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FORECASTING FOREIGN COTTON PRODUCTION: THE CASE OF INDIA, PAKISTAN AND AUSTRALIA

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Abstract

The objective of this study is to identify, analyze and measure the causes of cotton production variations in India, Pakistan and Australia. Cotton yield and acreage models are estimated for each country using 30 to 40 years of data. Updated estimates of the degree of responsiveness of cotton yield and planted areas to changes in economic and climatic factors, and of the current yield and acreage trends in these three countries are provided.

Introduction

Accounting for about 40% of total fiber production, cotton is the single most important fiber in the world. Although many countries produce, consume, and trade of raw cotton, a high percentage of these activities is concentrated in a few countries. The world cotton industry has experienced severe economic stress in recent years, and many changes have occurred in world cotton markets. This problematic situation confronted by the cotton sector has led to a greater need for understanding the production and marketing structures of countries other than the United States.

Since the production, consumption and trade of cotton is concentrated in a few countries, studies of the foreign cotton markets need to focus on those countries. This study analyzes the cotton-producing sectors of Australia, India and Pakistan. These three countries are key players in the world cotton market. India is the largest producing country in the world after China and the United States, and the second consuming country after China. Although India has not recently imported or exported large quantities of raw cotton, it is anticipated that this country will become a net importer in the near future (FAO, 1999a). Pakistan is the third largest consuming country, and the fourth largest cotton producing country in the world, and it is likely that it will become an importer in the future, as well (FAO, 1999b). Australia is the seventh largest producing country, but it is the third largest exporter. Current information about cotton production response in these countries is limited. Therefore, the general objective of this study is to identify, analyze and quantify the major causes of cotton production variation in India, Pakistan and Australia.

India's Cotton-Producing Sector

With over 5000 years of history, India's cotton production sector is a major and diverse producer. In 1994-1995, with 7.9 million hectares planted, India accounted for 25% of the total world cultivated area and 13% of cotton lint world production. India is also one of the few countries that can grow a wide spectrum of cotton varieties with different staple lengths from short to extra long staples (World Bank, 1997).

Cotton production in India is concentrated over three zones: the Northern Zone comprising the states of Punjab, Haryana and Rajasthan; the Central Zone comprising Maharashtra, Madhya Pradesh and Gujarat; and the Southern Zone comprising Andhra Pradesh, Karnataka and Tamil Nadu. These three regions account for around 99% of the cotton produced in the country. Besides these major regions, cotton is also grown in the states of Assam, Bihar, Kerala, Meghalaya, Orissa, Uttar Pradesh, Tripura and West Bengal (World Bank, 1997).

Cotton domestic prices in India have been managed to promote the textile industry. With this purpose, India sets yearly quotas for cotton lint exports, depending on the local supply and demand situation. Moreover, lint exports were a monopoly of the government and cooperative agencies until the 1995/96 season when they were opened to private trade. It has been estimated that Indian prices for extra long staple and short staple cotton lint were 40% and 15%, respectively, below the world price level between the period from 1980 to 1995 Long Staple (World Bank, 1997). The Government of India has announced the removal of all quota restrictions on exports of raw cotton for the upcoming marketing year 2001/02 (Beeghly, 2001). To compensate growers for low lint prices, production-stimulating oilseed polices during the 80s and 90s kept cottonseed prices above world levels. However, the effect of this stimulus varied across regions. Regions producing short and medium staples obtained more benefits than regions producing long staples (World Bank, 1997).

The Government of India has currently a minimum cotton support price (MSP) policy. This MSP policy dates back to the Second World War when the British Government prescribed statutory floor and ceiling prices for cotton lint. In 1967, ceiling prices were removed but the floor prices were retained to protect farmers from downward price movements. In 1972-1973, the support price for cotton lint was change to a support price for seed cotton (*kapas*), since the majority of Indian farmers sell their product in this form. The MSP for each variety of cotton is set every year by the Commission for Agricultural Costs and Prices, and the Cotton Corporation of India, another government organization, is responsible for providing support in all states, except for Maharashtra (Chakraborty et al., 1999).

In the case of the State of Maharasthra, since 1972, the Maharashtra State Cooperative Marketing Federation has held exclusive rights to procure all cotton produce in the state. Under this scheme, cotton growers earned average prices during the 1989/90 to 1994/95 seasons 50-70 % above the Government of India MSP. In contrast, free market prices exceeded the MSP by 30-50% (World Bank, 1997).

