$1	73.3
(2)	Equilibrium exchange rate (E*)			Pesos per US$1	105.4
(3)	Correction Factor: E^*/E				1.4
(4)	External market price of cotton fiber		Pw	Thousands of pesos/ton	139.2
(5)	External market price of cotton fiber with export subsidy		Pw'	Thousands of pesos/ton	149.2
(6)	Corrected external market price [(3)x(4)]		Pw"	Thousands of pesos/ton	199.0
(7)	Domestic market price of cotton fiber		Pd	Thousands of pesos/ton	143.4
(8)	Domestic consumption of cotton fiber		Qd	Thousands of tons	38.2
(9)	Consumer costs under price agreement [(6)x(7)]		PdxQd	Millions of pesos	5,477.0
(10)	Consumer cost without price agreement under devaluation		Pw"Qd'	Millions of pesos	6,750.0
(11)	Consumers gain under devaluation and price agreement [(10)-(9)]	6+10		Millions of pesos	1,273.0
			---------- PRODUCERS ----------		
(12)	Loss to producers from price agreement	6+10		Millions of pesos	1,273.0

TABLE XIX (CONT.)

Factor	Figure 7 Area	Figure 7 Price-Quantity	Units	1983
(13) Gain to producers from devaluation of exchange rate	12		Millions of pesos	1,223.0
(14) Net loss to producers under devaluation, not export subsidy, and price agreement	6+10-12		Millions of pesos	50.0
	TAXPAYERS			
(15) Gain to taxpayers (export subsidy)	3+4+5+8+9		Millions of pesos	222.0
	SOCIETY			
(16) Gain to society	3+4+5+8+9+12		Millions of pesos	1,445.0

Predictions and Simulation of Policy Alternatives

For prediction purposes, the Model IV with variables in linear terms was applied since it presented acceptable results in R^2, F and t statistics, signs and magnitude of the coefficients. To supply the values of the independent variable, a linear regression equation was estimated for each independent variable against its lagged value and the trend variable. Finally, values forecast for the independent variables were used to obtain the predictions for cotton fiber from 1984 to 1990. A comparison of the predictions with the actual production of cotton fiber for the period covered by the analysis and to the year 1990 is presented in Figure 8. As would be expected from the high R-square, the predictions are quite good. For 1984 to 1990 the model predicts an increase in the production of cotton fiber after several years of decreasing production caused principally by low international prices.

Scenarios for several policy alternatives were postulated. Effects of these policy alternatives on cotton production in 1983 are presented in Table XX. For scenario one, an increase of 10% in the price paid by DIAGONAL (domestic price) will raise cotton fiber production by 24% compared to the production reached in 1983. The export subsidy for 1983 was 7%. An increase of 1% in the export subsidy (up to 8%) will increase cotton fiber production by 52%. Overvaluation of the Colombian Peso has had a negative effect on cotton production; an increase of 20% in the nominal exchange rate will yield an increase in cotton production of 56%.

Rice and sorghum were postulated as competitive crops with cotton fiber in production resources. However, if the price supports of rice and sorghum were

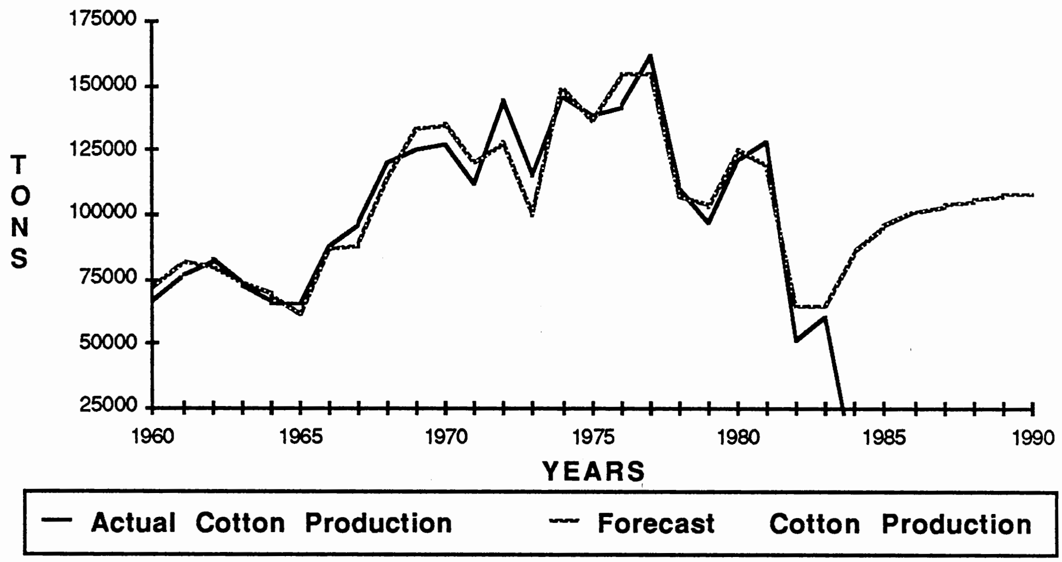


Figure 8. Forecast and Actual Values of the Production of Cotton Fiber in Colombia (1960-1990)

TABLE XX

EFFECTS ON THE PRODUCTION OF COTTON FIBER OF SEVERAL POLICY ALTERNATIVES

	Scenarios of Policy Alternatives[1]	Cotton Production Obtained	Percentage Change in Cotton Production[2]
1.	Increase of 10% in the price paid by DIAGONAL	75,376	+24%
2.	Increase of 1% in the export subsidy of cotton fiber	91,900	+52%
3.	An increase of 20% in the nominal exchange rate	94,484	+56%
4.	An increase of 20% in the price support of rice and sorghum, and IDEMA purchased 10% of the production of rice and sorghum	73,126	+21%
5.	An increase of 10% in the availability of credit for cotton fiber	80,633	+33%
6.	Increase in domestic demand of cotton fiber according with the growth rate of consumption fiber	72,916	+20%

[1]Changes in prices were considered in real terms.

[2]Changes were considered with respect to the 1983 values.

increased in 20% and IDEMA participates in the purchases of these crops by 10%, cotton production still will rise by 21%. This could be explained by the positive trend in cotton fiber production that the model reflected from 1984. An increase in the availability of credit in 10% is expected to increase cotton fiber production by 33%.

