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The Economics of Cotton Cultivation in India

Supply and Demand for 1980-90

Jon A. Hitchings

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ABSTRACT

This paper is part of continuing work on the Long Run Prospects of Indian Agriculture which places particular emphasis on supply and demand projections for principal agricultural commodities. The first articles in this series, covering foodgrains, vegetable oils, and sugar, appeared as World Bank Staff Working Paper 500 (October, 1981). The present paper extends the coverage to cotton which ranks third in area and fourth in value of output. Cotton is also the predominant input in the textile industry which is the largest industrial employer. The paper analyzes the contribution of irrigation to the production growth rate, and the returns to cotton cultivation through time, in a variety of areas and utilizing a number of production technologies. The potential for increasing profitability through improved varieties and cultivation practices is addressed. The effects of trade policy on output prices is discussed using nominal protection coefficients. The paper concludes by building a simultaneous supply/demand model for cotton and textiles which incorporates trade in textiles and cotton lint and the behavior of textile mills. The model is used for five and ten year projections given a range of policy alternatives.

EXTRACTO

Este documento forma parte del trabajo continuo sobre las perspectivas a largo plazo de la agricultura de la India, en el que se concede especial importancia a las proyecciones de la oferta y la demanda de los principales productos básicos agrícolas. Los primeros artículos de esta serie, que versaron sobre los cereales alimentarios, los aceites vegetales y el azúcar, aparecieron como el No. 500 (octubre de 1981) de la Serie de Documentos de Trabajo del Personal del Banco Mundial. Con el presente documento se amplía el alcance de esa colección para incluir el algodón, cultivo que ocupa el tercer lugar en términos de superficie y el cuarto en valor de la producción. El algodón es además el insumo predominante en la industria textil, que a su vez es el empleador industrial más importante. En el documento se analizan la contribución del riego a la tasa de crecimiento de la producción y a los rendimientos del cultivo del algodón a través del tiempo en una variedad de zonas y mediante el uso de diversas tecnologías de producción. Se examina también la posibilidad de aumentar la rentabilidad mediante el uso de variedades y prácticas de cultivo mejoradas. Asimismo, se exponen los efectos de la política comercial sobre los precios de los productos utilizando coeficientes nominales de protección. El documento finaliza con la elaboración de un modelo simultáneo de oferta y demanda para el algodón y los productos de la industria textil en que se incorpora el comercio de textiles y borra de algodón y el comportamiento de las fábricas de tejidos. El modelo se usa para proyecciones de cinco y diez años con una variedad dada de opciones de política.

Cette étude s'inscrit dans le cadre de travaux continus sur les perspectives à long terme de l'agriculture indienne, qui accordent une attention particulière aux projections de l'offre et de la demande des principaux produits agricoles. Les premiers articles de cette série, qui portaient sur les céréales alimentaires, les huiles végétales et le sucre, ont été publiés comme Document de travail No 500 des services de la Banque mondiale (octobre 1981). La présente étude porte sur le coton, qui vient au troisième rang pour la superficie cultivée et au quatrième pour la valeur de sa production. Le coton est également l'élément prédominant de l'industrie textile, qui est elle-même le plus gros employeur du secteur industriel. L'auteur analyse l'influence de l'irrigation sur le taux de croissance de la production cotonnière, et la rentabilité de la culture du coton au cours de ces dernières années, dans diverses régions et en fonction d'un certain nombre de techniques de production. Il examine les possibilités d'accroître la rentabilité en utilisant des meilleures variétés et meilleures méthodes de culture. Il étudie les effets de la politique commerciale sur les prix de la production en utilisant des coefficients de protection théorique. L'étude se termine par l'établissement d'un modèle simultané de l'offre et de la demande pour le coton et les textiles, qui tient compte du commerce des textiles et du coton-fibre ainsi que du comportement des usines textiles. Ce modèle est utilisé pour établir, à partir d'un éventail d'options, des projections sur cinq et dix ans.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION I

OVERVIEW AND CONCLUSIONS

Introduction. No crop in India can compete with cotton's potential for value-added in processing. Raw cotton is ginned, the seeds are crushed for oil, the oil is refined for consumption, the lint is pressed into bales, and the bales are spun into various yarns, which are dyed and woven (sometimes with viscose and synthetic fibers) into cloth and fabrics. These in turn are made into countless types of finished goods. Cotton is the overwhelmingly dominant raw material of the textile industry, which is the largest employer in the industrial sector. 1/ Part of the complexity of studying cotton derives from the fact that it is traded and marketed at all stages of processing. The importance of cotton as a raw industrial input, and its tradability in multiple forms, create involved, highly visible, and strongly-debated policy issues affecting the welfare of producers, processors, their employees, and final consumers.

The agronomy of cotton is also complex. The value of a crop, for example, is a function of the oil content of the seeds, the ginning percentage, the spinning counts of the lint, and the length and strength of the fibers. Numerous varieties are grown under rainfed and irrigated conditions occupying altogether about 5% of the total cultivated area in India, and distributed over nine principal states. India's cotton area is by far the largest in the world, while its production ranks fourth, and its yields are the lowest 2/ at 162 kg lint per hectare. 3/ Although India has achieved approximate self-sufficiency in cotton lint and remains a significant net textile exporter, over the last 20 years the per capita consumption of cotton cloth has been steadily declining, the consumption of all cloth has stagnated in per capita terms, and there has been virtually no trend in cultivated area.

This paper is oriented to issues of cotton production. It examines the sources of trends in production; the profitability of cultivation broken down by varieties, states, years, and growing conditions; the agronomic constraints to profitability and research efforts to surmount them. But the paper has a second focus on the supply and demand balance, export potential, and the price implications of trade policy. In this arena, a simultaneous model is constructed of production, mill consumption of lint, and private consumption of textiles, which incorporates

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1/ Over 80% of the cloth in India is cotton, including the cotton component of blended fibers.

2/ Excluding Uganda.

3/ 1979/80 crop year. The statement holds for other years as well.

trade balances of lint and textiles. The model is used to project sets of scenarios over the next decade. The study also draws on many of the World Bank appraisal reports of cotton or cotton-related projects in India to examine the output/input ratios and economic prices that have underpinned loans for cotton development.

Organization. The paper begins with a brief background section which describes characteristics of leading varieties, physical determinants of price, processing parameters, seed crushing and oil extraction rates, and the like. The role of irrigation in production is addressed in the next section, primarily by regressing yield growth rates in cotton-growing states against changes in irrigated proportions. The aggregate yield growth rate can thereby be decomposed into an irrigation component within states, and irrigation-independent component, and shifts in area between states affecting the composition of the total cotton area. The section presents summary data on production and changes in cotton's share of irrigated and rainfed cultivated area by state.

The returns from cotton cultivation are compared through time and between states in Section IV. Trends in domestic and world cotton prices are discussed in this context. The agronomic scope for increasing profitability is examined at length with particular attention to the development and distribution of improved varieties, cultivation practices, and pest management in Section V.

Section VI derives careful estimates of import parity prices at farmgate for several years and two cotton varieties. These economic prices are compared with prices actually received to measure the extent of protection or taxation farmers undergo through trade policies and economic distortions. The ratios (of prices received by farmers divided by economic prices) are matched against appraisal estimates to examine the discrepancy between financial and economic returns.

Section VII estimates the elasticities of a simultaneous supply/demand model of cotton lint and textiles. The model is used to project a number of scenarios for production, consumption of lint and textiles, trade balances, and prices over the next decade. A selection of cases is used for comparison with other forecasts. The paper closes with a discussion of the production outlook and a summary of salient points that were raised. The appendices provide projections for the intermediate period 1985/86, the reduced form of the model, and the time-series data that were utilized.

Conclusions. India is unlikely to become a significant net exporter of cotton lint during the next decade. A positive export balance was achieved in 1977 due to increases in production and a trend of declining consumption per capita. Gains in production may be attributed almost wholly to rising yields which in turn have depended on higher proportions of cotton area being placed under irrigation. There has been no significant total area trend over the last twenty years, and the cotton area planted under rainfed conditions has contracted. About three-quarters of the 2.0 percent growth rate for yields is related to expanded irrigation, particularly in Punjab, Gujarat, Rajasthan, Karnataka, Tamil Nadu and Andhra Pradesh. However, cotton's share of the total irrigated area for all crops has remained constant at around 3.5 percent. It appears that increased production will require further investment in irrigation.

Genetic improvements have not resulted in varieties which are causing cotton to significantly displace other crops on rainfed or irrigated land. Factors affecting the profitability of cotton are perhaps more numerous and complex than those affecting grains. Some important breakthroughs have yet to be made. Research continues with the objectives of raising the value of the output, through elevating ginning percentages, seed oil content, and staple length; boosting yields; and minimizing production costs, particularly expenditures for pest management. The potential of genetic improvements and altered cultivation practices are less fully realized for cotton than for grains. Existing improved and hybrid varieties tend to have much higher production costs (sometimes double), higher net returns, and a lower ratio of value of output to value of inputs. The higher production costs of specialized varieties make them appropriate for farmers who are financially able to assume greater risks, or for intensive cultivation on smaller plots.

The per capita consumption of cotton textiles has declined from about 14.5 square meters in 1960 to 12.25 presently, despite a drop in real prices. The expenditure elasticity for textiles, estimated from cross-sectional data, indicates a strong willingness to spend incremental income on clothing and textiles. This does not translate proportionately into greater physical consumption (e.g., kilos per capita) due to quality substitution. Reversing the trend and raising per capita consumption of cotton textiles one square meter by 1990 (including the cotton component of blended fabrics) would require net lint imports amounting to a quarter million tons by that year, or large reductions in textile exports, or a rapid drop in real foodgrain prices which would stimulate cotton production. This scenario assumes that the present pace of extending irrigation to new territory is maintained. The proportion of irrigated to total cotton area would then reach 46 percent by the end of the decade starting from 28 percent presently.

Over the next ten years, a ten percent increase in cotton textile exports and moderate cotton lint exports reaching 135 thousand tons (eight percent of production) would be consistent with stabilized per capita cotton consumption, expanded irrigation at the current rate, and declining real foodgrain prices. Foodgrain prices are a critical parameter owing to the large cross-price elasticity for cotton production. Projecting from the most probable set of assumptions, India would remain in balance with respect to trade in cotton lint, i.e., net imports or exports would be marginal, while cotton textile exports would continue at around 1.1 billion square meters. Under this scenario, most increases in production will be required to keep up with population growth with per capita consumption assumed to remain at around present levels.

Although trade in lint is expected to be in equilibrium, nominal protection coefficients indicate that cotton farmers are not receiving prices as high as would prevail under free trade policies. The lower profitability that results probably has reduced production. Producer interest in exporting cotton centers around the longer staple lengths which are less suited to domestic mills or the average domestic consumer. Lifting quantitative export restrictions and modifying or eliminating the regressive export tariff would probably stimulate production through higher farmgate prices. These measures might also alter the mix of staple lengths being produced so that mills would increase imports of medium length cotton.

The production of blended fabrics has risen dramatically since the mid-1970's. These fabrics normally are eighty percent cotton. One-eighth of all cloth is woven entirely from man-made fiber, and another eighth is made from blends. Increased production of synthetic fibers is unlikely to erode the income of cotton farmers given the small market share of synthetics and especially if larger exports of lint are allowed. It is possible that the advantages of blended fabrics may expand the consumption of cotton and generate some new markets. Demand for pure cotton textiles has been rather weak in per capita terms. Synthetics may serve as a complementary input in blended material, rather than displacing cotton utilization. Proposals for new synthetic fiber factories should probably not be viewed with alarm by cotton farmers. Trade issues in the short and medium term are likely to be more critical to the profitability of cotton cultivation.

SECTION II

TECHNICAL BACKGROUND ON COTTON VARIETIES, PROCESSING AND PRODUCTS

Raw cotton, i.e. seed mixed with lint fibers (called "kapas" in India) is separated at various ginning percentages depending on the variety. A typical value is 33%-34% for varieties such as American-320F, which is a reference variety for support prices, or J-34. These varieties are grown in Punjab, Haryana, and Rajasthan and have a staple length of 23-25 mm. Digvijay, V-797, (Gujarat) and AK-235 (Maharashtra and Karnataka) are at the high end of the ginning percentage scale yielding 40%-41% lint. Their staple lengths are somewhat shorter averaging around 22-23 mm. Some hybrids have quite long fibers and acceptable ginning rates. H-4 and varalaximi produce fibers above 29.5 mm, which place them in the long to extra long staple category, and have ginning rates of 34%-35%. In general, there is an inverse relationship between staple length and ginning percentage, both of which increase returns to farmers through higher prices, and higher lint yields. There is a direct relationship between either staple length or ginning percentage and price -- a 3% higher ginning rate or a 1 mm longer fiber boosts the price of raw cotton 5%-10%.

About 13%-15% of the fiber is lost in processing: 7%-8% of the fiber weight is waste material, 2%-3% is lost in carding, and 4% is lost in spinning. Therefore, the proportion of dry raw (seed) cotton weight that becomes yarn is in the range of 28%-35%. 1/

Over 85% of the seed weight becomes oilseed cake when the seeds of most varieties are crushed. For H-4, as an example, the oil extraction rate is 15% to 16-1/2%. The national average cottonseed oil extraction rate in the mid-1970s has been between 13.5% and 14.7%. The crushing rate has ranged from 40%-70% between 1970/71 and 1977/78 - a definite increase over the 30% level of the late 1960s. 2/ The author's estimate for the crushing percentage in 1979-80 is 73%. 3/ Around 20%-25% of the value of

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1/ 33% ginning rate for lint minus 0.33X15% for the lower bound; and 40%-0.4X13% for the maximum.

2/ Cotton In India -- A Profile, Directorate of Cotton Development, (Bombay, 1980), Table 10.

3/ See Footnote 6, Table 14.

raw cotton is in the seeds, almost exclusively because of their oil content. 1/ As a rough estimate, if a higher crushing percentage translated proportionately into higher raw cotton prices, moving from an average of 60% crushed to 100% would elevate the price by a maximum of 10%. Cottonseed oil production would then have reached 278 thousand tons per year, rather than the average of 167 thousand tons for 1975-78.

The economic value of cottonseed oil, as well as the value of the protein in the residual pressed cake, is limited by the presence of gossypol in cottonseed glands. This substance is toxic to humans and presently can be removed only through expensive extraction processes. Cottonseed oil with gossypol removed had a market value of about Rs 12/kg in Central Maharashtra (early 1981). Additional detail on some of these topics is presented in Section V.

1/ Based on kapas and seed average prices for several years and varieties in Bombay.

SECTION III

SOURCES OF PRODUCTION GROWTH

The expansion of cotton production at a growth rate of 1.8% over the last two decades can be attributed entirely to gains in yield. The estimate of the area trend is negative but not significantly different from zero (Table 1). Although the total cotton area has remained virtually unchanged, the irrigated cotton acreage has grown rapidly with an offsetting contraction of rainfed cotton. The shift in favor of irrigated cultivation is certainly a major contributor to the improvement in aggregate yields. It should be noted, however, that while the growth rate in irrigated area is lower over the last ten years than over the last twenty, the yield trend has accelerated, implying that other yield-increasing factors are present. Production in 1979/80 was 1.3 million tons of seed cotton from 8.08 million hectares, implying a yield of 162 kg/hectare.

Coefficients of variation (ratios of the standard deviation to the mean) can be used to measure variability in area, production and yield. The respective coefficients are 4%, 18%, and 17% for the period 1959 to 1979. Slightly higher variability for yield and production has been experienced in the 1970's than in the 1960's.