Government intervention in the cotton production sector has also included subsidized distribution of inputs and extension support, especially under the Incentive Cotton Development Program. This centrally sponsored initiative was created in the 70s to improved cotton productivity through the adoption of new technology (World Bank, 1997).

Pakistan's Cotton-Producing Sector

Cotton is the main cash crop in Pakistan and contributes significantly to the national economy. It is estimated that 60-65% of the national foreign exchange earnings come from exports of the cotton industry (FAO, 1999b). Pakistan is currently the world's fourth-largest producing country, with around 8% of the world total production. Cotton production in Pakistan is concentrated in two provinces, Punjab and Sind. These two provinces together account for about 99% of total production. During 1999, the Punjab and the Sind provinces produced 78% and 21% of the total country production, respectively.

The cotton area in Pakistan is irrigated. About two-thirds of the water is provided through a canal system, and tube wells, shallow wells and tanks supply the remainder. The average cotton farm size in the country is about 4.7 ha, with about one-third devoted to cotton (Eisa et al., 1994). Cotton in Pakistan is a kharif crop (monsoon season). The other main kharif crops in the country are rice, sugarcane and maize (Ali, 1990).

Cotton output in Pakistan has increased almost seven-fold, from 288000 tons in 1960 to 1.9 million tons in 1999. Cotton yields over this period have increase 2.8 times, and the cotton area has increased 2.3 times. According to Guillham et al. (1995), the increase in area has arisen from an improvement in the availability of water and mechanization while the yield increase has arisen from improved crop protection and varieties and higher use of fertilizers.

Pakistan government over the years has adopted different polices in order to regulate internal cotton prices. The main purpose of these polices has been to maintain the internal prices below the international prices to promote the textile industry. Hamid, Nabi, and Nasim (1990) identify four phases of government's intervention in the cotton sector in Pakistan from 1960 to 1988. These authors contend that previous to 1960 the role of the government in cotton trade was fairly passive. The first phase goes from 1960 to 1971. During this phase, the government intervened only through exchange distortion with the purpose of promoting industrialization of the economy. Raw cotton exports were allowed at an official exchange rate, which was less favorable to the exporter in comparison to the exchange rate for export of yarn or cloth manufactures.

The second phase started in 1972 when the exchange rate regime was eliminated and the government created the Cotton Export Corporation (CEC) in order to monopolize the raw cotton exports. This period ended in 1976 with the nationalization of the ginning industry. All of these actions left little room for private sector free trade activity. The third and fourth phase cited by Hamid, Nabi, and Nasim (1990) go from 1977 to 1988. In 1977, as a part of the process of liberalization of the economy, ginneries were again denationalized, and the private sector traders once again dominated the domestic trade. In 1987, raw cotton export by private sector was permitted.

From 1988 to 1992, the government of Pakistan set two prices, the minimum export price (MEP) and the benchmark price (BM) (Gillham et al., 1995). The MEP was set daily as the cheapest value at which cotton could be bought for the international market. The BM was only a reference price set periodically (usually once a year). The export tax was a variable percentage of the difference between the benchmark price and the MEP. In 1992, Pakistan's Economic Coordination Committee approved a major change in the cotton policy abolishing the benchmark system to calculate the export duty. Under the new system a duty was levied on MEP above 45 cents per pound, with increments of two cents for each cent above this level. Finally, in 1995 raw cotton export taxes were eliminated (U.S. Department of State, 1995).

In addition to the intervention of the government regulating internal prices, cotton production has also been influenced by input subsidies, the development and distribution of improved varieties and advances in crop protection (Eisa et al., 1994). Additionally, starting in the 1976-1977 season, a minimum support price for the cotton producers was introduced (Gillham et al., 1995).

Australia's Cotton-Producing Sector

Cotton in Australia was first grown more than 150 years ago. However, the development of the modern cotton industry commenced in the sixties and expanded rapidly since the early seventies. The development of the industry has been facilitated with the development of various projects of water storage from irrigation (FAO, 1999c).

Cotton production areas in the country are concentrated in New South Wales, which accounts for 70-75% of production and in Queensland, where the remaining 20-25% is grown. Most Australian cotton farms are owned and operated by about 1500 families which also grow other crops (many including grain), as well grazing sheep and cattle. On average, each family farm grows around 400 hectares of cotton each season (Cotton Australia, 2001; Morris and Stogdon, 1995).