The last scenario represents the increase in the domestic demand according with the growth rate of consumption of cotton fiber. To compute this growth rate in consumption the following equation was computed:

$$QC_t = TCP_{t-1} + \eta \, TCYP_{t-1} \quad (4.2)$$

where:

QC_t = Growth rate of consumption for year t

TCP_{t-1} = Growth rate of population in year t-1

η = Income elasticity of cotton demand fiber

$TCYP_{t-1}$ = Growth rate of the per capita income

Given the values of $\eta = 0.49$ obtained from the demand equation estimated in this study, and $TCP_{t-1} = 2.1\%$; $TCYP_{t-1} = 2.0\%$ (Bolling, 1987), the domestic demand of cotton fiber will be 39,981 tons. This higher domestic demand through the expected price formulation will increase the quantity supplied of cotton fiber by 20%.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

Summary

Colombia has an agricultural-oriented economy. The agricultural sector has been a major source of growth and the consensus is that it is in this sector that the country has the greatest comparative advantage. A recession in the agricultural sector has been present since the middle 1970's, precipitated by unsound macroeconomic policies. Cotton has societal and economical importance since it is one of the crops that demands the greatest level of human, economic and technical resources. International conditions have undoubtedly contributed to the problems of cotton which reflected principally by low international prices.

Cotton yields have been constant through the years. Technology that has been recommended for cotton is highly dependent on chemicals. In addition to lower real domestic and international prices, input costs have increased continuously, deteriorating terms of trade. Increases in the price of machinery, labor and land have also contributed to a growing profit squeeze that cotton producers have been facing for several years. High levels of instability in income and prices of cotton have been recognized by policy makers in general.

A reduction of risk is expected to promote investment, expand production and stabilize price significantly.

Raw cotton output declined 35 percent from 1977 to 1978 motivated principally by low international prices of cotton fiber . In 1977, the national area planted to cotton was 377,000 hectares with 17,069 cotton growers. In 1983, the area planted to cotton was 75,000 hectares with 5,661 cotton growers. The share of cotton to the value of agricultural production, in the value of production of oil seeds, and in the value of total agricultural exports at constant 1970 prices has decreased from 1960 to 1983.

Price policy in the cotton sector has been characterized by active intervention of the government. The government's most important objectives for the cotton sector have been to increase domestic price stability and to generate cotton grower's income. Policies implemented by the government to achieve these policies has been based on domestic market intervention, and export and credit subsidy.

Although unsound Colombian macroeconomic policies, performance of the international cotton sector, and lack of incentives have caused a recession in the Colombian cotton sector, their effects have not been measured. Models that allow researchers to analyze the effects of cotton production caused by changes in domestic and international policy variables need to be developed. For cotton this necessity is stronger since the number of studies realized are few, and the problems of this commodity are complex. Results from studies that considered estimates of supply response under risk conditions, introduction of policy variables into expectation of price formations, and the distribution of gains and losses of government among producers, consumers and taxpayers will help the decision makers of cotton policy.

This study had three main objectives: (1) estimate the supply function for cotton considering risk and policy variables in the formation of expected prices; (2) apply welfare analysis to estimate the distribution of gains and losses among consumers, producers, and taxpayers of the current price agreement and export subsidy policy for cotton fiber in Colombia; and, (3) simulate the effects on cotton fiber production of several cotton policy alternatives and government policies for related crops.

Exchange rates, export subsidies, internal prices and mandatory quotas that result from the agreement approved by the government between the FEDERACIONES and DIAGONAL were the policy variables considered in the formation of expected price for cotton. The price support and the quantity bought by the IDEMA were the policy variables considered in the expected price formulation for soybeans, rice and sorghum.

Risk in this study was based on the assertion that risk is directly related to the recorded instability or variability of prices in recent periods. The use of moving range and moving standard deviation for domestic and external prices were measures of variation postulated to capture aspects of this recent variability. Other shifters of cotton supply that were considered were production costs in Pesos per hectare, availability of credit and expenditures on research.

Four alternative models with a Nerlove type formulation were postulated. Model I was formed by a system of two behavioral equations (area and yield), and a identity (production). Models II and III were simultaneous equation models formed by four supply equations. They try to capture directly the interdependence between the cotton economy and those of soybeans, rice and sorghum. Model II considered the number of hectares harvested as the dependent variable, while quantity produced was the dependent variable in

Model III. Model IV is a single equation model represented by the cotton supply function of Model III.

The demand model for cotton postulated in this study consisted of two parts: a demand function and an adjustment equation based on the Nerlove hypothesis. Variables in linear and logarithmic terms were considered. Ordinary-least-squares (OLS) was applied to estimate the supply functions of models II and III. To correct for autocorrelation, the Cochrane-Orcutt technique was applied. The true period considered was 1960-1983. Most of the data utilized in this study came from reports of the Departamento Nacional de Planeacion, Federacion Nacional de Algodoneros, and from the study by Garcia and Montes (1986).

The statistical results for the supply functions were better when policy variables were included in the expected price formulation. Therefore, for purposes of estimation of supply elasticities, prediction, simulation, and analysis of cotton policy, it is recommended that policy variables be included directly, or through the expected price formulation, in the supply function. Even though production was more responsive than number of hectares harvested, results from both type of equations can be considered for effects of comparison. The R-square of the supply functions was high in general; the significance of the F and t statistics varied among models. For Model IV the significance, signs and magnitude of the coefficients were good, this model can explain with acceptable accuracy the supply function of cotton.

Short run and long run direct price elasticities, cross price elasticities, and elasticities with respect to other shifters of the supply functions as well as the adjustment period for each model were computed. Elasticities indicated that area and production of cotton fiber are highly responsive to price. For area, the range of the own price elasticity was between 0.16 and 0.91, and the range of the long run price elasticity was between 0.32 and 1.75. For production, the range of the own-price elasticity was between 0.12 and 0.76, and the range for the long run elasticity was between 0.22 and 1.37.

The statistical results obtained for the cotton demand model were not good. It means that there could be other important variables and/or other type of specifications that were not considered in this study.

The long run elasticity values determined in this study tend to be lower than the long run elasticity values reported in past studies. The range for adjustment periods was between 2 and 11 years. Although the risk variable did not always have the negative sign and the level of significance expected, representation of risk in the cotton supply functions should be another important factor to be considered in future studies. The elasticity of yields with respect to expenditures on research was very low, the effect of this variable was difficult to capture.