Reliable time-series data on yields of rainfed and irrigated cotton are not available. This makes it difficult to break the multicolinearity that exists at an aggregate level between expanded irrigation with new inputs and trends in yields within the irrigated and rainfed subsets. Recourse was therefore made to an indirect means of estimating the importance of irrigation in the overall yield trend. The adopted approach allows the aggregate growth rate in yields to be separated into three components: an irrigation-dependent trend within states, a yield trend which is independent of expanding irrigation within states, and an altered distribution of total cotton area across states. Although the approach can be used to estimate the irrigation-related and irrigation-independent sources of improved yields, it does not entirely solve the multicolinearity problem. For example, the contribution of more water versus more fertilizer or improved varieties within the irrigation-related component of improved yields cannot be identified through this analysis.

TABLE 1

CONTINUOUS GROWTH RATES FOR COTTON AREA
YIELD AND PRODUCTION

	Area			Yield	Production
	Irrigated	Rainfed	Total		
	(% per annum)				
1960/61-1979/80	4.3 **	-1.5 **	-0.2	2.0 **	1.8 **
1970/71-1979/80	2.7 *	-0.8	0.3	2.4 *	2.6 *

* Significant at 10%.
** Significant at 1%.

Notes: Data series stops in 1978/79 for irrigated and rainfed cotton area. Three years were averaged for the starting point of the 1970/71 - 1979/80 growth rates for yield and production since cotton yields in 1970/71 were very low and off trend.

Source: Cotton in India--A Profile, Directorate of Cotton Development, GOI, Bombay (January 1980), with updating for recent figures.

In this approach, yield growth rates were found for each of the leading cotton-producing states, setting those which were statistically indistinguishable from zero equal to zero. The trend in irrigated cotton area was found by dividing the difference between the ending and starting three-year average percent of cotton area under irrigation by the number of intervening years. 1/ Data on the proportion of cotton under irrigation in each state extended from 1961/62 to 1978/79. The yield growth rates were estimated for the same period. 2/

Finally, using each state as an observation, the yield growth rates were regressed against the trend in the proportion of irrigated cotton. The resulting equation was:

$$G = 1.08^{*} + 1.79^{**}IR \qquad R^2(\text{adjusted}) = 0.45$$

G = Growth rate in yield
IR = Per annum change in share of cotton under irrigation
* Significant at 10%
** Significant at 5%

Although the "sample" is small since it is limited by the number of important cotton-growing states, the coefficients were significant. An estimated yield growth rate of 1% has been realized within states, independent of increasing the share of irrigated cotton. If the irrigated proportion rises by 1% per year, an additional 1.8% (compounded) would be added to the state's yield growth rate.

The relationship is illustrated in Figure 1 with the state values identified. 3/ (They are given in tabular form in the left-hand columns of Table 2). Note that Haryana, Punjab, Maharashtra, and Madhya Pradesh

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1/ A growth rate for irrigated area would not suffice since it would miss the absolute magnitude of the expansion: the irrigated proportion would double whether the shift was from 1% to 2% or from 40% to 80% and the growth rate would therefore be the same. The expansion was uniform enough to dispense with a regression fit for the change in the irrigated proportion.

2/ The yield and irrigation trend values for Haryana began with 1966/67 data. A dummy variable was used in estimating the yield growth rate in Punjab to account for the creation of Haryana.

3/ The position of Andhra Pradesh in the graph might lead to speculation that it had an inordinate bearing on the shape of the regression. In fact, excluding the state had a minor effect on the slope.

FIGURE 1

REGRESSION OF YIELD GROWTH RATES AGAINST TREND IN IRRIGATED PROPORTION
(Each state is an observation graphed below)

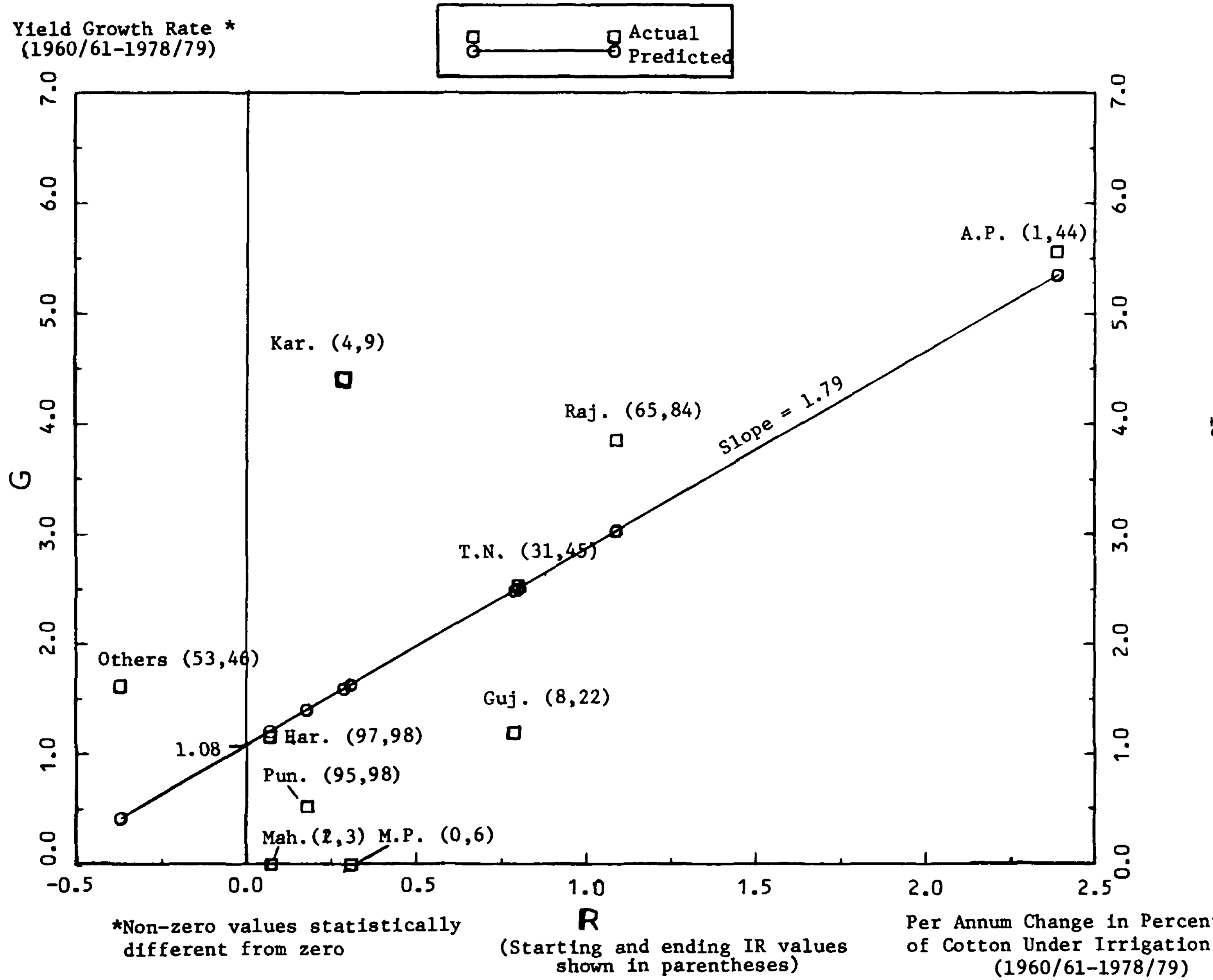


TABLE 2

Growth Rates in Cotton Yield, Irrigation, and Area by State
1960/61-1978/79

		Proportion Irrigated Cotton					
	Yield Growth Rate 1/ (%/yr)	Annual Change (%/yr)	Starting 2/ (%)	Ending 2/ (%)	Cotton Area Growth Rate 1/ (%/yr)	Trend in State Share of Total Cotton Area 1/ (%/yr)	Trend Yield in 1970/71 (kg lint/ha)
Punjab 3/	0.53	0.18	95	98	2.50 4/	0.254 4/	341.2 4/
Haryana 3/	1.16	0.07	97	98	-	-	-
Gujarat	1.19	0.79	8	22	0.0	0.087	165.0
Maharashtra	0.0	0.07	2	3	-0.8	-0.186	75.1
Karnataka	4.41	0.29	4	9	0.0	0.0	86.1
Rajasthan	3.85	1.09	65	84	2.93	0.114	167.9
Tamil Nadu	2.53	0.80	31	45	-2.41	-0.094	208.1
Andhra Pradesh	5.56	2.39	1	44	0.0	0.0	93.4
Madhya Pradesh	0.0	0.31	0	6	-1.53	-0.124	76.2
Others	1.62	-0.37	53	46	-4.45	-0.045	135.7
India	2.02	0.70	14	27	0.0	-	131.5

1/ Non-zero values statistically different from zero.

2/ The starting figure is the average for 1961/62-1963/64; the ending figure is the average for 1976/77-1978/79.

3/ Area growth rates and the trend in the share of total cotton area were not estimated separately for Haryana and Punjab since they were not separate prior to 1966. A dummy variable was used in the yield growth rate for Punjab to adust for the separation. The data on irrigated cotton begins in 1966/67 for Haryana.

4/ Haryana and Punjab combined.

Source: Cotton in India - A Profile, Directorate of Cotton Development, GOI, Bombay (January 1980), with updating for recent figures.

all had low yield growth rates although cotton is almost entirely irrigated in the first two states, but rainfed in the others. The common element appears to be that the irrigated proportion (shown in parentheses in Figure 1) had not changed. Three of the four states having rapid growth rates in yields are in southern India: Tamil Nadu, Andhra Pradesh, and Karnataka. The fourth, Rajasthan, has benefited from the development of an extensive canal system, and effective extension, funded in part through the World Bank. All of these, with the exception of Karnataka, (which is the most remote outlier) have dramatically increased the proportion of cotton under irrigation.

Although the intercept in Figure 1 shows the fitted yield growth rate that was realized within states independently of expanded irrigation, an appropriate growth rate for India requires weighting the states in the regression by their share of total production. The regression, using 1978/79 production weights and generalized least squares, had a slightly reduced slope:

$$G = 0.38 + 1.64^{*}IR \qquad R^2(\text{adjusted}) = 0.75$$

G = Growth rate in yield
IR = Per annum change in share of cotton under irrigation
* Significant at 10%

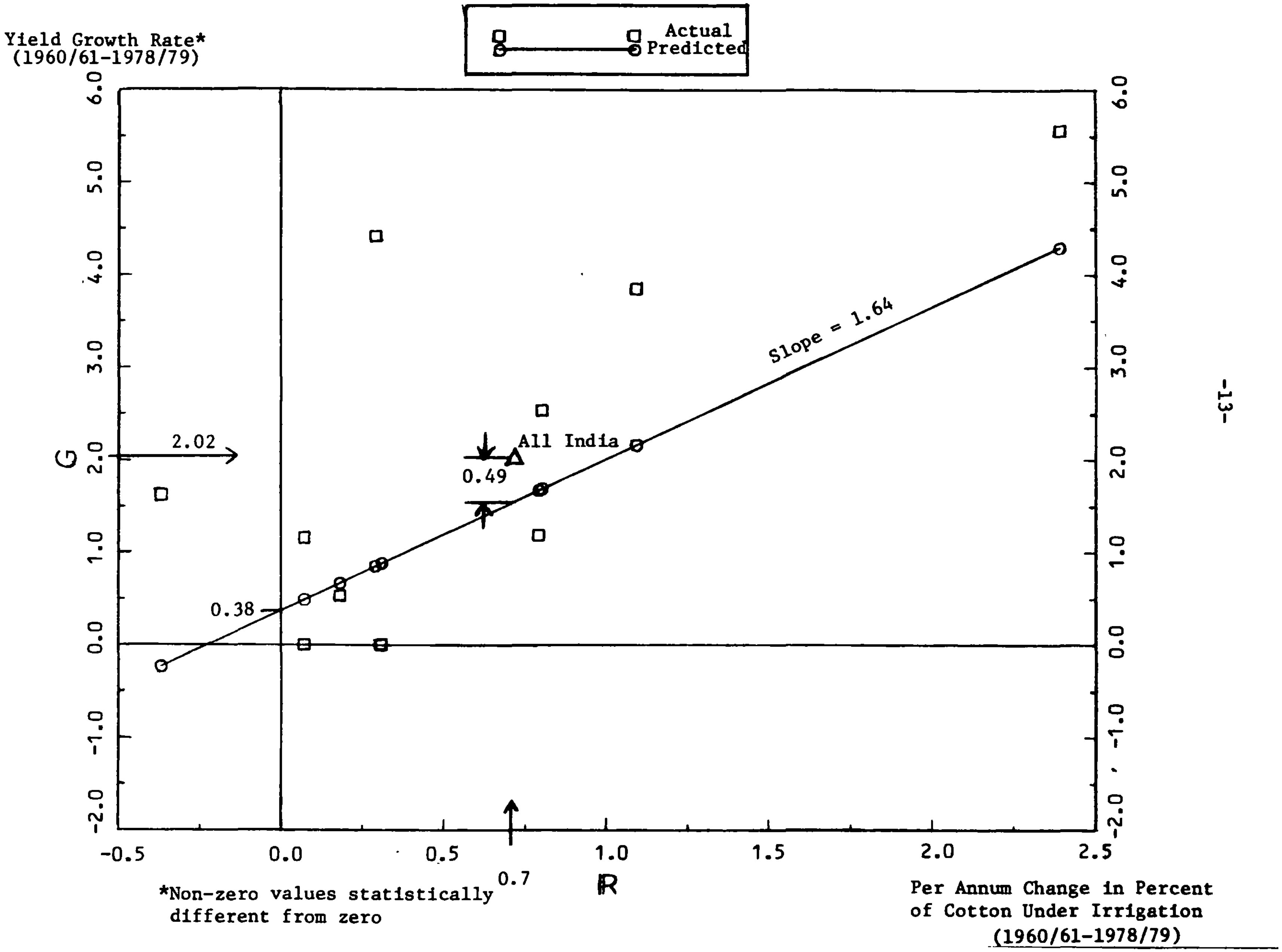
The weighted regression is shown in Figure 2. India lies somewhat above the regression line in this diagram. The discrepancy can be interpreted as the effect on the yield growth rate of shifts in area between states.

India's yield growth rate for cotton can now be decomposed into three elements: the irrigation-independent effect within states given by the intercept; the irrigation-dependent effect within states given by the slope times the rate of irrigation expansion; and the between-states shift in area given by the vertical distance of India's coordinates from the regression line. However, the shifts in area between states have also increased the total amount of irrigated cotton in India. These components are summarized in Table 3.

The components of the yield growth rate virtually equal the sources of production growth since it has already been shown that the total area trend is almost negligible, and in fact, slightly negative since 1960. Over half of the increase in production is therefore related to expanded irrigation and accompanying inputs within states. The remainder is divisible between gains in yields of rainfed and irrigated cotton, and shifts in total cotton area among states.

FIGURE 2

REGRESSION OF YIELD GROWTH RATES AGAINST TREND IN IRRIGATED PROPORTION WEIGHTED BY STATES' PRODUCTION IN 1978/79



*Non-zero values statistically different from zero

Table 3

THE COMPONENTS OF THE YIELD GROWTH RATE FOR COTTON

Source	Yield Growth Rate (%/year)	Percent of Growth Rate (%)
Irrigation-independent a/	0.38	19
Irrigation-dependent a/	1.15 b/	57
Area Shifts c/	0.49	24
TOTAL	2.02	100

Notes: a/ Within states
b/ 1.64 x 0.7%/yr. change in proportion of cotton under irrigation = 1.15%/yr.
c/ Between states. Also affected by irrigation.