Area devoted to cotton in Australia has multiplied more than 32 times since 1961. Cotton lint yields during the same period have also increased almost 800%, from 165 kg/ha in 1961 to 1,283 kg/ha in 2000, which is well above the world average cotton lint yield of 575 kg/ha.

The majority of Australia's cotton production is from irrigated land, but some is produced without irrigation. During the 1999 season, around 25% of cotton land (accounting for 15% of production) was not irrigated, but this area varies somewhat year to year (FAO, 1999c). However, since the majority of cotton is grown in areas where rainfall contributes half the crop's water requirement, in general, yields are affected by adverse weather conditions (Cotton Australia, 2001).

Although accounting for less than 4% of world cotton production, Australia is a significant global exporter. During the last three years, Australia has held around 10% of the global exports. The majority of Australia's exports of cotton are shipped to Asian processing countries such as Indonesia, China, Japan, South Korea and Thailand (FAO, 1999c). Water availability is said to be the main constraint for the further expansion of Australian's cotton production sector. With few sources of irrigation water likely to become available in the medium term, production growth is predicted to be low (FAO, 1999c; Morris and Stogdon, 1995).

Australian cotton market is open to the world market forces. The cotton growing sector is not subject to government regulation. The government only provides general assistance through the development of irrigation projects and by providing market information and technical research support (Townsend and Guitchounts, 1994; Morris and Stogdon, 1995).

Methods and Procedures

Conceptually, this study assumes that producers follow a two-step decision-making process. In the first step, they decide which crops to plant and the amount of land to be allocated to each crop. Later, they refine their decisions about the levels of inputs to use in each crop. Given the uncertainty about the production and marketing conditions prevailing at the time of the land-allocation decision, a utility-maximizing framework was considered more suitable to analyze this decision. Under this framework, a cotton producer's decisions are supposed to be affected by the expected returns and by the variability of the returns from cotton production and from the production of competing crops, and even by other characteristics of the producer's subjective probability distributions of cotton and competing crop returns.

The yield response is analyzed assuming profit-maximizing producer behavior. Under this assumption, cotton yields are supposed to be affected by cotton price, input prices, alternative crop prices, acreage planted, and climatic variables. A time trend was also included in the empirical models to account for any systematic changes in yields and acreage resulting from the adoption of improved technologies or from changes in the resource-base available for cotton production.

A log-linear functional form was chosen as the baseline for both, the yield and acreage models, because of the following reasons: (1) Its flexibility to accommodate different functional relationships between the dependent variable (i.e. yields and acreage) and each of the explanatory variables, and (2) It produces direct measures of the elasticities of the dependent variable with respect to changes in the explanatory variables; i.e. of the percentage changes in yields and acreage caused by a one percent change in each of the explanatory variables while holding all others factors constant. The log-linear model specification has been widely utilized in previous studies of supply response (e.g. Ali, 1990; Narayana and Parikh, 1981; Ahmad, 1985).

The empirical yield models included as explanatory variables cotton price, a price index of competing crops, fertilizer price, cotton area, rainfall, and a time trend. This model can be mathematically expressed as:

$$Y= f(Pc,Pcci,Pf,Rf,T_t), \quad (1)$$

where Y_t is cotton yields, P_c is cotton price, Pcci is the competing crops price index, Pf is fertilizer price, Rf is rainfall, Ac_t is the cotton harvested acres, and T_t is the time trend.

Regarding the acreage models, since only commodity yield and price data were available in the three countries under study, gross returns (GR= yield *x* price) were used instead of net returns. It could be argued that since producers have a good idea about their costs of production at the moment of making the acreage allocation decision, these can be considered as fixed from the producers' perspective, in other words, that crop yields and prices are the main sources of uncertainty affecting acreage response under the utility maximizing framework.

Conceptually, the acreage model should be based on planted acres. However, the governments of Australia, India, and Pakistan only report data on harvested acres. Most of the previous studies of supply response these countries have ignored this issue. Since harvested acreage is a function of planted acreage, the same variables believed to affect planted acreage will influence harvested acreage, plus other factors, especially weather conditions. Therefore, rainfall was also included as an explanatory variable in the empirical (harvested) acreage models.