Under partial equilibrium assumptions, classical welfare analysis was applied to provide some insight into the merits of the actual export subsidy, the price agreement policy, and the exchange rate policy for cotton fiber. The effects of these policies were measured by their impacts on producers, consumers, taxpayers, and on national income. With the agreement between the FEDERACIONES and DIAGONAL, and using the current export subsidy for cotton for the 1983 year, consumers lost 166.2 million Colombian Pesos, cotton fiber producers gained 341.1 million Colombian Pesos, taxpayers lost 218.6 million Colombian Pesos, and society as a whole lost 46.1 million Colombian Pesos.

Welfare measures were also determined in case that the government authorizes a devaluation of the Colombian Peso according to the real exchange rate, and the agreement with textile producers is kept to protect the textile industry. In this situation the export subsidy is eliminated since it is expected that competitiveness will be recovered for the Colombian cotton fiber in the external markets.

Based on the 1983 values, considering the devaluation of the peso, consumers gain 1,273.0 million Colombian Pesos, and producers would loss 50.0 million Colombian Pesos. This loss to producers is because of the price agreement, since under a devaluation the domestic price at which textile producers buy is lower than the external market price. Producers lose the difference between the new external price and the domestic market price times the quantity consumed domestically. However, in this case producers would be better off, especially in the long run, than in a situation of overvaluation of the Colombian Peso.

If the devaluation is authorized, taxpayers could gain 218.6 million Colombian Pesos, represented by the export subsidy that they do not have to pay. Society as a whole would gain 1,441.6 million Colombian Pesos. The social cost of these two policies must be balanced against unaccounted for benefits and losses on other sectors, as well as for inefficiency and administrative costs.

For predictive purposes, Model IV was applied. To determine the values of the independent variables, a linear regression equation for each independent variable against its lagged value and the trend variable was estimated. These forecasted values of the independent variables were used to obtain the predictions for cotton fiber from 1984 to 1990. As would be expected from this high R-square, the predictions were quite good. For 1984 to 1990, the model predicted a recuperation in the production of cotton fiber after several years of recession of the Colombian cotton sector.

Scenarios of policy alternatives were postulated for simulation purposes. Their effects on cotton fiber production and the variation with respect to the production obtained in 1983 was calculated. The simulation results showed that production of cotton fiber is very sensitive to changes in export subsidies and exchange rates. These effects of simulation could be overestimated, since 1983 was one of the years of lowest production, and from that year the model predicts a recovery of the sector which could make the results more sensitive to changes in policy variables.

Conclusions

Policy variables should be considered, either directly or through the formation of expected prices, in the specification of the cotton supply function if the interest is to estimate elasticity values. Area and production of cotton fiber are highly responsive to price; long-run elasticities values found in this study were lower than the estimates obtained in past studies.

Although not always the expected signs, magnitude and significance of production costs, expenditures on research, credit and risk aversion were maintained in all the models, inclusion of these variables is promising but refinements are required.

Interdependence of the cotton sector with the soybeans, rice and sorghum sector was found. Therefore, formulation of policies of related crops and their effects should be considered in the analysis of cotton fiber strategies.

Government intervention in the cotton sector based on the price agreement and export subsidy for cotton fiber represents an economic loss to the country. A devaluation of the peso will benefit not only cotton fiber producers, but also taxpayers and consumers of cotton fiber.

Limitation of the Study

Data availability was the major limitation of this study. For most of the variables, information of the recent years was preliminary. Variation in data for the same variable was found among sources. Data limitations were greater at the regional level.

The results presented in this study are for the entire country or aggregate level. The performance of a traditional farmer should be different from the performance of a commercial farmer. Differences in cotton growers' performance among regions is expected since the conditions are not the same. Estimation of parameters by econometric models under these circumstances could be underestimated or overestimated.

For welfare analysis purposes, a graphical representation for the current cotton situation was presented. Given the time constraint it was not possible to obtain criticisms of this approach by the cotton growers and policy makers of the Colombian cotton sector. The results presented in this study have to be considered as preliminary.

This study is based on partial equilibrium. Analysis of the input side problems of the cotton sector was weak in this study. The welfare effects of the current cotton policy on the output side presented in this study has to be balanced against welfare effects of cotton policy on the input side. Effects of the cotton seed market on the production of cotton fiber were not considered in this study. Estimation of elasticities values will change if additional equations to capture those effects can be included in the model.

Policy Recommendations and Suggestions for Future Research

The supply of cotton fiber is very sensitive to changes in export subsidy and exchange rate variations. Policy alternatives for the cotton could be implemented through modifications in these variables.

Related to the specification of the cotton supply model, alternatives formulations of expected price should be considered as well as accuracy in the data of production costs, expenditures on research and availability of credit. Results from studies with alternatives measures of risk aversion should be compared with those found by the approaches applied in this study.

This study was done at the national level. Cotton is produced in several zones of the country by both traditional and commercial farmers. Differences in the response of supply by zones and by type of farmers is expected. Therefore, values of supply and demand elasticities by zones and type of farm should be estimated. Cotton policy effects are expected to be different among them.

Time series data is a strong limitation in carrying out studies in the Colombian agricultural sector. Elaboration and updating of data banks by institutions is recommended. Data availability should be viewed as it is an important tool for researchers and policy makers.

One of the direct methods of estimation of the supply function was followed in this study. Prediction and simulation of policy analysis were based on econometric models. Estimates from the application of other methods such as duality is suggested. Given the limitation on time series data, linear programming is a good alternative that should be considered.

Classical welfare analysis is a powerful tool for evaluating impacts of agricultural policy. Application of this tool to the input side and other interventions in the cotton sector would be important. The cotton seed market is another part that has to be considered in the analysis of the cotton policy. Estimation of elasticities and policy conclusions can change if additional equations representing the cotton seed market are incorporated in the model presented in this study.

The production of cotton fiber in Colombia is very sensitive to changes in international prices of cotton fiber. Estimation of export supply elasticities are necessary.

An increase in yields is a very important alternative for the country to expand the production of cotton fiber. Economic evaluation and welfare analysis measures of the results of the research program in cotton is recommended.

Finally, agricultural economics research is recommended in the cotton sector, applied and basic, not only from the product but also from the input side. Any economic study for this crop will contribute to understanding the complex problems of this sector.

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APPENDICES

APPENDIX A

GENERAL ASPECTS OF COTTON PRODUCTION IN COLOMBIA

TABLE A.I.