The altered distribution of the total cotton area has mainly been in favor of Punjab and Haryana where cotton is almost entirely irrigated, and at the expense Maharashtra and Madhya Pradesh where cotton is overwhelmingly rainfed (Table 2). The ratio of state average yields is about three-to-one between these states. Consequently, the effect on yields of shifts in area between states is also an irrigation-related phenomenon. Therefore about 80% of the production gains for cotton over the last 20 years have depended on a growing proportion of cotton being cultivated under irrigated conditions. 1/

Given that the total cotton area has been almost constant, changes in cotton area within states can be regarded as a redistribution of the India total. Table 4 presents the distribution of area and production across states, yield by state, and cotton's share of the total irrigated and rainfed area. An independent estimate of the yield implications of this redistribution was made to check the interpretation that these shifts account for the residual portion of the national yield growth rate which is unexplained by the weighted regression. The independent

1/ Obviously this is not implying that water alone increases yields.

TABLE 4

Cotton Production, Area, Yield, and Share of Irrigated and Rainfed Area

	Production 1979/80	Area 1979/80	Yield 1/ 1979/80	Irrigated Cotton's Share of Irrigated Area 2/ 1966/67	1976/77	Increase in Irrigated Area, All Crops 3/	Rainfed Cotton's Share of Rainfed Area 4/ 1970/71	1976/77
	-------(%)-------		-kg/ha-	----------(%)----------		---(%)---------------	----------(%)----------	
Punjab and Haryana	23.4	11.8	323	11.7	10.1	52.9	(*)	(*)
Gujarat	23.2	21.3	177	18.2	16.0	28.1	13.6	18.1
Maharashtra	22.0	32.0	111	4.6	2.4	57.0	15.6	11.2
Karnataka	9.2	12.2	122	4.2	4.6	23.6	10.1	10.3
Rajasthan	6.2	4.8	211	8.4	7.9	40.3	(*)	(*)
Tamil Nadu	6.1	3.7	266	2.6	3.0	-11.0	5.0	4.0
Andhra Pradesh	5.5	5.1	175	0.2	0.6	8.7	3.5	2.0
Madhya Pradesh	3.4	8.3	67	0.5	1.2	84.2	3.5	3.3
Others	1.0	0.8	171	0.5	0.1	33.1	(*)	(*)
All India 5/	100.0	100.0	162	3.8	3.5	31.5	4.7	4.6

1/ Seed cotton ("kapas").
2/ Figures for these years were nearly the same as three-year averages. Gross cropped area basis.
3/ From 1966/67 to 1976/77.
4/ Data constraints necessitated a change in time period. (Total rainfed area changed very little in this interval.) Gross cropped area basis.
5/ Total production: 1.3 million tons seed cotton from 8.08 million hectares area (1979/80).
* Negligible amount.

Sources: Cotton in India - A Profile, Directorate of Cotton Development, Bombay, 1980.

Estimates of Area and Production of Principal Crops in India, Directorate of Economics and Statistics, Ministry of Economics and Statistics, various years.

estimate was made as follows. The trend in each state's share of the total cotton area was found by regression. Trends which were statistically insignificant were set equal to zero. The trends were multiplied by the fitted yield in each state as of 1970 (which served as weights) and summed across states. The total, divided by the fitted national yield at the mid-point of the time period, gave a yield growth rate of 0.53%/year attributable to the redistribution of cotton area between states. 1/ This estimate closely matches the residual "between states" effect on the yield growth rate found above which was 0.49%/year. 2/

Cotton has not been displacing other crops on irrigated land. The doubling from 14% irrigated cotton in the early sixties to 27% in the late seventies (Table 2) has simply accompanied the increase in total irrigated area for all crops. Cotton's share of irrigated area has remained constant at about 3.5% while the gross irrigated cropped area has increased by nearly a third (from 1966/67 to 1976/77, Table 4). 3/ In Punjab and Haryana, where much of this expansion has occurred, cotton's share of the gross irrigated cropped area has actually dropped somewhat. The proportion of rainfed cropped area devoted to cotton has been stable in each state from 1970-77, (the period for which these data were available), except for an increase Gujarat and a decrease in Maharashtra.

To summarize, the 40% increase in cotton production over the last 20 years can be ascribed to gains in yield. These gains in turn are very largely due to expanded irrigation of all crops and to a directly proportionate increase in irrigated cotton. Yields have been rising at an estimated rate of 1% per year independently of the expansion of irrigated area if measured within states. However, once the states are weighted by their share of production to arrive at a national estimate this rate drops

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1/ This result is the inner product of the two right-hand columns in Table 2 divided by the national trend yield in 1970/71.

2/ 2.02%/year national yield growth rate - 0.38%/year independent of irrigation growth within states - 1.64 (slope for irrigation-related effect within states) x 0.7%/yr increase in proportion of irrigated cotton = 0.49%/year effect between states. In other words, the slope in the regression captures the effect of expanded irrigation (in proportionate terms) within states, but it misses the influence of a state in which cotton is already totally irrigated growing in its share of national cotton area.

3/ Doubling the proportion of cotton that is irrigated while having cotton's share of all irrigated area remain unchanged does not imply the irrigated area for all crops doubles since there are changes in the rainfed cotton area.

to 0.38% per year and is no longer statistically significant. Most of the expansion of irrigated cotton has corresponded with a reduction of rainfed cotton cultivation in the same states. However, increases in cotton irrigation resulting from a redistribution of the total cotton area toward states which predominantly irrigate the crop account for a quarter of the aggregate production gains.

Trends in profitability are examined in the following section. Factors that may have contributed to the higher yield growth rate in the most recent decade, as well as profitability comparisons between rainfed and irrigated conditions are discussed in Section V. The contribution of irrigation to production is reintroduced in Section VII in the context of supply and demand projections.

SECTION IV

RETURNS FROM COTTON CULTIVATION

A. Comparisons Through Time

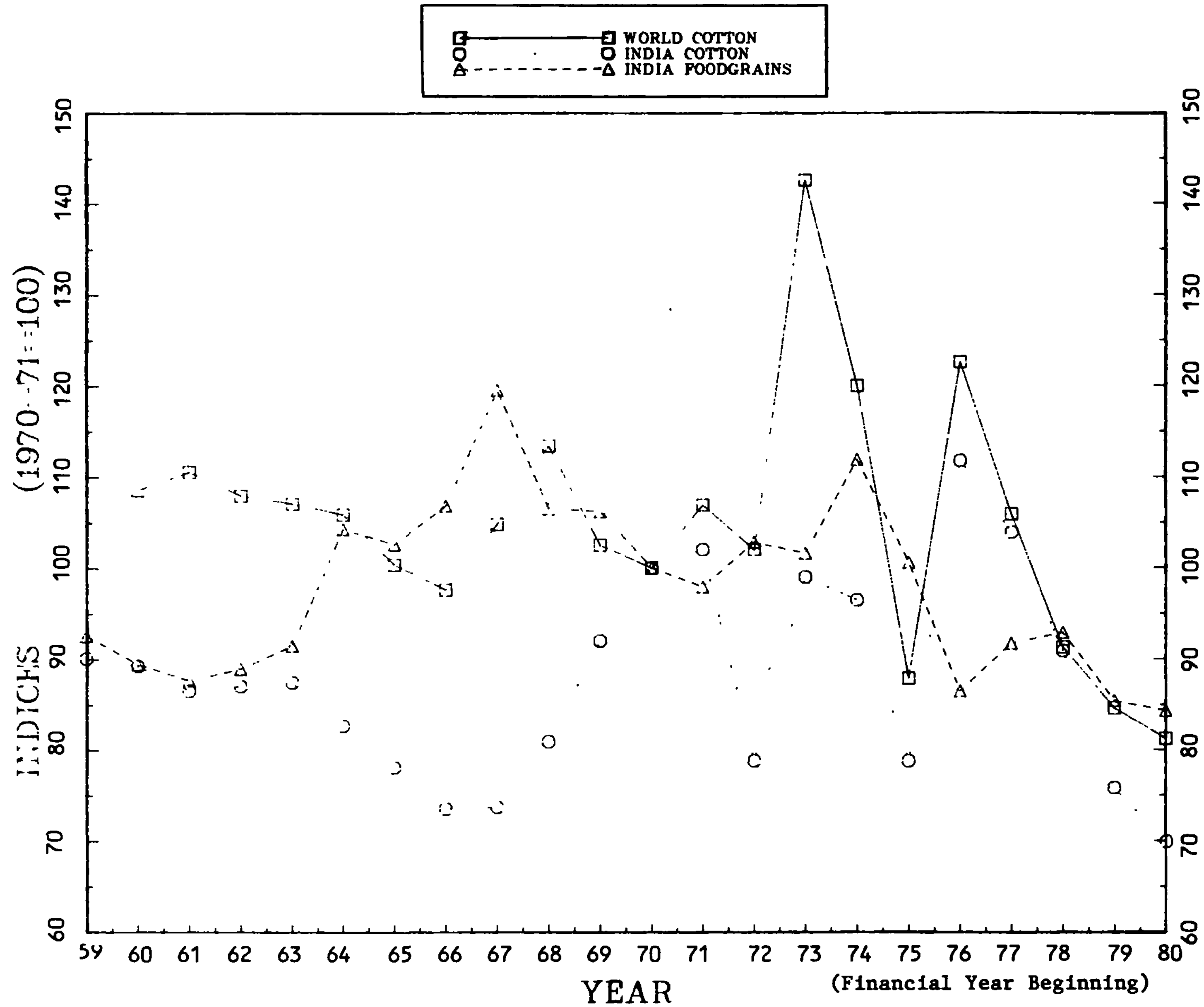
The constancy of cotton area in absolute terms, and of irrigated cotton area relative to the total irrigated cropped area (Table 4), suggests that its profitability vis-a-vis other crops may have been rather stable. Price indices for wholesale raw cotton and foodgrains in India, deflated by a wholesale price index for all commodities, are shown in Figure 3. World raw cotton prices, adjusted by an international price deflator, are also graphed 1/. For most of the 1960s, India's cotton prices were depressed relative to the prices of foodgrains and world cotton. Although total cotton trade has actually dwindled in recent years, lately India's prices have moved more in parallel with the world economy. However, neither internal nor international raw cotton prices have kept up with inflation in recent years. By the 1980/81 financial year, domestic cotton prices had dropped to 70 percent of their level (relative to inflation) in 1970/71. Domestic foodgrains and world cotton prices, adjusted for inflation, had fallen to about 80% of their levels at the beginning of the decade.

Raw cotton, somewhat surprisingly, is not an especially storable commodity. The ginning characteristics deteriorate through time and even the spinning quality of pressed bales of lint is not entirely stable. Seasonal price movements are nevertheless very weak. Averaging monthly index numbers for raw cotton from 1971/72 to 1979/80, the highest quarter, July/August/September, was only 5% above the lowest quarter comprised of the preceding three months. Double cropping and a staggered crop calendar within India serve to dampen seasonal price movements, while year-to-year shifts in yield and movements of world prices tend to dominate evidence of seasonal price adjustments.

1/ Wholesale Price Statistics, India, 1947-1978, Vol. 1, Economic and Scientific Research Foundation, New Delhi (October 1978), with updates, and Price Prospects for Major Primary Commodities, World Bank Report No. 814/80 (January 1980) and update of November 1980.

FIGURE 3

DEFLATED WHOLESALE PRICE INDICES



INDIA COTTON AND FOODGRAIN DATA ARE FOR FINANCIAL YEARS

Although price is only one component of profitability, the wide fluctuations in cotton prices in the 1970s drastically altered the returns to cotton cultivation, particularly in irrigated areas where yields were fairly stable. Central Agricultural Price Commission (APC) data for the Punjab, chosen for its compatibility through time, indicates rising cultivation costs and nearly constant yields (Table 5). (Family labor, opportunity costs of land and the amortized cost of owned fixed capital are not included in these cultivation costs.) The ratio of the value of output to the value of inputs follows the graph of prices received in the Punjab and the trend in the national raw cotton wholesale price index (Figure 4). The dip in 1975 and the recovery in 1976 follow the world price movements shown in Figure 3. 1/

Not surprisingly, profitability in rainfed areas is much more affected by variations in yield. A series of cost-of-cultivation data for Maharashtra, from the State Price Commission Cell, shows steadily rising costs although constant input coefficients were used (Table 6). These data have the advantage of referring to the same cotton variety, L-147. Ratios of output to input values were calculated using state average yields as well as the trend yield, which was flat. The average yields between 1975/76 and 1979/80 increase sharply, but not enough to offset rising production costs. Ratios of output to input values follow the yield series in Maharashtra (rainfed conditions, Figure 5), rather than the price series as in irrigated Punjab.

A clear trend in profitability is not discernable in either state, based on average yields, although there is improvement in Maharashtra through 1977/78. The recent gains in yield in Maharashtra appear less portentous when viewed against the protean background of a twenty-year series. Similar periods of rising yields have been experienced in the past despite an overall flat trend. There is evidence of a decline in profitability in Maharashtra between 1976/77 and 1979/80 when the output/input ratios are calculated using trend yields (Table 6).

Other sources of data for Maharashtra vary more in their results on yield than in their production cost or price estimates (Table 7). The similarity of production costs in the State Price Commission data and in other sources suggests the assumption of constant input coefficients may not have unreasonably biased the results on cultivation costs. (The prices of inputs were updated each year, but not the quantities.)

1/ The actual received Rs/kg price as well as the ratio of output to input values can be read on the left-hand vertical axis in the Figure.