For the purpose of parsimony, an index of gross returns from competing crops was used instead of the gross returns from each competing crop separately. This index was constructed as a weighted average of the gross returns from the competing crops identified in each of the countries. The weights were the proportion of area allocated to each crop in relation to the total area planted with competing crops. The final empirical specification for the acreage models is:

$$Ac= Ac(ERc, ERcc, VRc, VRcc, Rf, T), \quad (2)$$

where Ac is cotton harvested acreage, ERc and ERcc represent the expected returns from the production of cotton and competing crops, respectively, VRc and VRcc are measures of the variability of the returns from the production of cotton and competing crops, respectively, Rf is rainfall, and T is a time trend. ERc and ERcc, and VRc and VRcc, were computed using the mean and the variance of the gross returns observed during the three most recent years.

Harvested area, yield and production data were obtained from the database of the Statistics Division of the FAO, the "India Agriculture and Climate Data Set" of the World Bank and the Australian Bureau of Agricultural and Resource Economics (ABARE, 2000). Australian and Pakistani monthly rainfall data were obtained from the Climate Research Unit, UK (1999). Indian rainfall data were obtained from the Indian Institute of Tropical Meteorology (2000). Prices in Australia and Pakistan were deflated using the corresponding general consumer price indices (CPIs). Prices in India were deflated using the CPI for industrial workers CPI(IW). Sorghum, maize, soybeans and sunflowers were selected as the competing crops to be included in the cotton yield and acreage response models for Australia. Rice, maize, groundnuts and sugarcane were included as competing crops in the case of India. And finally, rice and sugarcane were considered as the main crops competing with cotton in Pakistan. All of the statistical analyzes were carried our using GAUSS 3.2 programs.

Results

Australia Cotton Yield Equation

$$\underset{(0.54)}{Ln(Y) = 3.39} + \underset{(0.04)}{0.10Ln(T)} - \underset{(0.09)}{0.32Ln(Pcci)} - \underset{(0.10)}{0.38Ln(Rf)} \quad (3)$$

R^2=0.69 Period: 1966-1999

An R^2 of 0.69 indicates that the model above is able to explain 69% of the variation in the cotton yields observed in Australia during the 1966 through 1999 period. Cotton yields in Australia appear to be affected by time, rainfall and competing crops prices (Figure 5.1). They have been increasing through time, but at a decreasing rate. Previous studies have not identified an effect of economic variables on cotton yields. A negative effect of rainfall was found in this study. There are several other studies reporting situations in which increased rainfall has a negative effect on yields in Australia.

India Cotton Yield Equation

$$Ln(Y) = -1.09 + 0.015T + 0.25Ln(Pc) - 0.24Ln(Pf) \quad (4)$$
$$(0.32) \quad (0.003) \quad (0.09) \quad (0.11)$$

R2=0.89 Period: 1956-1999

An R^2 of 0.89 indicates that the model above is able to explain 89% of the variation in the cotton yields observed in India during the 1956 through 1999 period. Cotton yields in India appear to be affected by time and cotton and fertilizer prices (Figure 5.2). They have been increasing at an increasing rate through time. This is important since yields in India are still below the world average. Previous studies have identified responsiveness of Indian cotton yields to planted acreage and rainfall, but not to economic variables. This study estimates the elasticity of yields with respect to cotton and fertilizer prices at 0.25% and -0.24%, respectively, suggesting that a 1% increase in cotton (fertilizer) price would cause a 0.25% increase (0.24% decrease) in yields.

Pakistan Cotton Yield Equation

$$Ln(Y) = 0.85 + 0.08Ln(T) - 0.21(Rf) \quad (5)$$
$$(0.44) \quad (0.03) \quad (0.08)$$

R^2=0.44 Period: 1962-1976

$$Ln(Y) = -1.35 + 1.53Ln(T) + 0.28Ln(Pcr) - 0.98Ln(Pf) - 0.18Ln(Rf) - 0.39D92\text{-}97 \quad (6)$$
$$(1.80) \quad (0.27) \quad (0.21) \quad (0.51) \quad (0.11) \quad (0.10)$$

R^2=0.84 Period: 1977-1997

Statistical tests indicated that two separate yield models had to be estimated for Pakistan, one for the 1962 to 1976 period and another for the 1977 to 1997 period (Figure 3). R^2's of 0.44 and 0.84 indicate that the models above are able to explain 44% and 84% of the variation in the cotton yields observed in Pakistan during the 1962 through 1976 and the 1977 through 1977 periods, respectively. During the 1962 to 1976 period yields appear to be only influenced by time and rainfall. Throughout the 1977 to 1997 period, they seem to be affected by time, the price of cotton, fertilizer price and rainfall. Rainfall showed a negative effect on yields during both periods. Yields seem to have increased at a decreasing rate during the first period, and at an increasing rate during the second. Apparently they have become more responsive to economic variables, although government intervention in the cotton sector was higher during the second period. This could be due to the adoption of technologies that have made producers more dependent on external inputs.