CLIMATOLOGICAL CHARACTERISTICS OF COTTON ZONES IN COLOMBIA

	Altitude m.a.s.l.*	Average Annual Temperature Min.	Average Annual Temperature Max.	Average Annual Precipitation Min.	Average Annual Precipitation Max.	Climate
Costa Atlantica	0-500	27	39	700	1,200	Semi-arid to sub-wet Tropical
Tolima - Huila	300-600	27	30	800	1,400	Semi-arid to sub-wet Tropical
Valle del Cauca	950-1,100	24	26	800	1,400	Sub-wet Tropical
Llanos Orientales	200-300	26	30	3,000	4,000	Wet Tropical

m.a.s.l.* = meters above the sea level.

Source: ICA - Informes Tecnicos, and FEDERALGODON - Informes de Gerencia.

TABLE A.II

AREA AND PRODUCTION BY ZONES (1983-1984)

Zone	Area (Thousand Hectares)	Production (Thousand Tons)	Municipalities
Costa-Meta			
Atlantico	2.8	4.0	Barranquilla, Repelon, Sabanalarga, Barranca, Luruaco
Bolivar	5.8	10.4	Carmen de Bolivar, Cordoba, and Magangue
Cesar	36.0	54.0	Valledupar, Codazzi, Aguas Blancas, Becerril, Chiriguana, Las Florez, La Paz, San Diego, Bosconia, El Copey, Aguachica, Pueblo Nuevo, and Casacara
Cordoba	14.0	22.6	Monteria, Cerete, Cienaga de Oro, San Carlos, Lorica, and San Pelay
Guajira	0.6	0.8	San Juan del Cesar, Villanueva, and Fonseca
Magdalena	3.0	5.4	Aracataca, Algarrobo, Fundacion, Caracolicillo, and Plato
Sucre	7.0	10.5	San Pedro, Sincelejo, and Corosal
Meta	7.2	8.7	Villavicencio, Granada, San Martin, Puerto Lopez, Acacias, Comaral, San

TABLE A.II (CONT.)

Zone	Area (Thousand Hectares)	Production (Thousand Tons)	Municipalities
			Carlos de Guaviare, Restrepo, and Puerto Porfia
Total Costa-Meta	76.5	116.5	
<u>Interior</u>			
Boyaca	-	-	Puerto Boyaca
Caldas	-	-	Dorada
Cundinamarca	3.0	6.0	Girardot, Ricaurte, Nariño, Tocaima, Nilo, Aguas de Dios, Jerusalen, Guataqui, Beltran, Puerto Salgar, and San Juan de Rioseco
Huila	1.8	3.3	Neiva, Tello, Baraya, Colombia, and Aipe
Tolima	25.7	54.2	Ibague, Armero, Ambalema, Lorica, Venadillo, Honda, Alvarado, Piedras, Mariquita, Espinal, Guamo, Ortega, Flandes, Valle del San Juan, San Luis, Coello, Carmen de Apicala, Suarez, Natagaima, Prado, Saldana, Purificacion, and Coyaima.
Valle del Cauca	8.5	19.7	Palmira, Buga, Zarzal, Tulua, Cartago, Roldanillo, La Union, Yumbo, Ginebra, and Bugalagrande
Total Interior	39.0	83.2	

SOURCE: ICA - Informes Tecnicos, and FEDERALGODON - Informes de Gerencia.

TABLE A.III

STRUCTURE OF PRODUCTION COSTS FOR COTTON PER HECTARE BY ZONE (1983-1986)

	INTERIOR				COSTA-META			
Items	1983	1984	1985	1986	1983	1984	1985	1986
Plow	1,900	2,000	2,800	3,382	1,800	2,000	2,500	4,000
Disc	2,972	3,500	5,000	6,040	2,800	3,000	3,400	6,000
Pre-emergent	2,377	3,474	4,488	5,764	3,225	3,323	4,241	5,459
Seed	892	1,475	1,875	2,325	950	1,200	1,656	2,070
Planting	951	1,500	2,200	2,658	800	1,000	1,200	2,000
Replanting	475	800	1,100	1,364	400	500	600	1,000
Fertilizers	7,013	8,940	11,862	14,182	4,014	6,453	10,640	14,163
Cultivation	951	1,500	2,200	2,658	800	1,000	1,200	2,000
Crown-cover (1/2)	951	1,500	2,200	2,658	800	1,000	1,200	2,000
Crown-cover	951	1,500	2,200	2,658	800	1,000	1,200	2,000
Thining	2,972	3,900	4,500	5,580	2,100	2,500	2,500	3,000
Weed Control	4,755	5,200	6,000	7,440	3,500	4,200	4,500	5,400
Pest Control	14,264	21,782	26,445	34,747	12,573	15,721	18,394	35,174
Bags and materials	1,189	1,410	1,255	2,335	1,000	1,171	1,225	1,142
Harvesting	13,551	19,449	22,775	28,113	9,600	12,485	12,000	13,950
Packing	357	826	973	1,207	200	225	451	600
Internal Transportation	2,377	2,000	2,880	3,479	2,000	2,500	3,000	4,410
Loading	238	177	206	256	175	200	250	350
Processing	238	354	419	519	200	225	250	350
Transportation to plant	1,783	2,360	3,398	4,105	2,000	2,500	3,000	4,450
Technical Assistance	1,783	2,200	2,500	2,800	1,000	1,300	1,500	2,100
Technical Management	8	8	8	8	6	7	6	6

TABLE A.III (CONT.)

Items	INTERIOR 1983	1984	1985	1986	COSTA-META 1983	1984	1985	1986
Crop Development Quota	30	31	31	31	26	27	24	24
Leveling	12,600	12,538	16,157	19,517	8,000	8,960	9,300	13,269
Field Cleaning	2,972	3,500	5,000	6,040	3,500	4,500	4,500	6,620
Quota to Federaciones	2,763	3,225	3,936	4,524	1,968	2,610	2,767	3,240
Fences, Roads, Drainage	951	1,950	2,250	2,790	800	960	1,150	1,438
Insurance	380	645	787	905	390	513	553	648
Marketing Quota	0	0	0	0	0	0	0	0
Wages	1,426	2,000	2,400	2,976	800	1,000	1,200	1,500
Bank Interest Rate	4,487	6,160	7,350	10,080	4,693	5,740	6,720	8,260
Management	2,972	4,200	4,960	6,150	2,000	2,500	3,000	3,610
Land Rental	11,887	15,000	16,500	18,000	5,000	8,000	12,000	15,000
Sena-ICBF-SS-Subfamiliar	1,783	2,200	2,600	3,224	1,500	2,000	2,900	3,500
Irrigation	4,753	5,717	7,146	8,632	0	0	0	0
Export Quota	0	1,722	2,039	2,753	3,680	3,180	9,000	12,000
Research Quota	0	329	416	447	0	0	279	332
Total	109,952	145,072	178,856	220,347	83,100	103,500	128,306	182,065

SOURCE: FEDERALDOGON - Informe de Gerencia 1985-1986.