TABLE 5

CENTRAL AGRICULTURAL PRICE COMMISSION

RETURNS FROM COTTON CULTIVATION IN PUNJAB

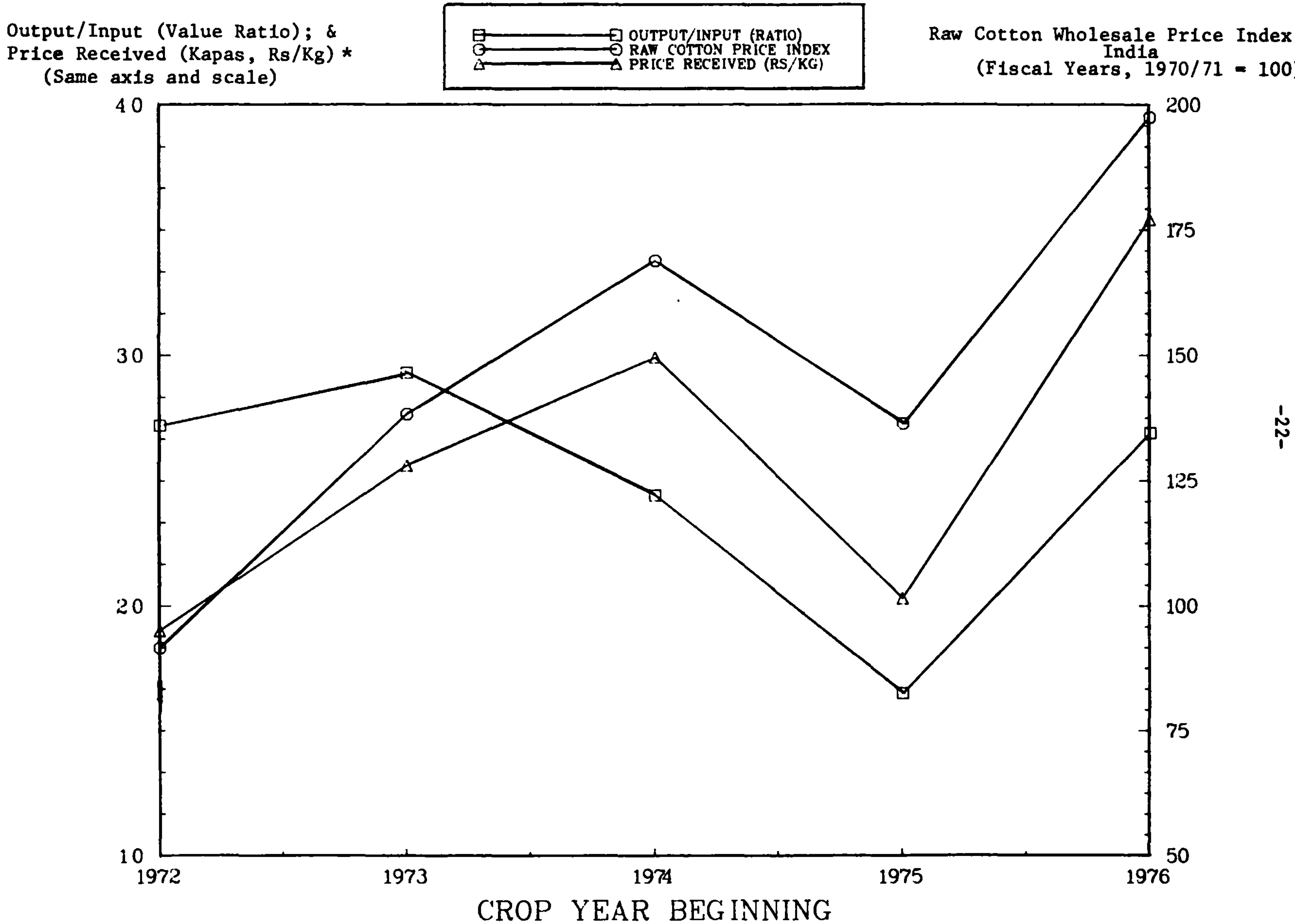
	1972/73 1/	1973/74	1974/75	1975/76	1976/77 2/
Yield (kg kapas/ha)					
Used by Source	977	952	921	911	1,040
State Average 3/	1,034	1,074	1,066	1,034	991
Price (Rs/kg)	1.90	2.56	2.99	2.03	4.11
By-Product (Rs/ha)	78	81	94	96	125
Gross Return (Rs/ha) 4/	1,933	2,521	2,846	1,941	4,397
Cultivation Costs (Rs/ha) 5/	711	861	1,167	1,174	1,634
Net return (Rs/ha) 6/	1,222	1,660	1,679	767	2,763
Output/Input (Value)	2.72	2.93	2.44	1.65	2.69

1/ American and Desi varieties.
2/ American variety only.
3/ Assuming 35% ginning rate typical of American 320-F.
4/ Based on yield used by source.
5/ Based on the "A2" cost representing paid out cash and in kind expenses including rent paid on leased-in land.
6/ Measures returns to owned fixed capital, owned land, and family labor.

Source: "Cost of Cultivation and Input Structure for Principal Crops in Punjab," Dept. of Economics and Sociology, Punjab Agricultural University, Ludhiana, and Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, reports for various years.

FIGURE 4

TRENDS IN PRICE AND OUTPUT/INPUT RATIOS IN PUNJAB



*Combined American and Desi varieties. Output/Input ratio for 1976/77 based on American variety alone, which brought a price of 4.11 Rs/Kg. Prices received in Punjab.

TABLE 6

STATE AGRICULTURAL PRICE COMMISSION CELL

RETURNS FROM COTTON CULTIVATION IN MAHARASHTRA 1/

	1975/76	1976/77	1977/78	1978/79	1979/80
Yield (kg kapas/ha)					
Used by source	267	279	279	267	267
State Ave. 2/	158	186	258	247	308
Trend Fit	212	213	213	214	214
Price (kapas Rs/kg) 3/	3.39	4.62	4.14	3.52	3.55
Gross Return Ave. Yield (Rs/ha)	536	861	1,068	869	1,093
Gross Return Trend Yield (Rs/ha)	719	984	882	753	760
Cost of Production (Rs/ha) 4/	578	597	654	762	887
Net Return Ave. Yield (Rs/ha) 5/	-42	264	414	116	206
Net Return Trend Yield (Rs/ha) 5/	141	387	229	107	-127
Output/Input: Ave. Yield (Value)	0.93	1.44	1.63	1.14	1.23
Output/Input: Trend Yield (Value)	1.24	1.65	1.35	0.99	0.86

1/ The table refers to the cultivation of L-147 (rainfed) in all years.

2/ Average yield in kapas assumes 36% ginning factor which pertains to L-147 (Cotton in India, Table 4d).

3/ Prices from Annual Cotton Statistics, 1975/76 Table 5.4, and 1977/78 (Maharashtra Agriculture and Co-op Dept), and Maharashtra State Cooperative Marketing Federation. Generally referenced to fair average quality.

4/ Uses constant input coefficients. Refers to paid out costs for hired human and animal labor, seeds, manures, fertilizers, insecticides, fungicides, land taxes and depreciation.

5/ Net returns to owned land, family labor, fixed and working capital.

Source of cost of cultivation data: "Estimates of Cost of Cultivation of Cotton (L-147 variety)" various years, Agricultural Price Commission Cell, Agriculture and Co-op Department, Government of Maharashtra.

FIGURE 5

Trends in Yield and Output/Input Ratios in Maharashtra

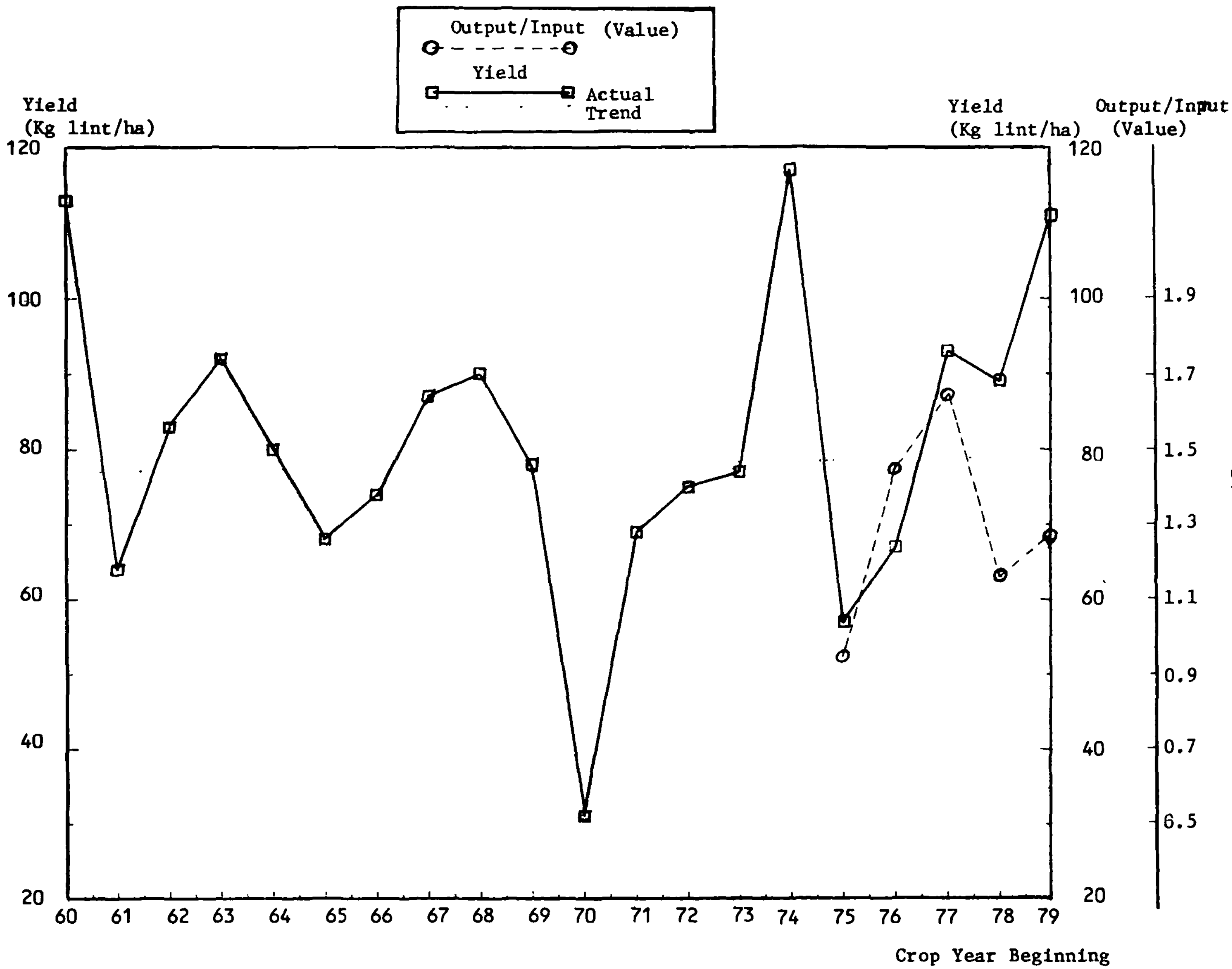


TABLE 7

COMPARISONS OF COST OF CULTIVATION DATA FROM VARIOUS SOURCES FOR MAHARASHTRA

	Variety	Source	Yield 1/ (kg/ha)	Price 1/ (Rs/kg)	Production Cost 2/ (Rs/ha)
1975/76	L-147	(1)	267	3.39	578
	"Long Staple"	(2)	369	3.39	616
1976/77	L-147	(1)	279	4.62	597
	B-1007	(3)	420	2.31 3/	534
1979/80	L-147	(1)	267	3.55	887
	L-147	(4)	361	3.69	785
	B-1007	(4)	420	3.50	764

1/ Yield and price refer to seed cotton (kapas).
2/ Based on paid-out costs.
3/ This low price evidently refers to the guaranteed price rather than the final price received from the Maharashtra State Cooperative Marketing Federation.

Sources: (1) State Agricultural Price Commission Cell. (Used in previous table).
(2) Central Agricultural Price Commission.
(3) "Economics of Cotton Production in Akola," Dept. of Economics, Punjabrao Agricultural University, Akola, Maharashtra.
(4) "Production Constraints in Cotton in Vidarbha and Measures to Overcome the Same," by N. D. Arora, World Bank Consultant, Punjabrao Agricultural University, Akola, Maharashtra.

B. Comparisons Between States

Production costs, excluding family labor, fixed assets, and the opportunity cost of land, were about twice as high in Punjab, Haryana, and irrigated areas of Tamil Nadu as in Karnataka and Maharashtra in the mid-1970s. Yields were generally more than double in irrigated areas on a fitted trend basis, which compensated for higher production costs and resulted in higher output/input ratios in value terms. Comparisons between states using trend yields are presented in Table 8. 1/ Although these estimates of costs, yields, and prices are no more recent than the mid-1970s, a number of states can be contrasted using similarly-constructed data. Costs of bullock labor and fertilizers/manure were each between about Rs/ha 120 and 280 in all six states listed. The quantity and cost of human labor and insecticide were among the leading sources of variation in production costs (Table 9). However, irrigation charges were prominent in Tamil Nadu (Rs/ha 200 versus 126 in Haryana and of course zero in Maharashtra and Karnataka) and machine labor was 142 Rs/ha in Punjab, but insignificant elsewhere.

The proportion of all paid-out costs accounted for by various labor inputs and insecticide in the mid-1970s ranged from 39% in Maharashtra to 86% in Punjab (Table 9). These proportions are equally high or higher in more recent data. The State APC estimate for the 1979/80 crop year in Maharashtra was 69%. The sharp increase is accounted for by substantial insecticide inputs and higher human (non-family) labor costs. A 1979/80 estimate for Haryana was 68% for Desi varieties and 57% for American varieties. 2/ A corresponding figure for Gujarat was 69% in 1978/79 for rainfed V-797. 3/

1/ Since state yield trends were estimated on the basis of kg lint per hectare, ginning percentages, typical of the various states, are shown in the Table. These were used to convert to kg seed cotton per hectare.

2/ See Table 12.

3/ See Table 10 for the source. Since the cost of hired labor is not given separately in these reports, the assumption was made, in calculating this figure, that the proportion of family labor was the same as given in Table 9. In Gujarat, an estimate of the fraction of paid-out costs attributable to human, bullock and machine labor, and insecticide was 37% for irrigated Co-2 cotton varieties. This low fraction is due to high fertilizer/manure costs (684 Rs/ha) and irrigation charges (1002 Rs/ha) in the study by the Institute of Co-operative Management, Ahmedabad.

TABLE 8

Returns from Cotton Cultivation Using Trend Yields
Comparison Between States

	1974/75					1975/76			
	Punjab	Haryana	Gujarat	Karnataka	Tamil Nadu 7/	Punjab	Gujarat	Tamil Nadu 7/	Maharashtra 1/
Reported Yield (kg/ha)	921	739	462	354	612	911	459	985	369
Trend Yield (kg/ha)	1,054 2/	931	450	281	638	1,059	455	655	212
Ginning Percentage (%) 3/	34	34	38	35	35	34	38	35	36
Price (Rs/kg)	2.99	3.00	3.34	3.24	3.78	2.02	3.32	4.40	3.39
By-Product (Rs/ha)	94	114	50	17	14	96	55	27	25
Gross Return Trend Yield (Rs/ha)	3,245	2,907	1,553	927	2,426	2,235	1,566	2,909	744
Cost of Production (Rs/ha) 4/	1,167	934	928	502	1,315	1,174	911	1,416	634
Net Return Trend Yield (Rs/ha) 5/	2,078	1,973	625	425	1,111	1,061	655	1,493	110
Output/Input (Value)	2.78	3.11	1.67	1.85	1.84	1.90	1.72	2.05	1.17
Percentage of Irrigated Cotton 6/	99	99	23	10	37	99	22	37	3

1/ Short Staple.
2/ A dummy variable was used in the yield regression to adjust for the creation of Haryana.
3/ Used in converting trend yield measured in lint to trend yield measured in raw cotton. (Cotton in India--A Profile, Directorate of Cotton Development, GOI, Bombay, 1980).
4/ Cash and in-kind paid out costs. Based on "A2" costs including rent on leased-in land.
5/ Return to owned land, family labor, and fixed assets.
6/ Based on area.
7/ Irrigated.
Source: Central Agricultural Price Commission Cost of Cultivation Data. Also reported in Indian Agriculture in Brief, 18th ed., Directorate of Economics and Statistics, Ministry of Agriculture.

TABLE 9

Sources of Variation in Production Costs

	Punjab 1/ 1975/76	Haryana 1/ 1974/75	Gujarat 1974/75	Tamil Nadu 1/ 1975/76	Maharashtra 2/ 1975/76	Karnataka 1974/75
Human Labor						
Man Hours Per Hectare	811	691	489	707	561	431
Per Cent Family Labor	11	60	25	9	40	37
Cost Per Hour (Rs)	0.90	0.80	0.60	0.75	0.35	0.38
Total Human Labor Cost 3/ (Rs/ha)	730	553	293	530	196	164
Insecticide (Rs/ha)	52	12	193	187	2	55
Bullock Labor (Rs/ha)	160	279	224	172	178	116
Machine Labor (Rs/ha)	142	35	46	11	0	1
Per Cent Paid Out Costs 4/ (For Labor, Insecticide)	86	59	74	65	39	55

1/ Irrigated.
2/ Short Staple.
3/ Including imputed value of family labor.
4/ Excluding imputed value of family labor; including bullock and machine labor in the numerator.