Australian Acreage Models

$$Ln(Ac) = 22.51 + 0.47Ln(T) - 1.71Ln(GRcci) - 0.12Ln(Std\text{-}GRc) - 0.19Ln(Rf) \quad (7)$$
$$(2.15) \quad (0.07) \quad (0.32) \quad (0.04) \quad (0.08)$$

R^2=0.90 Period: 1968-1978

$$Ln(Ac) = 6.11 + 1.85Ln(T) + 0.13\ Ln(Std\text{-}Grcci) \quad (8)$$
$$(0.41) \quad (0.10) \quad (0.06)$$

R^2=0.95 Period: 1979-1999

Statistical tests indicated that two separate acreage models had to be estimated for Australia, one for the 1968 to 1978 period and another for the 1979 to 1999 period (Figure 4). R^2's of 0.90 and 0.95 indicate that the models above are able to explain 90% and 95% of the variation in the cotton areas observed in Australia during the 1968 through 1978 and the 1979 through 1979 periods, respectively. Several water storage projects were constructed in Australia during the late 1970s and early 1980s. These might have increased the rate of acreage growth through time and altered the degree of responsiveness of acreage to changes in economic climatic variables. During the 1968 to 1978 period acreage appears to have been influenced by time, competing crop revenues, the variability of cotton revenues, and rainfall. During the 1979 to 1999 period, cotton acreage seems to be affected by time and the variability of competing crop revenues. The models suggest that areas increased at a decreasing rate during the first period and at an increasing rate during the second.

Indian Acreage Models

$$\text{Ln(Ac)} = \underset{(0.12)}{16.32} + \underset{(0.02)}{0.06}\text{Ln(T)} - \underset{(0.08)}{0.33}\text{Ln(GRcci)} \qquad (9)$$

R^2=0.48 Period: 1959-1979

$$\text{Ln(Ac)} = \underset{(0.54)}{14.95} + \underset{(0.15)}{0.20}\text{Ln(T)} + \underset{(0.08)}{0.16}\ \text{Ln(GRc)} \qquad (10)$$

R^2=0.84 Period: 1980-1999

As in the case of Australia, statistical tests indicated that two separate acreage models had to be estimated for India, one for the 1959 to 1979 period and another for the 1980 to 1999 period (Figure 5). R^2's of 0.48 and 0.84 indicate that the models above are able to explain 48% and 84% of the variation in the cotton areas observed in India during the 1959 through 1979 and the 1980 through 1999 periods, respectively. Only time and competing crop revenues appear to have affected cotton areas during the first period. Positive autocorrelation was identified in the acreage model for the second period, implying that cotton areas followed a cyclical behavior. However, only time and cotton gross revenues showed an effect on cotton acreage during this second period. Areas appear to have been increasing at a slow and decreasing rate during the last 20 years. The 1980 to 1999 model also predicts that a one percent increase in cotton gross revenues would cause a modest 0.16% increase in planted areas.

Pakistan Acreage Models

$$\text{Ln(Ac)} = \underset{(0.16)}{14.73} + \underset{(0.01)}{0.11}\text{Ln(T)} - \underset{(0.03)}{0.10}\text{Ln(Rf)} \qquad (11)$$

R^2=0.87 Period: 1965-1976

$$\text{Ln(Ac)} = \underset{(0.00)}{14.54} + \underset{(0.00)}{0.49}\text{Ln(T)} - \underset{(0.00)}{0.31}\text{Ln(Grcci)} - \underset{(0.03)}{0.02}\text{Ln(Std-Grc)} - \underset{(0.00)}{0.05}\text{Ln(Rf)} \qquad (12)$$

R^2=0.84 Period: 1977-1997

Statistical tests also indicated the need to estimate two separate acreage models for Pakistan, one for the 1965 to 1976 period and another for the 1977 to 1997 period (Figure 6). R^2's of 0.87 and 0.84 indicate that the models above are able to explain 87% and 84% of the variation in the cotton areas observed in Pakistan during the 1965 through 1976 and the 1977 through 1977 periods, respectively. Only time and rainfall appear to have influenced cotton areas throughout the first period. During the second period, time, the gross returns from competing crops, the variability of cotton gross returns, and rainfall seem to have affected cotton acreage. Rainfall showed a negative effect during both periods. Cotton areas appear to have increased at a meager rate during the first period, and at a higher but still decreasing rate throughout the second period. The 1977 to 1997 model also predicts that a one percent increase in the gross returns from competing crops would cause a moderate 0.31% decrease in planted areas.