TABLE A.IV

VARIATION INDEXES OF FINANCING AND COST OF PRODUCTION PER HECTARE OF COTTON IN COLOMBIA (1970-1986 PERIODS WITH RESPECT TO 1970 PERIOD)

Zone and Period	Semester	FINANCING		COST OF PRODUCTION	
		Value Per Hectare	Index of Variation	Value per Hectare	Index of Variation
Interior 1970	A	2,200	100	6,882	100
Costa-Meta 1970/71	B	2,400	100	7,009	100
Interior 1971	A	2,500	114	7,858	114
Costa-Meta 1971/72	B	2,500	104	8,252	118
Interior 1972	A	2,500	114	8,592	125
Costa-Meta 1972/73	B	2,500	104	10,486	150
Interior 1973	A	2,500	114	12,246	178
Costa-Meta 1973/74	B	3,000	125	12,714	181
Interior 1974	A	3,500	159	17,847	259
Costa-Meta 1974/75	B	5,000	208	17,483	249
Interior 1975	A	5,000	227	23,021	335
Costa-Meta 1975/76	B	5,500	229	21,138	301
Interior 1976	A	5,700	259	24,813	360
Costa-Meta 1976/77	B	6,000	250	27,459	392
Interior 1977	A	6,000	273	34,486	506
Costa-Meta 1977/78	B	7,000	292	36,866	526

TABLE A.IV (CONT.)

Zone and Period	Semester	FINANCING Value Per Hectare	FINANCING Index of Variation	COST OF PRODUCTION Value per Hectare	COST OF PRODUCTION Index of Variation
Interior 1978	A	7,500	341	36,038	524
Costa-Meta 1978/79	B	10,000	417	36,000	514
Interior 1979	A	14,000	636	42,537	618
Costa-Meta 1979/80	B	14,000	583	44,938	641
Interior 1980	A	15,800	718	53,273	774
Costa-Meta 1980/81	B	19,000	792	60,947	870
Interior 1981	A	20,000	909	73,994	1,075
Costa-Meta 1981/82	B	24,000	1,000	73,890	1,054
Interior 1982	A	26,000	1,181	87,960	1,278
Costa-Meta 1982/83	B	32,000	1,333	83,100	1,186
Interior 1983	A	36,000	1,636	109,952	1,598
Costa-Meta 1983/84	B	41,000	1,708	103,500	1,477
Interior 1984	A	44,000	2,000	145,072	2,108
Costa-Meta 1984/85	B	48,000	2,000	128,306	1,831
Interior 1985	A	52,500	2,386	178,856	2,599
Costa-Meta 1985/86	B	59,000	2,458	182,065	2,596
Interior 1986	A	72,000	3,273	220,347	3,202

SOURCE: FEDERALGODON - F.F.A.P., Informe de Gerencia 1985-86.

APPENDIX B

IDENTIFICATION CONDITIONS OF

MODELS II AND III

APPENDIX B

IDENTIFICATION CONDITIONS OF MODELS II AND III

The Order Condition of Identification

Identification of an equation was made possible by an exogenous variable that was excluded from the equation of interest but was part of the specification of another equation of the model, in other words, identifiability was achived with exclusion restrictions on the exogenous variables or put another way prior information that certain variables had zero coefficient in the other supply equations. This, however, is not the only way in which identification may be obtained, but is the most common, and was the procedure followed in this study.

Cotton Supply Equation:

$K^{**} = 7$ (RVS_t, RVR_t, RVG_t, PCR_t, CDR_t, RSR_t and XSR_t)

$G^{\Delta} = 4$ (HHC_t, HHS_t, HHR_t, and HHG_t)

$G^{\Delta} - 1 = 4 - 1 = 3$

Since $K^{**} > G^{\Delta} - 1$ ===> Cotton supply equation was overidentified.

Soybeans Supply Equation:

$K^{**} = 10$ (CDC_t, RSC_t, PCC_{t-1}, RVC_t, RVR_t, PCR_t, CDR_t, RVR_t, XSR_t, and RVG_t)

$G^{\Delta} = 4$ (HHC_t, HHS_t, HHR_t, and HHG_t)

$G^{\Delta} - 1 = 4 - 1 = 3$

Since $K^{**} > G^{\Delta} - 1$ ===> Soybeans supply equation was overidentified.

Sorghum Supply Equation:

K^{**} = 10 (CDC_t, RSC_t, PCC_{t-1}, RVC_t, RVS_t, PCR_t, CDR_t, RSR_t, XSR_t, and RVR_t)

G^{Δ} = 4 (HHC_t, HHS_t, HHR_t, and HHG_t)

$G^{\Delta} - 1 = 4 - 1 = 3$

Since $K^{**} > G^{\Delta} - 1$ ===> Sorghum supply equation was overidentified.

Rice Supply Equation:

K^{**} = 6 (PCC_t, CDC_t, RSC_t, RVC_t, RVS_t, and RVG_t)

G^{Δ} = 4 (HHC_t, HHS_t, HHR_t, and HHG_t)

$G^{\Delta} - 1 = 4 - 1 = 3$

Since $K^{**} > G^{\Delta} - 1$ ===> Rice supply equation is overidentified.

Where:

G^{Δ} = The number of endogenous variables that appears in the equation of interest.

K^{**} = The number of predetermined variables that do not appear in the equation of interest but in the system.

The equations were overidentified; therefore, two stages least squares (TSLS) were applied. It was mentioned that from TSLS the properties of the estimators are biased, consistent, and asymptotically efficient if the error terms are contemporaneously uncorrelated and the sample size tends to be large.