Source: Central Agricultural Price Commission, various reports.

While it can be argued that high labor inputs for cotton are an important generator of rural employment opportunities, they may also erode profitability and account for the lack of expansion in total cotton area. Multiple pickings at harvest, and sprayings which can range from five to fifteen in number, obviously boost labor inputs. Labor costs and insecticide expenses are thus obviously partially correlated, and both can rise as pests gain resistance to chemical applications and the number of doses are increased. Pests can cut yields at least in half in a bad year. These considerations have turned the attention of cotton breeders and agriculturalists to the labor and pest control components of production costs. A strong case can be made that in some geographical areas pest control is the prime constraint on profitability because of its pivotal relationship to yields and cultivation costs. The issue of pest management is addressed in the following section.

SECTION V

AGRONOMIC SCOPE FOR INCREASING PROFITABILITY

A number of agronomic factors affect the profitability of cotton cultivation as well as standard economic determinants such as marketing and processing margins or trade and price policy. These factors broadly fall into two categories: genetic potential and characteristics on one hand, and cultivation practices on the other.

A. Genetic Characteristics

As a general rule, a 3% higher ginning percentage, or a 1 mm longer staple length boosts the price of raw cotton by 5% - 10%. 1/ Spinning counts, fineness, and tensile strength are also elements of quality, and hence price. Two of the newer varieties developed and grown in Maharashtra, AKH-4 and AKH-605 have a ginning percentage of 40% - 41%, which compares with 38% - 39% for the older AK-235. 2/ The highest ginning percentage attained was 47% whereas 35% is considered normal. Staple length and ginning percentage are two characteristics which plant geneticists are attempting to maximize. Desi varieties have also been developed for semi-arid conditions which have deep and vigorous root systems and excellent pest resistance.

The hairiness of cotton leaves affects susceptibility to pests. Cotton breeders have developed varieties with hairy leaves early in the plant cycle, which acts as a barrier to sucking pests and moths. The same varieties loose the hair covering later in the life cycle, which would have provided a growth medium for worm eggs.

1/ For example, spot lint prices in Bombay for September - November, 1980 (1979-80 crop) for CO-2, Shanker-4, and Varalaxmi varieties show that an additional 1 mm staple length within each variety adds 7% - 12% to the value, with the larger differential being paid when the 1 mm increment starts from a higher base. Since about 80% of the value of raw cotton is in the lint, this adds 5% - 10% to the price of raw cotton. Similar reasoning applies to the ginning percentage. (Spot prices were obtained from the East India Cotton Association.)

2/ Production Constraints in Cotton in Vidarbha and Measures to Overcome the Same, by N. D. Arora, Punjabrao Agricultural University (1981).

Genetic removal of seed fuzz can increase profitability by facilitating seed crushing and oil removal, and by raising the germination rate. Mechanical separation of seed from clean seeded varieties is possible which could boost germination rates to 90% from levels of 60%-65% for some varieties. Higher germination obviously raises yields and could remove altogether the need for gap-filling and replanting which is now recommended. High-germinating seed (around 80%), presently available from hand separation and acid delinting, can boost yields 20% with an expenditure of 25% more for the seed. The added seed cost would be a very small fraction of the total cost of production. There has been a genetic link between clean-seeded characteristics and a low ginning percentage. This link has been broken in the laboratory, but clean-seeded, high-ginning varieties have not yet been developed and multiplied for general release.

Another endeavor for plant breeders is to make the toxic gossypol, present in cotton seed glands, inactive unless the seed germinates. This would render cotton seed oil and high-protein cotton seed cake available for human consumption without the use of expensive extraction processes. The gossypol content of screw pressed cotton seed oil is 0.25%-0.47% compared with 0.15%-0.42% for hexane press extraction, 0.02%-0.11% for hydraulic press extraction, and under 0.01% for cold pressed methods. 1/

B. Cultivation Practices

Several approaches to overcoming the water constraint for rainfed cotton are being recommended or experimented with. The "crow bar system" is a labor-intensive method of irrigation which involves pouring water by hand down a hole punched in the soil beside the seed at the time of sowing. 2/ Early sowing of H-4 and other improved varieties gave yield increases of 20%. One reason is that this system allows the sowing dates to be advanced. The added labor costs were recovered by the increment in yield in experiments in 1979/80 on the World Bank Cotton Project near Akola, Maharashtra. 3/ Research on transplanting seedlings in rainfed areas showed even higher gains in yield, but lower net income and lower value-of-output to value-of-input ratios than the crow-bar system. (The

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1/ Cotton at a Glance, edited by Chokhey Singh (Central Institute for Cotton Research, Nagpur, 1980), p. 53.

2/ So named for the crow-bar like instrument used in making holes about six inches deep.

3/ N. D. Arora, op. cit.

output/input ratio for transplanting was also lower than for normal sowing although the net income was higher.)

The most widely-recommended agronomic practice for improving yields is early sowing. This recurrent advice was heard from cotton breeders and agronomists alike in Maharashtra, Gujarat, and Haryana. The "crow bar" irrigation system and transplantation were both researched as means to facilitate earlier planting. Usually, 15 days are required for complete sowing after the showers are received. The varieties B-1007, SRT-1, H-4, S-31 and L-147 all mature in 150-180 days. Advancing the sowing dates to 7-10 days before the normal onset of monsoons increased yields 150 - 200 kg/ha, in experiments in 1980/81 in Maharashtra. A 20-30% yield increase is often cited as the effect of planting at an earlier, optimal date. Research from earlier periods bears this out. Trials on fields in Amravati, Maharashtra between 1967 and 1972 gave mean yields on the sowing dates May 20, June 5, and June 20 as kg/ha 1321, 1082, and 675 respectively. 1/ The late May sowing produced 22% higher yields. Under irrigated conditions in Madhya Pradesh, sowing in the first half of May increased yields 13% compared with sowing in the latter half. The increment for irrigated cotton in northern India was about 5% (three years averaged for Hissar, and six years averaged for Srigangangar). 2/ Earlier sowing can also inhibit the growth of weeds.

Planting is often delayed by several factors in addition to understating the importance of early sowing. The cultivated area is divided equally between sorghum and cotton on many holdings in semi-arid regions. Prior to the advent of hybrid sorghum, cotton was generally planted first. Now cotton planting is delayed and precedence is given to high yielding varieties of sorghum. Although rainfed cotton has the advantage of offering more stable yields than sorghum, price uncertainty and the prospect of marketing cotton to buy food with the proceeds, keeps farmers dependent on sorghum for security reasons and restricts substitution between the two. Bullock pairs are in high demand during planting and waits for draft animals cause some farmers to get their cotton crop in late. At least 25% of cotton growers within the Integrated Cotton Development Project at Amravati, Maharashtra depend on hired draft animals. 3/ Sowing delays in

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1/ Cotton Research in Maharashtra, PKV, Akola.

2/ Recent Advances in Cotton Production Technology in India, M.S. Kairon, (H.A.U. Hissar, 1979), pp 13 - 14.

3/ Cost of Production of L-147 and H-4 under Rainfed Conditions in Integrated Cotton Development Project, Amravati, (Maharashtra). During 1976-1977, N. P. Wankhede and V. G. Patel.

irrigated areas are usually caused by canal irrigation schedules and double cropping timetables.

The spacing of cotton plants now recommended by researchers for several varieties is 10 cm apart down the row, and 80 cm between double rows. This spacing doubles the population of plants per hectare, and the wider gap between rows allows deep harrowing by draft animals to prevent weed growth. The reduction in labor compared with hand-weeding can be considerable. An estimated two-thirds of Desi variety cotton grown in Gujarat is planted with this spacing pattern. This spacing also allows better access for spraying and picking.

Perhaps the most exotic area of experimentation is treatment of cotton plants with a growth-stunting hormone. The plant responds by concentrating growth in the bolls which can gain one third in weight for a total of eight grams. The cost of the treatment is high although remunerative, so use is limited to a trial basis by the largest farmers. An application of the imported hormone costs Rs 1,000/ha, or about a quarter of the cost of fertilizer and insecticide under a high-technology production system. 1/

C. Pest Management

Pest control is a central concern of agronomists as well as plant breeders. An estimated 60% of all pesticides used in India are applied to cotton. Working from the figures in Table 9, 28% of paid-out costs for cotton production in Gujarat in 1974/75 were for pesticides -- 193 Rs/ha. The proportions were 22% for Karnataka, 6% for Punjab and negligible for Maharashtra. However, these data are meant to represent state averages, and do not portray the high plant protection costs for some varieties. Furthermore, these costs (and those that follow) do not include the labor costs for pesticide application. Total pesticide costs are therefore much higher for specific high-input varieties. The three-year mean pesticide outlay for irrigated Digvijay cotton among a sample of farmers in Gujarat, 1974-1977, was 380 Rs/ha, and over 1,200 Rs/ha for irrigated H-4. 2/ Even rainfed cotton can have high plant protection costs when newer varieties are sown which have an increased yield potential, but reduced pest resistance. The three-year average cost of plant protection for these same

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1/ Labor costs for the treatments and applications are included in the comparison.

2/ Production Economics of Hybrid-4 and Digvijay Cotton in Gujarat, S. M. Patel and M. K. Pandey (Gujarat State Co-operative Cotton Marketing Federation, Ahmedabad, 1978), pp 22, 35.

varieties under rainfed conditions in Gujarat was 94 Rs/ha and 867 Rs/ha, respectively. Costs of pesticides in Maharashtra were 213 Rs/ha (L-147) and 506 Rs/ha (H-4) in a farmer sample interviewed in 1976/77. 1/ Multiple sprayings, which often exceeded twenty times in areas around Ludhiana and Coimbatore, resulted in exorbitant pesticide expense and high labor costs for application. Twelve to fifteen sprayings were not uncommon in Gujarat, and the average was above six for improved varieties in Maharashtra. 2/

Studies in Gujarat showed that insect damage was still heavy, farmers were spraying too much too soon, and beneficial insects were reduced in numbers while harmful pests gained resistance. These observations led to the establishment in 1978/79 of the Gujarat Integrated Pest Management system which utilized scouts and traps to monitor insect and especially moth populations. About 24% of the total cotton area was receiving pesticide applications. 3/ The system was implemented through the Training and Visit agricultural extension network which was already functioning. Flexible and more optimal spraying schedules were introduced based on threshold infestation levels which varied from area to area. 4/ The number of sprayings were often cut in half and yet their effectiveness was enhanced. Pesticides used on irrigated Co-2 cotton in Gujarat cost 354 Rs/ha in 1977/78 but had been reduced to 210 Rs/ha in 1978/79, and may have decreased further in the last year or two. 5/

The threshold spraying system has been replicated elsewhere, notably in Tamil Nadu, Punjab, and Haryana. There is evidence of cost reduction for plant protection in Haryana between 1976/77 and 1979/80, particularly for Desi varieties (Table 12). Even the slight absolute cost reduction for American varieties (from 229 Rs/ha to 194 Rs/ha, Table 12)

1/ N. P. Wankhede and V. G. Patil, op. cit.

2/ Personal communication, Central Institute for Cotton Research, Nagpur.

3/ Present Status of Cotton Development and Future Prospects in Gujarat, G. B. Kasad, Ahmedabad (paper from the National Seminar on Cotton at Coimbatore, December 1980), p. 3.

4/ For example, threshold levels recommended in Maharashtra by Punjabrao Krishi Vidyapeeth are ten per leaf for aphids, thrips and mites (average population) and five to ten jassid nimphs per leaf, depending on the cotton variety.

5/ Production Economics of V-797 and Co-2 Cotton in Gujarat State, 1977-78 and 1978-79 (Two Volumes), S. M. Patel and M. K. Pandey (Institute of Co-operative Management, Ahmedabad).

is remarkable given the sharply rising unit costs of chemical applications which follow petroleum prices.

Light traps offer an alternative, albeit high-technology, approach to pest control. (These are contrasted to pheromone traps which are used to monitor insect populations.) They require electrification which is often not available, and are an example of new technology cutting production costs. Labor inputs and therefore employment opportunities are also reduced compared with spraying, however. The most sophisticated and effective is a blacklight (ultraviolet) trap which costs Rs 2,000. The capital outlay is substantial but the trap covers two hectares and will operate for four years. A replacement bulb is less than half of the initial cost. The amortized cost is competitive with, or less expensive than pesticides; and electricity, where available, is far cheaper than labor for spraying. The traps only need to be operated periodically. Other light traps are less costly than the blacklight system. Research into their effectiveness vis-a-vis chemicals is promising and continues in Gujarat. Systematic disposal of cotton stalks and debris is now undertaken in many areas to destroy the eggs of pests and their breeding sites.

D. Improved Seed

The availability of improved/hybrid seed is often given as a limiting factor in increasing yields. Prior to the Integrated Cotton Development Project (1970/71) 3.54 million hectares of cotton were planted with improved seed, or 47% of the total. The Project raised the proportion to two-thirds by 1977/78, or 5.21 million hectares. 1/ Hybrid cotton area expanded from virtually zero at the beginning of the 1970s to 0.76 million hectares by 1978/79. 2/ Genuine hybrids are hand-pollinated which restricts supply and makes seed costly. Typical improved seed costs 20 - 50 Rs/ha depending on the variety and area. 3/ Staple-7 seed for planting can cost 75 - 100 Rs/ha in Haryana (1979/80) but most farmers receive a

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1/ Chokhey Singh, op. cit., p. 44.

2/ Cotton in India, A Profile, p. 54.

3/ Seed costs were 18.5 Rs/ha in Maharashtra as an average (State APC cell, 1979/80), and estimated at around twenty Rs/ha for B-1007 and AK-235 in Maharashtra (1976/77, "Econ. of Cotton Production in Akola" Department of Economics, P.K.V.); 30 - 35 Rs/ha for V-797, rainfed in Gujarat, (1978/79, Production Economics of V-797 and Co-2...) and Desi and American varieties in Haryana (1979/80, see Table 12); and 50 Rs/ha for irrigated Co-2 in Gujarat (1978/79, Production Economics of V-797 and Co-2...).

50% subsidy through the Intensive District Programme. 1/ Farmers in Maharashtra planting H-4, the most popular hybrid variety, spent over 120 Rs/ha on seed in 1976/77. H-4 seed costs would be around 225 Rs/ha in 1980/81. 2/

The distribution of improved seed is uneven. About 85% of the planted cotton area in Gujarat is covered by improved or hybrid seed. 3/ Nearly 30% is devoted to H-4; V-797, Co-2, and Digvijay account for the remainder under improved varieties. 4/ Punjab and Haryana are even more exclusively planted with improved varieties. However, the proportion was only 15% in Maharashtra in 1979/80. Most of the area under improved cotton was planted with H-4 (10% of all cotton area), followed by Varalaxmi and Savitri. 5/ The constraint of insufficient improved seed was frequently mentioned in Maharashtra. One proposal to expand supply is to introduce a "registration" phase in seed multiplication undertaken by private growers. Presently, seed is multiplied in three stages, all outside of private channels: breeding, foundation, and certification seed.