Conclusions

Since the most recent yield and acreage response studies for India and Australia date back to the 1980s, and to the early 1990s in the case of Pakistan, an important contribution of this study is that it provides updated information and numerical estimates of how different economic and climatic factors affect of cotton production in India, Pakistan and Australia, and the about how production levels are more recently trending through time.

Previous studies dealing with cotton production response in Australia have not found economic variables affecting cotton yields. This study establishes that Australia's cotton yields are affected by changes in competing crop prices. It also concludes that, after controlling for the effect of economic and climatic variables, the rate of yield growth during the last three decades has been modest and decelerating, which could indicate that yields are near a maximum. This is not surprising since Australia currently shows some of the highest yields in the world. Any significant increase in Australia's cotton production, therefore, would likely come from expanding acreage rather than yields.

As in the case of Australia, previous empirical studies of supply response in India have not found cotton yields to be affected by economic variables. This study establishes that changes in cotton and fertilizer prices affect cotton yields in India. The time trend, included with the purpose of capturing the effect of the introduction of technological innovations, indicates that yields have been increasing at an increasing rate. This implies that the efforts made by the Indian government to increase cotton yields, especially since the mid 1980s, have succeeded. The two previous results could be used to reassess the future of the cotton sector and to evaluate alternative government policies to incentive cotton production.

In Pakistan, both cotton yields and acreage have become more responsive to changes in economic variables during the 1980s and 1990s, in comparison with the two previous decades. This result could seem surprising since government intervention in the cotton sector has increased during this period. However, the adoption of technologies from the green revolution might have made producers more dependent on external inputs and, therefore, more responsive to the changes in input and output prices. In addition this study suggests that cotton yields in Pakistan could currently be more responsive to changes on input (i.e. fertilizer) than on output (i.e. cotton) prices. This should be considered when designing policies to incentive cotton production in this country. The rates of growth of Pakistani cotton yields are also very different during the two periods analyzed. Throughout the 1960s and 1970s, yields were barely increasing, and at a decreasing rate, whereas during 1980s and 1990s they grew much rapidly, at an increasing rate. These results could be used for reappraising the future of the cotton sector in Pakistan, given that this country has been predicted to become a net importer of cotton in the near future.

This study finds that cotton acreage in Australia is affected by changes in the revenues from competing crops, but the effect of changes in the revenues from cotton production on planted acres could not be statistically established. The magnitude of the competing crops revenue effect, however, seems to have diminished during the last two decades. The accelerated increase in cotton areas during the last two decades, detected by the 1979-99 model, is likely due to the increased availability of water for irrigation, and to the adoption of technologies that improve the efficiency of water use. Although, since the mid 1990s, it has been predicted that the rate of expansion of cotton areas in Australia was likely to taper off, this study concludes that they continue to increase at an increasing rate.

A generally important contribution of this study is that it empirically demonstrates that the farmers' decisions about how much land to allocate to cotton production is not only affected by the economic returns that they expect to obtain from cotton versus those from alternative (i.e. competing) crops, but also by their perceived degree of uncertainty (i.e. variability) associated with these returns.

After controlling for the effect of economic and climatic variables, the rate of growth of cotton acreage in India and Pakistan, likely due to the adoption of improved technologies and/or an increase in the availability of irrigation water, has been decreasing in recent years. Hence, further increase in cotton production in these two countries is more likely to result from higher cotton yields, which rate of growth appears to be increasing.

As in previous studies, this finds that cotton acreage in India during the last 20 years has been affected by changes in the revenues expected from the production of cotton. In addition, this research establishes that acreage has also been affected by the uncertainty about (i.e. variability of) cotton revenues. The reasons for the cyclical behavior of India's cotton plantings during the last two decades identified in this study require further research. However, it is hypothesized that producers might have become slower to adjust planted areas in response to economic and other stimuli because of the increasing fixed costs resulting from the introduction of the technological advances of the green revolution. If this hypothesis is correct, this cyclical behavior should continue or even increase in the future if fixed-cost increasing technological innovations continue to be adopted by Indian cotton producers.