APPENDIX C

DATA USED IN THE ESTIMATION AND ANALYSIS

APPENDIX C

DATA USED IN THE ESTIMATION AND ANALYSIS

List of Variables:

QC	=	Production of cotton (tons)
HHC	=	Hectares harvested of cotton
Y	=	Yield of cotton (tons/hectare)
PC	=	Producer price of cotton (country avg. pesos/ton)
PD	=	Price paid by DIAGONAL (pesos/ton)
QD	=	Domestic production of cotton fiber bought by DIAGONAL (tons)
PX	=	External price of Colombian cotton (pesos/ton)
PXW	=	External price of Colombian cotton without export subsidy (pesos/ton)
PI	=	International price of Colombian cotton (dollars/ton)
FOBC	=	Average of fob export price of cotton fiber (pesos/ton)
S	=	Export subsidy for cotton (percentage)
XSCP	=	Export subsidy for cotton (pesos/ton)
WAGE	=	Average rural wage (pesos/day)
CPRE	=	Costs of preemergents for cotton (pesos/hectares)
CFER	=	Costs of fertilizers for cotton (pesos/hectare)
CPES	=	Costs of pesticides for cotton (pesos/hectare)
CWAGE	=	Costs of labor for cotton (pesos/hectare)
PPC	=	Cotton production costs (pesos/hectare)

CDC = Approved credit for cotton (millions of pesos)

RSC = Expenditures on cotton research (million of pesos)

RIC = Interest rate for cotton credit

RIM = Market interest rate

MC = Imports of cotton fiber (tons)

XC = Exports of cotton fiber (tons)

CCF = Domestic consumption of cotton fiber (tons)

RVC1 = Risk variable for cotton fiber formed by the moving range of cotton domestic price (3 years)

RVC2 = Risk variable for cotton fiber formed by the moving range of cotton external price (3 years)

RVC3 = Risk variable for cotton fiber formed by the moving standard deviation of cotton domestic price (3 years)

RVC4 = Risk variable for cotton formed by the moving standard deviation of cotton external price (3 years)

QS = National production of soybeans (tons)

HHS = Hectares harvested of soybeans

PS = Producer price of soybeans (country avg. pesos/ton)

PSS = Price support of soybeans (pesos/ton)

IDES = Domestic production of soybeans bought by IDEMA (tons)

RVS = Risk variable for soybeans formed by the moving standard deviation of soybeans producer price

QG = National production of sorghum (tons)

HHG = Hectares harvested of sorghum

PG = Producer price of sorghum (country avg. pesos/ton)

PSG = Price support of sorghum (pesos/ton)

IDEG = Domestic production of sorghum bought by IDEMA (tons)

RVG	=	Risk variable for sorghum formed by the moving standard deviation of sorghum producer price (3 years)
QR	=	National production of rice (tons)
HHR	=	Hectares Harvested of sorghum
PR	=	Producer price of rice (pesos/ton)
PSR	=	Price support of rice (pesos/ton)
IDER	=	Domestic production of rice bought by IDEMA (tons)
CDR	=	Approved credit for rice (millions of pesos)
XSR	=	Export subsidy for rice (millions of pesos)
RSR	=	Expenditures on research for rice (millions of pesos)
GDP	=	Price index of gross domestic product (1975=100)
CPI	=	Consumer price index (1975=100)
IPNAS	=	Price index of the nonagricultural sector (1975=100)
PESO	=	Overvaluation of the Colombian peso
NER	=	Nominal exchange rate
EER	=	Equilibrium exchange rate
YNC	=	National income (millions of pesos)
POP	=	Population (thousands of persons)

In the tables of results the R at the end of the variable name indicated variable in real terms, while the L at the beginning of the variable indicated variable in logarithms. The period of study was 1960-1983. Most of the above data came from the study performed by Garcia and Montes (1986), and from several reports of the Departamento Nacional de Planeacion - Unidad de Estudios Agrarios, and Federacion Nacional de Algodoneros.

TABLE C.I

DATA USED IN THE ESTIMATION AND ANALYSIS

obs	QC	HHC	Y	PC	PD	QD	PX	PXW	PI	FOBC
1960	66,900	152,150	0.54	1,753	4,417	43,300	3,769	3,769	571.0	3,769
1961	76,500	152,341	0.58	1,934	4,649	59,300	5,054	4,447	766.9	5,054
1962	82,300	176,905	0.50	2,002	4,572	55,900	5,668	4,987	861.3	5,668
1963	72,600	142,011	0.51	2,719	5,857	54,800	5,513	4,851	614.6	5,513
1964	66,000	150,044	0.47	2,821	6,319	53,500	5,637	4,960	626.3	5,637
1965	65,500	134,249	0.48	2,986	6,795	49,300	7,655	6,736	780.3	7,655
1966	88,000	164,876	0.63	3,604	8,107	83,300	6,648	5,850	514.5	6,648
1967	96,600	174,538	0.69	3,786	8,133	66,100	8,340	7,226	591.9	8,340
1968	120,100	198,879	0.69	4,158	8,767	73,000	9,249	8,070	576.9	9,250
1969	125,300	236,060	0.59	3,958	8,687	62,840	9,897	8,606	574.7	9,898
1970	127,800	266,935	0.63	4,040	8,898	72,572	9,622	8,352	524.3	9,622
1971	112,300	218,960	0.58	5,177	10,646	70,233	12,966	11,313	648.3	12,967
1972	144,500	246,961	0.63	6,176	12,022	76,664	15,829	13,811	719.1	15,830
1973	115,600	252,387	0.53	7,579	16,556	72,142	20,125	17,953	845.2	20,125
1974	145,800	258,226	0.60	12,902	27,872	96,128	35,555	31,811	1,311.9	35,556
1975	138,700	280,967	0.57	11,650	26,060	58,895	27,210	26,108	872.1	27,210
1976	142,100	283,358	0.60	18,699	43,705	80,681	42,660	40,954	1,219.9	42,660
1977	161,600	377,246	0.45	22,406	53,756	84,903	55,726	55,247	1,509.3	55,727
1978	110,600	327,842	0.46	20,970	47,472	75,986	48,361	46,378	1,232.1	48,361
1979	97,200	188,400	0.63	29,292	65,931	68,605	76,262	70,977	1,837.6	70,440
1980	121,600	220,629	0.60	34,561	84,379	71,237	82,899	77,427	1,840.1	82,899
1981	128,900	221,017	0.60	37,727	97,072	67,900	86,747	81,047	1,694.6	86,747
1982	51,200	98,080	0.65	45,932	111,132	33,600	100,790	94,259	1,682.9	100,790
1983	60,400	80,332	0.68	65,983	143,434	38,700	149,276	139,200	2,035.1	149,277

TABLE C.I (CONT.)