E. Varietal Comparisons of Profitability

The adoption of improved production practices and inputs generally increases financial outflows and receipts. Even if net returns rise, the ratio of output to input values may not improve. Comparisons of net returns and output/input ratios between varieties and between rainfed and irrigated conditions casts light on whether the economic efficiency of capital and labor are increased by higher-technology production practices. As defined above, these ratios measure the rate of return to family labor, land, and fixed capital.

Detailed studies in Gujarat indicate that in 1977/78 and 1978/79 rainfed cotton outperformed irrigated cotton with respect to output/input value ratios and net returns (Table 10). Varieties V-797 and Co-2 can be

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1/ Staple-7 planting seed was priced at 5 Rs/kg without subsidization and the recommended seed rate is 15 - 20 kg/ha.

2/ Economics of Cotton Production in Akola. H-4 seed cost 70 - 100 Rs/kg and the recommended seed rate is 2.5 kg/ha.

3/ Present Status of Cotton Development and Future Prospects in Gujarat, G. B. Kasad, p. 3.

4/ S. M. Patel and M. K. Pandey (1978/79), p. 6.

5/ Cotton Cultivation in Maharashtra State.

TABLE 10

Returns from Cotton Cultivation in Gujarat
Comparisons between Irrigated and Rainfed Conditions

(Family labor cost is included)

	1977/78		1978/79	1977/78		1978/79
	------Irrigated-----		Irrigated	--------Rainfed-------		Rainfed
Variety	V-797	Co-2	Co-2	V-797	Co-2	V-797
Yield (kg kapas/ha)	900	1,033	820	338	277	353
Price (Rs/kg)	3.65	3.65	3.65 1/	3.65	3.65	3.30 1/
Gross Return (Rs/ha)	3,285	3,370	2,993	1,234	1,011	1,165
Production Cost (Rs/ha)2/	3,178	4,316	3,239	1,091	761	1,140
Net Return (Rs/ha)	107	-946	-246	143	250	25
Output/Input3/	1.03	0.78	0.92	1.13	1.33	1.02

1/ The sources did not give the mean price received in this year and variety. This price is the highest in the reported range.
2/ In this table the imputed cost of family labor is included since it could not be separated out using the available date. The interest on crop loans is also included; the opportunity cost of land is excluded.
3/ Gross value of output divided by gross value of inputs.

Sources: Production Economics of V-798 and Co-2 Cotton in Gujarat State (1977/78 and 1978/79, two volumes), S.M. Patel and M.K. Pandey, Institute of Co-operative Management, Ahmedabad (July, 1979, and March, 1980).

compared under rainfed and irrigated conditions in 1977/78, and rainfed V-797 with irrigated Co-2 in 1978/79. The irrigated technology multiplies gross returns by about 2.5, but raises production costs by a somewhat larger factor. The sources for Table 10 do not allow netting out the imputed value of family labor, which was the procedure in other tables. This might lead to the argument that the higher production costs for irrigated cotton accrue in part to the family as employment compensation making the irrigated technology more attractive. However, the opportunity cost of land is excluded from the comparison which would have further eroded the profitability of irrigated cotton. Furthermore, only about a quarter of labor inputs for cotton in Gujarat are supplied by the family (Table 9).

The percent of cotton area under irrigation in Gujarat grew slowly from 8%, average of 1961-1964, to 22%, average of 1976-1979. The state lies below the trend relating the irrigated proportion to the yield growth rate (Figure 1). Irrigation in other states contributed more to yield increases, and may have been more profitable. Sugarcane has been competing irrigated land away from cotton, and oilseeds and pulses have been reducing the rainfed cotton area. Bananas are also a competing crop in Gujarat. The state's total cotton area has dropped steadily since 1977/78, and is estimated in 1980/81 to be 15% below the peak. 1/ The reduction is partly attributed to falling cotton prices. Cotton specialists in Gujarat suggest concentrating more inputs on less area to hold down costs and boost profits.

Varietal comparisons in Maharashtra show clearly that H-4 is superior with regard to net returns (Table 11). The output/input ratio is not consistently higher, however. H-4 had four times the production cost of AK-235 in 1979/80 and generated four times the gross returns and hence four times the net returns. SRT-1 had nearly double the production cost of AK-235, but only 50% higher net returns. The output/input ratio therefore falls from 2.49 to 1.81. The performance of B-1007 in 1979/80 was similar: higher net returns, but a lower output/input ratio. In other words, the intermediate-level technology was not terribly attractive. The high technology system was rewarding but required substantial extra capital. The profitability of all the varieties in these studies generally exceeds the state average based on L-147 as estimated by the Maharashtra State Agricultural Commission (Table 6).

1/ G. B. Kasad, op. cit., p. 2.

TABLE 11

VARIETAL COMPARISONS OF RETURNS FROM COTTON CULTIVATION IN MAHARASHTRA 1/

	1976-77			1976-77		1979-80				
Variety	H-4	B-1007	AK-235	H-4	L-147	H-4	B-1007	SRT-1	L-147	AK-235
Source	(1)	(1)	(1)	(2)	(2)	(3)	(3)	(3)	(3)	(3)
Yield (kg kapas/ha)	671	420	399	885	468	1027	420	545	361	345
Price (Rs/kg)	3.24	2.31	2.10	5.1	4.3	4.11	3.5	3.48	3.69	3.00
Gross Return (Rs/ha)	2177	970	838	4514	2012	4222	1472	1899	1333	1036
Production Cost (Rs/ha)	1426	534	401	2246	1258	1811	764	1050	785	416
Net Return (Rs/ha)	751	436	437	2268	754	2410	708	881	548	606
Output/Input	1.53	1.82	2.09	2.01	1.60	2.33	1.92	1.81	1.70 2/	2.49 2/
Sample Size	50	50	50	21	20	105	133	53	8	46

Notes: 1/ This table is meant to illustrate varietal comparisons, rather than be representative of the State. Maharashtra's average yields are far below those shown here.

2/ These ratios were recomputed from the data given by the source.

Sources: (1) Economics of Cotton Production in Akola, Department of Economics, Punjabrao Agricultural University, Akola.

(2) Cost of Production of L-147 and H-4 Under Rainfed Conditions in Integrated Cotton Development Project, Amravati, during 1976-77, by N. P. Wankhede and V. G. Patil.

(3) Production Constraints in Cotton in Vidarbha and Measures to Overcome the Same, by N. D. Arora, Punjabrao Agricultural University, Ahola.

Desi and American varieties in Haryana are compared in Table 12. The American variety, although having higher production costs, outperforms the Desi cotton in net returns, both in 1976/77 and 1979/80. Note the higher fertilizer, plant protection, water, and labor costs for the American variety. By 1979/80, the gap in profitability has narrowed, partly due to rising production costs. A second reason is that a higher premium was paid for the American variety in the earlier period.

A ranking of projected output/input ratios derived from World Bank appraisal reports, along with baseline estimates, are presented in Table 13. Comparably calculated ratios discussed earlier in this paper were mostly in the range 1.50 - 1.80 under rainfed conditions, and up to 2.70 for irrigated conditions. (Occasionally, higher ratios were found as in Punjab and Haryana in the mid-1970s.) Thus most of the appraisals' estimates coincide with other investigations. Two appraisals indicate ratios in excess of 4.0, however. In the case of the Haryana Irrigation Project, 60% higher yields for American varieties were forecast than recently observed in a study from Haryana Agricultural University (Table 12). The anticipated yield in the post-1985 period seems ambitious at 2,000 kgs/ha for seed cotton. The combination of a high projected yield and low production costs in the appraisal of the Haryana Irrigation Project for American cotton in 1987/88, implies an output/input ratio of 4.03. This level of return appears to be out of keeping with other data.

Low anticipated production costs, around 800 Rs/ha, were again a significant factor in the high ratio for the Rajasthan Canal Project. Unfortunately, independent estimates of profitability are not available. Indications are that cotton has been quite profitable along the canal system since cotton has accounted for most of the expansion of kharif-season cropped area. 1/ Note that since most of the projected output/input ratios in Table 13 are similar to those estimated in past studies cited above, given similar technologies, increases in the rate of financial returns beyond present levels are not generally forecast by the appraisals.

1/ "Agriculture Development in Rajasthan Canal Project 1974/75 to 1978/79," Commissioner, Area Development, Rajasthan Canal Project, Bikaner.

TABLE 12

RETURNS FROM COTTON CULTIVATION IN HARYANA
AND COMPARISONS WITH APPRAISAL REPORTS

	1974/75	1974/75	1976/77		1979/80		After 1985 1/	1987/88 2/	
Variety	-	-	Desi	American	Desi	American	-	Other	American
Source	(1)	(2)	(3)	(3)	(4)	(4)	(1)	(5)	(5)
	(appraisal)						(appraisal)	(appraisal)	
Yield (kg kapas/ha)	739	900	685	746	740	970	2000	800	1600
Price (Rs/kg)	3.00	2.5	3.10	4.60	3.15	3.50	2.60	2.80	3.50
Gross Return (Rs/ha)	2250	2331 3/	2410 3/	3411 3/	2404 3/	3413 3/	5200	2280 3/	5650 3/
Costs (Rs/ha)									
Labor	900 4/	855 5/	690 5/	838 5/	732 5/	934 5/	1200 4/	597 5/	801 5/
Seed	40	35	26	33	30	35	80	38	50
Fertilizer/Manure	40	135	153	240	107	370	200	100	250
Chemical Plant Protection	140	12	161	229	53	194	420	100	300
Water/Irrigation	100	126	244 6/	324 6/	132 6/	281 6/	120	-	-
Interest 7/	35	26	52	67	43	62	60	-	-
Miscellaneous	50	75	41	57	61	87	100	-	-
Total Costs (Rs/ha)	1305	1264	1367	1788	1158	1963	2180	835	1401
Net Return (Rs/ha)	945	1067	1043	1623	1246	1450	3020	1445	4249
Output/Input	1.72	1.84	1.76	1.91	2.10	1.74	2.39	2.73	4.03

Notes:
1/ In 1975 rupees.
2/ In 1977/78 rupees.
3/ Includes value of by-products.
4/ Human and animal labor, hired only.
5/ The imputed value of family labor is included.
6/ Cost of irrigation and pre-sowing irrigation.
7/ Interest on loans or working capital; not interest on fixed capital.

Sources:
(1) India: Appraisal of Integrated Cotton Development Project, World Bank Report No. 923-IN (December 15, 1975, Cr. 610-IN), Annex 12, Table 1. The data are taken from financial budgets.

(2) Central Agricultural Price Commission cost of cultivation data.

(3) Dynamics of Cotton Production and Marketing in Haryana, Kapil Choudhry, I. J. Singh, and R. C. Goel, Research Bulletin No. 3 (March 1979), Department of Ag. Econ., Haryana, Agricultural University, Hissar, Table 3.20.

(4) Package of Practice for Kharif Crops, 1980, Haryana Agricultural University, Hissar, (1980), p. xxxv.

(5) Haryana Irrigation Project Appraisal, World Bank Report No. 2038a-IN (July 1978, Cr. 843-IN), Table 5.2a. The data are taken from financial budgets.

TABLE 13

Present and Projected Output/Input Ratios for Cotton
In World Bank Appraisal Reports
(Ranked from high to low)

Project	Area/Variety	Growing Condition 1/	Appraisal Date	Output/Input Ratio 2/ Present	Output/Input Ratio 2/ Future 3/
Rajasthan Canal	Sandy Soil	Rain/Irr	1974	3.17	4.10
Rajasthan Canal	Tal Soil	Rain/Irr	1974	2.55	4.10
Haryana Irrigation	American Variety	Irr/Irr	1978	-	4.03
Karnataka Tank	Northeastern Dry Zone	Rain/Irr	1981	1.39 4/	3.13
Punjab Irrigation	American Variety	Irr/Irr	1979	1.81	2.90
Haryana Irrigation	"Other"	Irr/Irr	1978	-	2.73
Maharashtra Irrigation II	Medium Staple	Rain/Irr	1979	1.49	2.68
Integrated Cotton Development	Haryana - Sirsa	Rain/Irr	1975	1.72	2.38
Gujarat Irrigation II	Hybrid	Irr/Irr	1980	2.58	2.35
Integrated Cotton Development	Punjab - Faridkot	Rain/Irr	1975	1.91	1.89
Integrated Cotton Development	Maharasthra - Amraoti	Rain/Irr	1975	1.50	1.74
Gujarat Irrigation II	Desi	Rain/Rain	1980	1.45	1.51

Notes: 1/ The "present" growing condition, associated with the "present" output/input ratio, is contrasted with the future technology in terms of rainfed or irrigated cultivation. Rain/Irr implies a switch to irrigation which is assumed in the future output/input ratio.

2/ In value terms, excluding family labor and the opportunity cost of land. Based on financial prices.

3/ 1985 or beyond.

4/ This is the estimated future ratio without the project.

F. Summary

There is scope for increasing the profitability of cotton along several genetic and agronomic fronts. Yet moving to a higher-technology production pattern does not unequivocally assure farmers of a higher rate of return on capital. Declining rates of return were encountered for some varieties and some years (Desi vs. American, Haryana 1979/80, for example, or H-4 vs. B-1007 vs. AK-235, Maharashtra, 1976-77, and some comparisons in more recent years) although placing more capital at risk tended to augment net returns 1/. Switching to irrigated cultivation in Gujarat, however, may even reduce net returns. Improved cotton varieties are often regarded as presently not offering the same jump in production possibilities as HYV grains. The dimensions of yield and market value are more complex than with the grains and diminishing returns from water and fertilizer inputs are more quickly encountered. Investments in the new technology may also be "lumpier" than for the grains. Some higher-potential varieties are less pest-resistant and imply higher labor and insecticide costs as well as more outlays for seeds and fertilizer. Production costs can easily double with adoption. Finally, cotton is probably unique in its labor requirements, and its profitability is highly sensitive to wage rates.

On a more positive note, the sheer complexity of cotton has meant that many genetic "breakthroughs", realized or foreshadowed in the laboratory, have not yet reached the farmer. Among these are further improvements in pest resistance, ginning percentage, staple length, root structure, boll size and number, maturity period, seed oil content, clean seededness and germination rate, in addition to inactivating gossypol in seed oil. Optimizing varietal characteristics for a particular geographic and economic environment involves maximizing in more dimensions than in the case of grains. To cite yet another example, the ease of picking and the totality with which the lint and seeds are removed from the boll (instead of clinging and shredding) can have dramatic implications for yields and labor costs at harvest. These traits are consequently among the concerns of cotton breeders. Apart from the possibility of symbiotic nitrogen fixation in grains, cotton varieties seem to offer more as-yet-untapped potential than the grains. Yield gap analysis shows that multiples of current typical yields are attainable, although of a lower order of magnitude than when comparing HYV with traditional grains. The untapped potential must be thought of in broader terms than yield alone.

The cultivation of cotton is particularly complex, and the potential for agronomic improvement is also significant. The number and timing

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1/ The issue is different average rates of financial productivity, not simply falling marginal rates of physical productivity.

of insecticide applications and pickings at harvest are an involved set of decisions added to more routine matters of sowing schedule, seed rate and spacing, etc.

The limited amount of compatible longitudinal data on returns from cotton cultivation do not indicate a trend of increasing profitability, whatever the potential. Instead, highly variable yields, fluctuating around a flat trend, have dictated output/input ratios in Maharashtra, chosen as one example of rainfed cultivation. The ratios in Punjab have followed price movements which have been unfavorable in recent years when measured against either inflation or prices of foodgrains. However, price indices have also declined in the world market since 1976. The historical series of prices have been discussed above, but critical issues of price outlook and policy, which are elemental to the future profitability of cotton, remain. Some of these are discussed in the following section.