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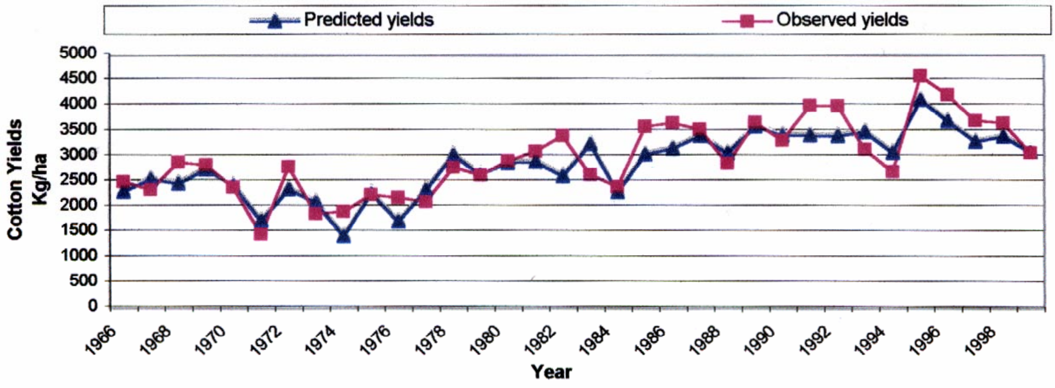

Figure 1. Observed vs. Predicted Cotton Yields in Australia (1996-1999)

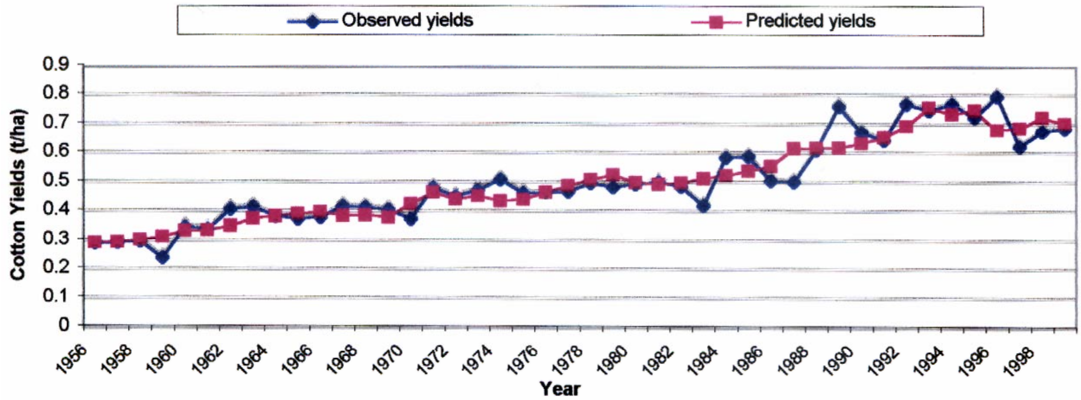

Figure 2. Observed vs. Predicted Cotton Yields in India (1956-1999)

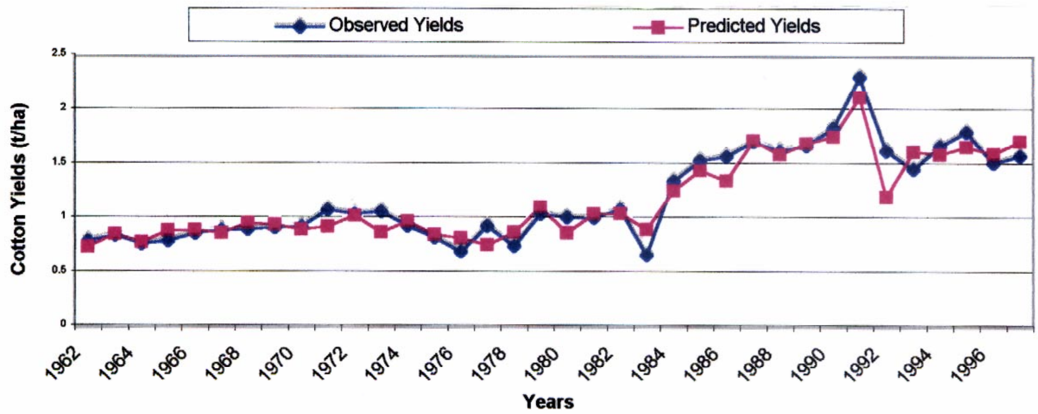

Figure 3. Observed vs. Predicted Cotton Yields in Pakistan (1962-1997)