obs	S	XSCP	WAGE	CPRE	CFER	CPES	CWAGE	PPC	CDC	RSC
1960	0.12	0.0	5.12	127.35	62.0	420.87	271.36	881.58	19.2	0.3
1961	0.12	606.1	5.86	136.25	62.0	499.50	310.58	1,008.33	26.9	0.4
1962	0.12	680.1	6.59	118.50	135.0	684.50	349.27	1,287.27	30.9	0.4
1963	0.12	661.3	8.34	154.00	175.0	890.00	442.02	1,661.02	40.1	0.5
1964	0.12	676.2	10.04	174.00	197.5	1,003.50	532.12	1,907.12	50.3	0.5
1965	0.12	918.6	10.77	176.50	201.0	1,020.50	570.81	1,968.81	75.5	0.6
1966	0.12	797.3	12.52	207.50	235.0	1,205.00	663.56	2,311.06	191.6	0.6
1967	0.13	1,113.1	13.30	249.00	197.5	1,253.00	704.90	2,404.40	249.3	0.7
1968	0.13	1,178.8	14.74	298.00	309.0	1,473.00	781.22	2,861.22	356.5	0.8
1969	0.13	1,291.0	16.27	338.00	357.5	1,697.00	862.31	3,254.81	466.8	1.8
1970	0.13	1,269.9	17.21	381.00	308.5	1,844.00	912.12	3,445.63	436.6	2.8
1971	0.13	1,652.5	19.38	457.00	375.0	2,289.00	1,027.14	4,148.14	341.6	3.0
1972	0.13	2,017.5	24.99	540.00	511.5	2,682.50	1,324.47	5,058.47	487.6	3.1
1973	0.11	2,171.5	32.22	584.50	583.0	3,121.50	1,707.66	6,266.66	624.1	2.3
1974	0.11	3,743.4	41.54	668.50	1,773.0	3,958.50	2,201.62	8,601.62	1,300.1	2.1
1975	0.04	1,102.0	53.39	848.00	2,020.0	6,378.00	2,829.67	12,075.67	1,174.3	2.5
1976	0.04	1,706.0	67.75	954.50	2,013.5	6,832.00	3,590.75	13,390.75	1,780.5	3.1
1977	0.01	478.5	89.17	1,090.50	2,047.5	12,763.50	4,726.51	20,627.51	2,353.5	3.4
1978	0.04	1,982.3	93.50	1,215.50	2,666.0	8,444.50	4,955.50	17,281.50	1,280.4	4.3
1979	0.07	5,284.8	105.00	1,347.50	2,264.0	6,398.50	5,565.00	15,575.00	2,485.0	5.1
1980	0.07	5,471.2	140.00	1,672.00	4,226.5	6,921.50	7,420.00	20,240.00	2,978.1	10.0
1981	0.07	5,699.1	177.00	2,034.50	5,170.5	10,916.00	9,381.00	27,502.00	2,789.5	15.9
1982	0.06	6,531.0	234.00	2,612.50	4,957.0	12,286.50	12,402.00	32,258.00	1,368.9	2,147.1
1983	0.07	10,075.5	292.50	2,850.00	6,733.0	14,992.50	15,502.50	40,078.00	3,318.2	3,362.6

TABLE C.I (CONT)

obs	RIC	RIM	MC	XC	CCF	RVC1	RVC2	RVC3	RVC4
1960	6.0	10.5	700	23,600	28,000	1,108	1,285	246.5	642.5
1961	6.5	11.6	300	17,200	66,600	423	1,285	95.0	524.5
1962	7.0	11.1	600	26,400	60,500	158	1,899	18.1	560.4
1963	9.0	13.2	1,700	17,800	56,500	813	155	50.4	791.2
1964	9.0	12.3	3,000	12,500	46,500	1,215	31	209.5	260.0
1965	9.0	15.7	8,900	16,200	64,900	1,068	2,142	295.5	66.9
1966	9.0	19.2	6,500	4,700	91,100	1,492	2,018	537.9	382.9
1967	9.0	18.6	500	30,500	61,000	1,885	1,692	453.3	823.8
1968	9.0	16.5	900	47,100	70,100	941	2,601	92.2	694.9
1969	9.0	12.7	900	59,100	57,300	491	1,557	116.2	1,077.7
1970	11.0	12.5	1,500	71,300	64,400	2,227	648	63.3	638.6
1971	11.0	15.2	900	50,600	68,500	1,972	3,344	40.5	265.5
1972	13.0	17.3	1,000	69,600	72,300	1,612	6,207	367.8	1,515.7
1973	13.5	18.9	6,600	46,200	84,500	6,744	7,159	491.8	2,536.5
1974	14.5	25.4	900	34,100	102,900	10,585	19,726	1,849.2	2,942.1
1975	15.5	25.2	800	79,800	68,800	11,999	15,430	1,885.2	8,469.0
1976	15.5	28.2	1,000	53,400	91,500	6,782	15,450	715.7	6,306.2
1977	17.5	26.7	700	71,300	77,100	17,803	28,516	3,696.9	6,314.2
1978	18.0	28.8	400	45,500	84,000	27,744	13,066	4,558.7	11,655.1
1979	18.5	33.3	7,500	26,200	70,500	9,941	10,051	1,575.7	5,348.5
1980	21.0	34.6	4,300	48,500	70,300	18,459	18,459	2,088.2	11,806.0
1981	21.0	37.4	600	56,200	72,300	35,739	36,906	5,171.3	149,643.0
1982	21.0	38.0	200	17,600	39,400	33,380	31,140	3,811.5	4,330.6
1983	21.0	33.4	700	14,300	38,200	29,995	26,754	4,962.1	7,689.1

TABLE C.I (CONT)