SECTION VI

PRICE IMPLICATIONS OF TRADE POLICY

Market prices for raw cotton are generally 25%-30% higher than support prices which are derived from cultivation costs for varieties 320-F and F-104. The Cotton Corporation of India is the sole buying agent under the price support scheme, but has never made purchases on that basis. 1/ One criticism of support price determination is that yields, and hence profitability, are systematically overstated for various reasons, including reliance on recall rather than measurement, and hence support prices are set at unsupportively low levels. Another is that the announcement of support prices is made too late to plan production. One effect of low support prices is to reduce the availability of credit from the Reserve Bank of India to farmers, cooperative societies, and marketing federations.

Trade policy is generally more vital to price issues than the price support scheme. India has been a net importer of cotton in seven of the last ten years at a volume of around 500 thousand bales (170 kg each). Both imports and exports have declined in recent years, leaving India nearly self-sufficient except in the medium staple lengths. Exports, which were 200-300 thousand bales between 1960 and the mid-1970s are now less than 50 thousand. Meanwhile, imports fell to under 100 thousand bales from a peak ten times that high in 1964. Export decisions are made primarily through the Ministries of Commerce and Industry, with little input from the Ministry of Agriculture. Restrictive export quotas are typically set with the objectives of supplying lint to the textile industry and boosting domestic cloth availability.

Cotton growers and cooperative marketing agencies are eager to expand exports to their former levels and beyond to take advantage of higher world prices. Textile manufacturers generally contend that employment and foreign exchange objectives are better served by exporting products having a higher value-added component than raw cotton: preferably finished piece items, but at least cloth or yarn. It is further maintained that significantly higher prices for cotton would force a drop-off in operations with serious dislocational effects, especially in employment. Growers tend to respond that they ought not to be penalized

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1/ Within the recollection of the officials interviewed.

for the inefficiencies of the industrial sector if it cannot compete with foreign textile producers unless raw inputs are priced below the world market. 1/ The controversy bears on the mix of staple lengths that are produced since longer fibers are more attractive for export but are unsuited to either the bulk of installed spinning capacity or the quality of garment or cloth affordable by the average domestic consumer.

Measuring the effects of trade restrictions and other distortions on prices received by farmers requires careful derivation of economic prices from world market prices. The world prices must be appropriately adjusted for physical movement back to farmgate and for an earlier stage of processing. Ideally, the procedure should be applied to data from several years to lessen the sensitivity of the conclusions to the oddities of a particular production or marketing cycle.

Farmgate import parity prices have been calculated for two staple lengths of cotton in two production areas for three recent years (Table 14). These economic prices were found using transportation costs to the middle of the major growing areas for the respective staple lengths, approximately 1,250 km and 650 km from Bombay. Rail freight rates were based on studies of economic costs of shipping cotton specific distances. Documentation for the various components of the derivation including seed value, ginning percentage, pressing charges, ginning charges, etc. appears in the notes following Table 14. 2/

The ratio of the actual price received to the economic parity price is defined as the Nominal Protection Coefficient (NPC), which is one measure of the extent of distortions introduced by trade policy. The

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1/ Concerns have also been expressed by those in favor of larger exports that incentives may exist for mill owners to actually squeeze the profitability of mills and use the low returns as a rational for holding back exports of lint. The argument is that in some cases mill owners are involved in marketing lint to and textiles from the mills. The distribution of profits is more concentrated in marketing and the return to capital higher than in mill operation, it is contended. Therefore, there would be a tendency to try to move profits out of the mills into the marketing arena by selling lint at higher prices to the mills and buying textiles from them at artificially low prices.

2/ Bombay is the major price-determining market in India. The c.i.f. Bombay price is therefore the appropriate alternative to domestic production. However, for domestic production to fetch this parity price in Bombay, the producers would have to receive less reflecting processing and transportation costs. Hence internal transportation charges between the wholesale market and the farmgate are subtracted.

TABLE 14

Derivation of Import Parity Farmgate Prices for Seed Cotton

	Orleans Texas 1" (25.4 mm) Middling (1,250 km from Bombay)			Mexican 1-1/16" (27 mm) Strict Middling (650 km from Bombay)		
	1977/78	1978/79	1979/80	1978	1979	1980
C.I.F, N. Europe, $/mt (current) 1/	1,713	1,482	1,661	1,610	1,710	2,070
Insurance Freight, Handling $/mt 2/	100	110	120	100	110	120
F.O.B. Wholesale, Bombay $/mt	1,813	1,592	1,781	1,710	1,820	2,190
F.O.B. Wholesale, Bombay Rs/mt 3/	15,525	13,064	14,383	14,643	14,935	17,686
Transportation from Ginnery Rs/mt 4/	-172	-197	-224	-134	-153	-174
Ginning Charges Rs/mt 5/	-299	-315	-360	-299	-315	-360
Pressing Charges Rs/mt 5/	-249	-262	-300	-249	-262	-300
Lint Value Net of Processing at Ginnery Rs/mt	14,805	12,290	13,499	13,961	14,205	16,852
Seed Value Net of Ginning at Ginnery Rs/mt 6/	1,117	1,248	1,387	1,370	1,539	1,710
Lint Ginning Percentage (%) 7/	34	34	34	36	36	36
Value of Seed Cotton at Ginnery Rs/mt 8/	5,771	5,002	5,505	5,903	6,099	7,161
Transportation and Marketing to Ginnery Rs/mt 9/	-68	-90	-112	-68	-90	-112
Farmgate Import Parity Price Rs/mt 10/	5,703	4,912	5,393	5,835	6,009	7,049
Farmgate Import Parity Price Rs/kg 10/	5.70	4.91	5.39	5.83	6.01	7.05

(NOTES ON FOLLOWING PAGES)

NOTES FOR TABLE 14

1/ Orleans, Texas variety quoted for crop year August-July (Cotton Outlook, Liverpool Services, Liverpool, England). Mexican variety quoted for calendar year ("Commodity Price Forecasts - Updating", World Bank memorandum from EPDCE, November 12, 1980).
2/ Insurance and freight charges are based on differences between actual f.o.b. prices from sales in Tanzania and corresponding c.i.f. prices in northern Europe. Shipping routes from Dar es Salaam and Bombay through the Suez Canal are approximately equal in distance. India is a net cotton importer historically.
3/ Converted at the official exchange rates: Rs. 8.563:$1.00 (1977/78); Rs. 8.206:$1.00 (1978/79); and Rs. 8.076:$1.00 (1979/80).
4/ Rail transportation charges are based on estimates of economic costs for 1978/79 specific to raw cotton and the selected distances of 650 km for the Mexican variety, and 1,250 km for the Texas variety. These distances correspond to the middle of the growing belt for comparable varieties in India. These costs assume diesel locomotives travelling double line routes. Charges for other years are adjusted by the WPI of diesel oil. Cost estimates are found in Annexure 3.2 to the Report to the National Transportation Policy Committee, May 1980 (GOI Planning Committee) which is considered to be the most comprehensive study available. Implied costs for 1978/79 are 0.158 Rs/mt-km over the longer route, and 0.235 Rs/mt-km on the shorter route. Estimates of economic costs by the Ministry of Railways for raw cotton (1979/80) are 0.151 and 0.173 Rs/mt-km over 800 and 1,500 km, respectively ("Memorandum for Explaining Proposals for Adjusting Freight Rates and Fares in 1980/81"). An estimate of non-rail transportation from mid-Maharashtra and M.P. to Bombay implied actual costs were 0.15 Rs/mt-km in 1976/77 (A Comparative Study of Cotton Marketing System in India, Indian Merchants Chamber, Economic Research and Training Foundation, Bombay, September 1978, p. 129). Wholesale price determination is assumed to take place in Bombay, so internal transportation is subtracted from that location.
5/ Average ginning charges in 1976/77 for Maharashtra and M.P. were Rs 29.5 per quintal, and pressing charges were Rs 24.6 per quintal for the two states (A Comparative Study of Cotton Marketing Systems in India, Indian Merchants Chamber, Economic Research and Training Foundation, Bombay, September 1979, p. 129). These charges were adjusted by the WPI for fuel, power, light and lubricants for the subsequent years. The total in 1976/77 of 54.1 Rs/quintal is almost exactly equal to an independent estimate of ginning and pressing costs in Haryana (American cotton) for that year of 55.8 Rs/quintal (Dynamics of Cotton Production and Marketing in Haryana, I.J. Singh, et. al, Department of Agricultural Economics, Haryana Agricultural University, Hissar, January 1979, Table 3.18). Therefore, the same charges were used for both varieties and locations. The figure for Haryana includes marketing charges incurred by the ginner, ginning and pressing costs and margins, and the value of wastage and losses in ginning.

CONTINUATION OF NOTES FOR TABLE 14

6/ The 1977/78 value of cotton seed is based on a 10-month average in Bombay, Berar variety (Annual Cotton Statistics 1977/78, Agriculture and Cooperative Departments, Government of Maharashtra, Bombay, Table 5.10). The average is 153 Rs/quintal. A price of 190 Rs/quintal was obtained from the Maharashtra State Cooperative Marketing Federation for 1979/80, and the price for 1978/79 was interpolated. These prices were adjusted by crushing percentages since the value of the seed is in the oil. The crushing percentage for Maharashtra of 90% (Cooperative Marketing Federation) was applied to the Texas variety. Distortions in seed prices were ignored. The national average percent crushed was estimated as follows:

$$\frac{(3.5 \text{ mmt vegetable oil production})(8\% \text{ from cotton})/(15\% \text{ oil from seed})}{(1.373 \text{ mmt lint production})(1.86 \ \frac{\text{mt seed}}{\text{mt lint}})}$$

= 73% crushed.

7/ A ginning percentage of 36 is typical of L-147, DHY-286, and an average of varieties in the central region. A 34% ginning rate applies to American 320-F, and H-4, and is an approximate average of varieties grown in Punjab and Haryana (Cotton in India - A Profile, Directorate of Cotton Developments, Bombay, January 1980, Table 4(c)).

8/ For the Texas variety, the value of seed cotton equals 0.34 times (lint value net of and losses processing) +0.66x(seed value net of ginning).

9/ Transportation and marketing charges incurred by the producer were estimated to be 6.18 Rs/quintal in Haryana in 1976/77 (Dynamics of Cotton Production and Marketing in Haryana, Table 3.18). Costs in Maharashtra are given as 7.50 Rs/quintal in 1978/79, and 11.20 in 1979/80 (Maharashtra Agriculture and Cooperative Department, A.P.C. cell). The latter figure was used for 1979/80, the two sources were averaged for 1977/78, and the estimate for 1978/79 was interpolated. Note that some marketing costs are borne by the ginner, and are included in ginning costs (c.f. Note 5).

10/ Does not include the value of cotton sticks for fuel which was estimated to be 50-55 Rs/ha in Haryana in 1979 (Package of Practices for Kharif Crops, 1980, "Economics of Important Kharif Crops in Haryana, 1979", Haryana Agricultural University, Hissar, p. xix).

TABLE 15

Nominal Protection Coefficients for Seed Cotton 1/

	Punjab/Haryana			Maharashtra			Gujarat	
	1977/78	1978/79	1979/80	1977/78	1978/79	1979/80	1977/78	1978/79
Typical Realized Producer Price Rs/Kg	3.81 2/	3.33 3/	3.50 4/	4.14 5/	3.52 5/	3.55 5/	3.65 6/	3.02 6/
Maximum Realized Producer Price Rs/Kg	4.19 7/	3.66 7/	3.85 7/	4.35 8/	4.26 8/	4.18 8/	4.41 9/	3.65 10/
Farmgate Import Parity Price Rs/Kg 11/	5.70	4.91	5.39	5.83	6.01	7.05	5.83	6.01
Typical Nominal Protection Coefficient 12/	0.67	0.68	0.65	0.71	0.59	0.50	0.63	0.50
Maximum Nominal Protection Coefficient 12/	0.74	0.75	0.71	0.75	0.71	0.59	0.76	0.61

1/ Prices refer to seed cotton (kapas); nominal protection coefficients are measured at farmgate as the ratio of the received price to the import parity price.

2/ American 320-F in Punjab, monthly wholesale averages for Abahar and Bhatinda. Although this variety is about 1.5 mm shorter than the Orleans, Texas variety used for international comparison, this particular price quotation includes some compensating marketing costs (c.f. Note 7). Source: Agricultural Prices Commission, Report on Price Policy for Raw Cotton for the 1978/79 Season, June 1978, p. 20.

3/ Found from quotation for 1977/78 using the WPI for raw cotton.

4/ American 320-F in Haryana, from farm survey (Package of Practices for for Kharif Crops, 1980, "Economics of Important Kharif Crops in Haryana, 1979", Haryana Agricultural University, Hissar, 1980, p. xxxv).

5/ L-147 (26.2 mm) FAQ, Maharashtra State Cooperative Marketing Federation (c.f. Note 3, Table 6 and Tables 7 and 11 for comparisons with other sources).

6/ Co-2 (Cambodian-C variety, 27 mm), producer surveys (Production Economics of V-797 and Co-2 Cotton in Gujarat State, 1977/78 and 1978/79 (two studies), S.M. Patel and M.K. Pandey, Institute of Co-operative Management, Ahmedabad, published July 1979 and March 1980, p. 77 (earlier study) and p. 72 (later study). The estimate for 1978/79 is a mid-range point.

7/ These estimates are simply 10% higher than the typical figures above. This differential more than captures the normal premium of SRT-1 and J-34 above American 320-F. These varieties are somewhat longer and hence more comparable to the Texas variety.

8/ Represents final prices received for B-1007, S&S, superior, in Maharashtra. This is a high "upper bound" since the prices are for the top grade of a longer variety. The prices are similar to those in Andhra Pradesh and Karnataka. (Annual Cotton Statistics, 1977/78, Agriculture and Co-op Departments, Government of Maharashtra State Cooperative Marketing Federation.

9/ Derived from the differential between the mid-point and the maximum for 1978/79. Another estimate of a maximum for this year can be obtained from the mean of the monthly averages for Digvijay (23 mm) and H-4 (29 mm), giving an average length of 26 mm compared with about 25.4 mm for the Orleans, Texas variety. The combined wholesale figure for Broach, Gujarat is 4.91 Rs/kg (source as in Note 2), yielding a maximum Nominal Protection Coefficient of 0.82.

10/ Actual maximum price received for Co-2 in the survey (c.f. Note 6).

11/ Found from the previous table. The Orleans, Texas variety is matched to 320-F, and estimates for SRT-1 and J-34 in Punjab and Haryana; the Mexican variety is matched to L-147 and B-1007 in Maharashtra and Co-2 in Gujarat.

12/ The Nominal Protection Coefficients express ratios of what a farmer receives to an estimate of what he would receive under free trade and no economic distortions, except in exchange rates or in factor markets.

coefficients are very low in three key production areas of India, and have been declining (Table 15). For example, cotton growers in Maharashtra received about 80% of the price that would have prevailed under free trade in 1977/78, but only 60% of the parity price in 1979/80. The NPCs in the Punjab/Haryana area averaged 0.77. The NPCs were also computed using the maximum realized producer prices rather than those considered most representative. These NPCs found from maximum received prices did not exceed 0.87 and also exhibit a decline in the most recent period. 1/

Income to cotton farmers is severely reduced by restricted access to world markets, viz. they are receiving "negative protection". Alternatively phrased, cotton spinners and weavers are significantly benefited by not having to pay world prices for cotton lint. 2/ *A priori*, it cannot be said whether these benefits eventually reach the consumer in terms of lower clothing and cloth prices. However, the real cotton textile price index has been steadily dropping (see Table 21).