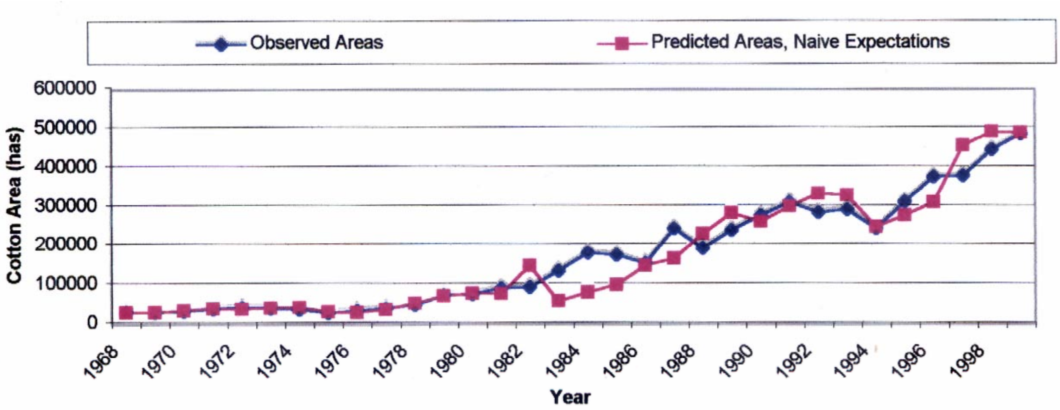

Figure 4. Observed vs. Predicted Cotton Areas in Australia (1968-1999)

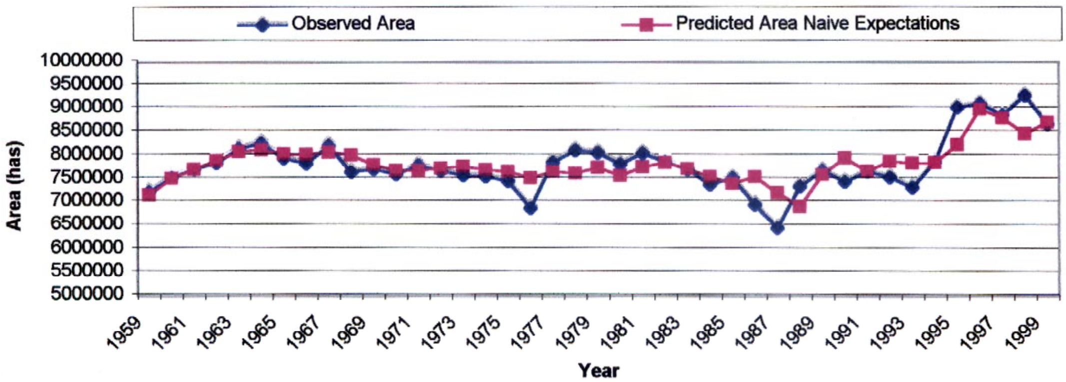

Figure 5. Observed vs. Predicted Cotton Areas in India (1959-1999)

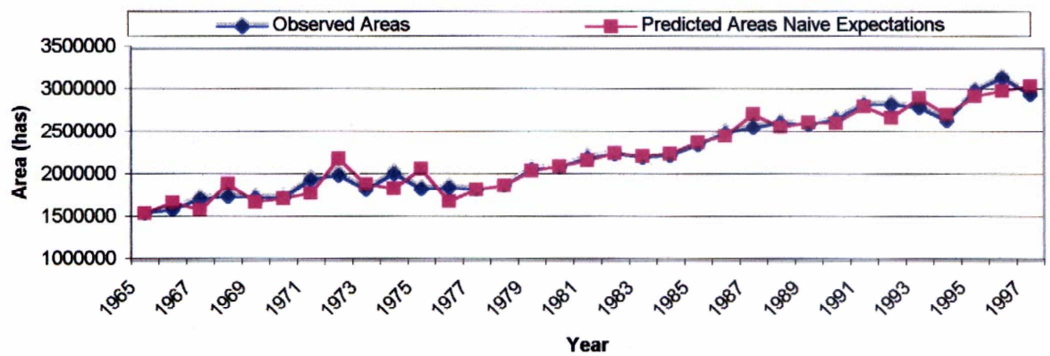

Figure 6. Observed vs. Predicted Cotton Areas in Pakistan (1965-1997)