obs	QS	HHS	PS	PSS	IDES	RVS	QG	HHG	PG	PSG
1960	19,000	10,200	800	0	0	100.6	6,300	2,800	369	0
1961	20,000	13,500	856	0	0	108.0	7,000	3,100	490	0
1962	22,000	16,400	900	0	0	107.1	7,600	3,300	410	0
1963	30,000	18,500	1,200	0	0	40.9	12,100	5,400	619	0
1964	40,000	24,800	1,300	0	0	152.8	60,000	24,000	750	0
1965	50,000	29,700	1,580	0	0	169.0	70,000	30,000	815	0
1966	52,000	35,000	1,900	0	0	160.8	60,000	30,000	1,083	0
1967	80,000	48,000	1,930	0	0	245.1	90,000	40,000	1,120	0
1968	101,000	50,500	2,167	0	0	158.3	110,000	40,300	1,363	0
1969	120,000	58,000	2,397	0	0	119.4	100,000	44,500	1,243	0
1970	131,900	66,500	2,945	2,000	0	190.6	118,000	53,600	1,336	1,170
1971	100,700	55,100	3,050	2,600	0	326.3	239,600	92,100	1,379	1,200
1972	104,600	54,000	3,202	2,600	0	286.3	210,000	84,000	2,050	1260
1973	97,200	54,000	4,346	2,871	0	105.5	280,200	135,400	2,781	1,864
1974	114,000	57,000	6,067	5,982	0	578.4	336,600	152,200	3,175	2,623
1975	168,900	87,800	6,936	7,000	8,445	1,177.5	33,500	134,000	3,599	3,600
1976	75,100	37,600	8,052	7,807	0	1,076.2	427,700	173,600	4,100	3,700
1977	102,900	56,700	12,106	9,240	0	812.4	406,200	189,500	5,743	4,529
1978	131,100	74,000	12,639	12,020	0	2,221.3	516,700	224,800	5,981	5,700
1979	145,600	71,300	15,100	13,045	0	2,047.4	501,300	221,100	8,574	6,322
1980	154,400	78,100	18,500	15,170	0	1,308.2	430,400	206,000	10,745	9,129
1981	89,000	43,900	23,067	22,284	2,225	2,402.6	532,000	231,300	12,933	12,171
1982	98,800	49,200	29,687	28,789	1,086	3,621.0	567,900	291,100	16,813	15,910
1983	122,400	59,500	36,515	34,057	0	4,592.6	595,200	270,400	20,797	28,531

TABLE C.I (CONT.)

obs	IDEG	RVG	QR	HHR	PR	PSR	IDER	CDR	XSR	RSR
1960	0	24.0	450,000	227,000	883	0	0	1.0	767.0	0.3
1961	0	29.2	474,000	237,000	954	0	0	1.8	767.7	0.5
1962	0	61.7	585,000	280,000	919	0	0	1.8	834.6	0.6
1963	0	50.2	565,000	260,000	1,046	0	0	2.2	46.8	0.4
1964	0	86.1	600,000	302,000	1,347	0	0	2.3	31.2	0.9
1965	0	140.0	672,000	365,000	1,703	0	0	7.6	0.0	1.1
1966	0	81.5	680,000	350,000	1,884	0	0	12.7	0.0	1.2
1967	0	144.1	662,000	300,000	1,914	0	0	24.7	26.0	2.0
1968	0	135.8	766,000	277,000	2,106	0	0	25.8	15,809.5	2.4
1969	0	124.1	689,000	250,000	1,867	0	0	12.3	4,361.9	6.0
1970	2,360	99.2	752,600	233,200	1,850	2,250	65,466	4.5	294.5	7.1
1971	9,823	51.4	904,300	253,500	1,931	2,250	140,166	23.5	3,334.3	8.6
1972	1,260	56.4	1,043,423	273,800	1,882	2,250	139,818	25.4	25,345.8	8.0
1973	10,927	327.1	1,175,900	29,100	2,514	2,408	43,508	43.6	2682.9	9.0
1974	7,405	572.9	1,569,901	368,500	3,694	4,227	164,839	157.9	142,459.7	8.6
1975	22,110	466.0	1,622,201	381,400	3,913	4,163	129,776	178.8	1,177.4	11.2
1976	25,243	334.0	1,480,701	355,600	4,106	4,650	79,957	223.5	1,599.5	17.2
1977	21,122	381.4	1,307,000	324,400	6,723	5,332	10,456	183.3	4.7	13.4
1978	12,558	914.6	1,714,400	406,200	7,072	7,013	77,161	350.6	587.0	18.5
1979	21,054	832.5	1,932,500	442,000	8,253	8,436	154,600	609.4	822.9	17.5
1980	14,203	1,282.1	1,797,899	415,800	10,517	12,001	293,057	672.8	429.1	23.1
1981	26,600	1,947.4	1,788,000	420,700	14,110	14,505	37,548	1,186.2	501.8	43.2
1982	77,234	1,779.5	2,018,201	445,900	18,343	18,077	373,367	1,879.7	177.5	64.9
1983	44,044	2,509.1	1,779,831	396,460	21,421	21,810	179,762	1,617.5	6,900.0	68.0

TABLE C.I (CONT)

obs	GDP	CPI	IPNAS	PESO	NER	EER	YNC	POP
1960	14.7	15.3	14.4	1.17	6.6	7.69	26,746	15,417
1961	15.9	16.6	15.7	1.19	6.59	7.83	39,421	15,910
1962	17.0	17.1	17.0	1.19	6.58	7.85	34,199	16,418
1963	20.9	22.5	20.9	1.23	8.97	11.07	43,526	16,943
1964	24.8	26.5	23.5	1.36	9.0	12.22	53,760	17,485
1965	26.6	27.4	26.0	1.20	9.81	11.81	60,798	17,966
1966	30.6	42.8	30.0	1.36	12.92	17.55	73,612	18,461
1967	33.1	35.5	32.7	1.17	14.09	16.43	83,083	18,970
1968	36.2	37.6	35.9	1.22	16.03	19.50	96,422	19,492
1969	39.2	41.4	38.7	1.22	17.22	21.01	110,953	20,029
1970	43.2	44.2	42.8	1.30	18.35	23.81	132,768	20,581
1971	47.8	47.9	47.8	1.36	20.00	27.26	115,866	21,148
1972	54.0	54.3	53.6	1.20	22.01	26.44	189,614	21,731
1973	64.9	65.5	62.8	1.19	23.81	28.41	243,160	22,500
1974	81.4	81.4	80.3	1.22	27.10	33.08	322,384	22,945
1975	100.0	100.0	100.0	1.08	31.20	33.57	405,108	23,577
1976	125.5	120.4	122.0	1.21	34.97	42.47	532,270	24,226
1977	162.0	160.2	150.5	1.34	36.92	49.5	716,029	24,894
1978	189.7	188.7	183.3	1.32	39.25	51.87	909,487	25,580
1979	235.4	235.2	233.8	1.28	41.5	53.24	1,188,817	26,284
1980	300.3	297.6	299.7	1.32	45.05	59.26	1,579,130	27,009
1981	368.7	379.0	377.3	1.40	51.19	71.86	1,982,773	27,753
1982	460.0	472.6	469.9	1.49	59.89	89.26	2,497,298	28,363
1983	559.6	566.1	565.0	1.44	73.35	105.47	3,054,137	28,987

VITA

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