The import parity prices, or economic prices in this study, are generally higher than those used in World Bank appraisal reports relative to prices actually received (Table 16). Although the prices used in the appraisals are calculated for various locations and points in time, the economic and financial prices are often nearly equal, implying NPCs of about 1.0. The implication is that there is very little distortion in cotton prices and farmers are neither positively nor negatively protected. (The Maharashtra Irrigation II and Gujarat Irrigation II appraisals also imply NPCs of about 1.0 in 1990). The Haryana Irrigation project appraisal is the major exception: the NPC is 0.67 in 1977/78, compared with the NPC of 0.75 found here for that year (Table 15) and is 0.79 and 0.76 for 1978/79 and 1979/80.

Exports are inhibited by tariffs in addition to policy decisions on quotas. Export duties left over from the 1960s of 1 Rs/kg equal *ad valorem* rates of 8%-12% depending on the price and year. In recent years,

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1/ The recent decline can be inferred from the drop in domestic cotton price indices, relative to world indices, shown in Figure 3 above. However, since the figure does illustrate indices, it does not portray the relative levels of domestic and world prices, but only their inflation-adjusted movements.

2/ The atomistic and cooperative-society nature of primary marketing and ginning supports various studies which indicate disproportionate profits are not being skimmed away at these stages. Wholesale marketing to the mills and textile marketing are not examined here.

TABLE 16

COMPARISONS OF NOMINAL PROTECTION COEFFICIENTS FOR SEED COTTON IN VARIOUS APPRAISALS AND THE PRESENT STUDY

Project	Appraisal Date	Year of Prices	Prices Deflated to Year	Farmgate Seed Cotton Prices Financial	Farmgate Seed Cotton Prices Economic	Implied NPC
				---------------Rs/kg---		
Rajasthan Canal	July 1974	1974	-	2.10	2.10	1.00
Integrated Cotton Development	December 1975					
Sirsa, Haryana		1980	-	2.50	1.80	1.39
Amraoti, Maharashtra		1980	-	2.80	2.00	1.12
Faridkot, Punjab		1980	-	2.50	1.80	1.39
Haryana Irrigation	July 1978	1977/78	-	3.30 1/	4.92 1/	0.67
		1987/88	1977/78	3.50 1/	4.90 1/	0.71
Punjab Irrigation	March 1979	1978	-	3.50 2/	4.24 3/	0.85
Maharashtra Irrigation II	October 1979	1979	-	5.00 4/	5.06 4/	0.99
		1990	1979	5.40 4/	5.44 4/	0.99
Gujarat Irrigation II	April 1980	1979	-	5.08 5/	4.58 5/	1.11
		1990	1979	5.36 5/	5.76 5/	0.93
Karnataka Tank Irrigation	February 1981	1980	-	5.50 6/	5.02 6/	1.09
Present Study						
Punjab/Haryana		1979/80	-	3.50	5.39	0.65
Maharashtra		1979/80	-	3.55	7.05	0.50
Gujarat		1978/79	-	3.02	6.01	0.50

1/ Prices refer to American varieties. Implied NPCs for "other" varieties were 0.66 1977/78 and 0.70 for 1987/88.

2/ American varieties.

3/ The appraisal estimates an economic price of Rs 5.20/kg for 1985, but gives no estimate for 1978. This implied economic price for American varieties in 1978 followed through the appraisal's derivation substituting a world price for that year. A similar approach for Desi varieties yielded an NPC of 0.73 for 1978 implied in the appraisal.

4/ Hybrid varieites. The NPCs implied in this appraisal for local varieties were 0.98 for both time periods.

5/ Prices refer to hybrid varieties. The appraisal's NPCs for local varieties were 1.11 for 1979 and 0.93 for 1990.

6/ Medium/long staple varieties. The appraisal gave the financial price for 1980 and the economic price forecast for 1990. The implied economic price for 1980 was worked out as explained in footnote 3/.

the duty has been lifted on the longer staple lengths, being those over 24.5 mm. The remaining flat rate per kg on shorter-fiber lengths is regressive and has perverse income distribution effects. Poorer farmers tend to grow the shorter varieties since the longer hybrids require additional inputs, but the longer varieties fetch higher prices. Therefore, the wealthier farmers tend to escape duties on exports of long fiber cottons. The implicit ad valorem rate is highest for the shortest and least valuable varieties, characteristically grown by less affluent farmers.

The price effects of trade restrictions have held down production, as evidenced by significant own and cross-price elasticities of supply. A regression of total production on lagged nominal indices of raw cotton and foodgrains prices, and lagged proportion of irrigated cotton over the 25 years 1955/56 to 1979/80, gave this result: 1/

$$LN(PROD) = \underset{(0.188)^{***}}{7.5} + \underset{(0.127)^{**}}{0.284}\, LN(PCOT_{-1}) - \underset{(0.152)^{*}}{0.282}\, LN(PGRA_{-1}) + \underset{(0.179)^{**}}{0.405}\, LN(IRR_{-1})$$

R^2 (adjusted) = 0.65 F(3,21) = 15.7 DW = 2.5

LN	=	log base e
PROD	=	cotton lint production (thousand 170 kg bales)
$PCOT_{-1}$	=	previous raw cotton price index, nominal terms, (1970/71 = 100)
$PGRA_{-1}$	=	previous foodgrains price index, nominal terms, (1970/71 = 100)
IRR_{-1}	=	previous proportion irrigated cotton (percent)
***	=	significant at 1%
**	=	significant at 5%
*	=	significant at 10%

Standard errors are shown in parentheses.

The coefficients of cotton price and foodgrains price, which are approximately equal in magnitude but opposite in sign, can be interpreted as supply elasticities since the double natural log form is used. Production has been significantly sensitive to both price series. If cotton

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1/ The irrigated proportion behaves like a trend variable since it grows smoothly. Lagging the proportion reduces the number of contemporary endogenous variables when the equation is used in a larger system, and reflects the assumption that land and water allocations reflect previous prices and behavior (see Section VII).

farmers received 100% of the import parity prices adjusted to farmgate, output would increase 10%-15% according to this regression. Similarly, if nominal index prices for foodgrains fell to the level of cotton prices, or if cotton prices moved up to meet grains prices (changes of 16%-18%) cotton production would expand by about 5%. The near equality of the elasticities in absolute value implies a quite rational symmetric response to relative price movements between grains and cotton. However, these estimates are based on nominal prices. When the regression is run in real prices, emphasis shifts toward the role of foodgrains prices in determining the supply of cotton through the negative cross-price elasticity. This finding is discussed in the context of a simultaneous supply/demand model developed in the following section.

SECTION VII

A MODEL OF SUPPLY AND DEMAND FOR COTTON AND COTTON TEXTILES WITH PROJECTIONS AND POLICY ALTERNATIVES

A. The Model

Since cotton can be traded and consumed in various stages of processing, an integrated supply-demand model should include the behavior of cotton mills in order to link producers to final consumers. One formulation of such a model is shown below:

(1) $\mathrm{PROD} - a_1 - b_1\ \mathrm{PLINT}\ (-1) - c_1\ \mathrm{PGRAIN}\ (-1) - d_1\ \mathrm{IRR}\ (-1) = E_1$

(2) $\mathrm{MILLCON} - a_2 - b_2\ (\mathrm{PLINT} + \mathrm{PLINT}\ (-1))/2 - c_2\ \mathrm{PTEX}\ (-1) - d_2\ (\mathrm{TIME}) = E_2$

(3) $\mathrm{PRICON} - a_3 - b_3\ \mathrm{PTEX} - c_3\ \mathrm{EXPEND} = E_3$

(4) $\mathrm{PROD} - \mathrm{MILLCON} - \mathrm{BALRAW} = 0$

(5) $k\mathrm{MILLCON} - \mathrm{PRICON} - \mathrm{BALTEX} = 0$

Equations (1) - (3) are stochastic giving the supply of lint, mill consumption of lint, and private consumption of cloth, respectively. Equations (4) and (5) are identities in raw cotton lint and cloth, which largely depend on imports and exports (see discussion below). The stochastic equations are shown solved for the error terms (Ei) for reasons that will become apparent, although the first variable is the dependent quantity in each case. The definitions, means, and growth rates of the variables are given in Table 17. In the following section, this model is estimated and used for five- and ten-year projections.

Equation (1) relates lint production to lagged real lint and foodgrains price indices, and to the lagged proportion of cotton area under irrigation. Of course, it could be argued that production depends on the current irrigated proportion, but here production is viewed as a land and water allocation decision at the beginning of the crop cycle. The decision depends on previous profitability in this model, which is affected by irrigation in the last crop cycle. In practice, the irrigation variable grows in a uniform manner which minimizes the significance

TABLE 17

Definitions, Means and Growth Rates of Model Variables

Variable	Definition 1/	Units	Mean Value 1954/55-1979/80	Growth Rate 1954/55-1979/80 (percent)
Endogenous				
PROD	Domestic Production of Cotton Lint	1,000 metric tons	913.00	1.98*
MILLCON	Mill Consumption (Purchases) of Lint	1,000 metric tons	1086.20	1.16*
PRICON	Total Private Consumption of Cotton Cloth	1,000,000 square meters	6962	1.36*
PLINT	Deflated Wholesale Price Index of Raw Cotton	Percent (1970/71=100)	89.93	-0.10
PTEX	Deflated Wholesale Price Index of Cotton Textiles	Percent (1970/71=100)	105.94	-1.53*
Exogenous				
PGRAIN(-1)	Lagged Deflated Wholesale Price Index of Foodgrains	Percent (1970/71=100)	97.16	0.08
IRR(-1)	Lagged Proportion of Cotton Area Under Irrigation	Percent	18.11	4.97*
EXPEND	Total Real Private Consumption Expenditure	Billion Rs. (1970/71 Prices)	267.9	2.78*
BALRAW	Identity Balance of Cotton Lint: See text (Positive=Exports)	1,000 metric tons	-114.4	-6.16*
BALTEX	Identity Balance of Cotton Cloth: See text (Positive=Exports)	1,000,000 square meters	1130.5	0.01
Lagged Endogenous				
PLINT(-1)	Previous Period Value of PLINT	-	-	
PTEX(-1)	Previous Period Value of PTEX	-	-	
Constant or Trend				
TIME	Annual Time Trend (1954/55=1)	Counting units	-	-
k	Conversion Factor from Lint to Cloth (assumed constant)	7.45 m^2/kg	7.45	-
Coefficients				
a_1, b_1, c_1, d_1		-	-	-
$a_2, b_2, c_2, d_2, a_3, b_3, c_3$	Unknown Structural Coefficients to be Estimated	-	-	-
Stochastic				
E_1, E_2, E_3	Random Error Terms in Stochastic Structural Equations	-	-	-

* Statistically significant at 5% type I error level (95% confidence).

1/ Data represent financial years.

of whether it is used as a current or lagged variable. (Its uniform growth also allows it to serve as a trend-capturing variable.) 1/

Equation (2) states that mill consumption of cotton lint is a function of the average of current and lagged real lint prices, lagged real cotton textile prices, and a trend variable. It is theorized that carry-over stocks of lint and yarn, and adjustments in lint prices between the production and mill-consumption cycles, result in current mill consumption depending heavily on earlier acquisition prices, but equally influenced by current lint prices. Equation (2) uses an average price over two periods for this reason. (Current prices affect purchases by mill agents in anticipation of future mill demand, and may have a simultaneous effect on the current rate of consumption and stocking policies.) Mill consumption also responds to the previous period's real wholesale cotton textile price.

Private total consumption of cotton cloth, measured in square meters, is represented as a function of current real textile prices, and current total consumption expenditure in real terms (equation (3)). It is estimated that 80% of blended and mixed fabrics are cotton, and this proportion of these textiles is added to pure cotton cloth when measuring private consumption (see Table 21).

The difference between production and mill consumption is defined as a raw cotton balance. This variable, "BALRAW" captures changes in mill stocks, and net trade. Since changes in mill stocks cumulatively can be assumed to equal zero (except for small net build-ups), the variable largely represents net trade. Powerloom and handloom textile production utilize yarn from cotton mills, so their demands for cotton are almost all accounted for in mill consumption. Losses in storage and processing of pressed bales equal to about 3% are also present in this variable. Most of the losses occur in spinning. Production is measured in pressed bales of lint in the model. Therefore, the much larger losses occurring during ginning are already netted out. Exports of lint receive a positive sign according to equation (4), but the mean of BALRAW, or the raw lint balance has been -114.4 thousand tons since 1955 (Table 17). This gap between production and mill consumption can be decomposed as follows: 3% losses in storage and processing (0.03 X 913 thousand tons average production) plus 70 thousand tons average net lint imports plus 17 thousand tons

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1/ This multicollinearity weakens the interpretation of the pure impact of irrigation. Hence the approach adopted in Section III entitled "Sources of Production Growth".

extra-mill consumption 1/ (equal to an estimated average of one hundred thousand bales). The growth rate of the cotton lint balance is -6.16 per cent per year (statistically significant) on a negative base level. This implies India is systematically reducing its position of being a net importer.

A similar balance exists for cotton textiles between mill consumption of cotton converted to a cloth equivalent figure, and private cotton cloth consumption, adjusted for the cotton content of blended fabrics. This balance is called "BALTEX" in the model. Net exports correspond to positive values. Year-to-year changes in cotton textile stocks are included in BALTEX. The conversion factor between lint and cloth, defined as "k" in equation (5), is 7.45 square meters (m^2) per kg. This figure is the average ratio of the square meters of cloth produced to the weight of spun yarn for the decade of the 1970s. 2/ The ratio is nearly constant over the decade, but has a slightly downward trend, indicating cloth is getting heavier. The ratios used to find the average include handloom and powerloom production, blended, and mixed-manmade fabrics. This actual average is lower than the typical industry figure of $10m^2$/kg.

BALTEX has no significant trend, and a mean value of 1.13 million m^2 over the last 25 years. Although the mean is found from the balancing identity in equation (5), it can be compared with actual net trade in textiles. Net exports of cotton cloth from mills, handlooms, and powerlooms, plus the cloth equivalent of net exports of cotton yarn over the last 15 years equals about 0.6 million m^2. Cotton apparel, cotton hosiery, handloom and powerloom manufactures account for 0.3-0.4 million m^2. 3/ The remainder of the 1.13 million m^2 is approximately accounted for by other cotton manufactures including made-up items, and blended fabrics and fibers.

The identities expressed in equations (4) and (5) are necessary to close the model, and they allow projections to be made given parametric

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1/ Extra-mill consumption averages about 1.5% of mill consumption, and is included in mill consumption as domestic utilization in this discussion. From the standpoint of projections, it is assumed to drop to zero.

2/ Handbook of Statistics on the Cotton Textile Industry, Indian Cotton Mills Federation (Bombay, 1980), Table 18.

3/ This is a rough estimate derived from the value of trade assuming the cost per square meter for finished goods 1.5 to 2 times higher than for cotton cloth. See Table 37 of the Handbook of Statistics on the Cotton Textile Industry.

assumptions about trade flows. This five-equation simultaneous model has five current endogenous variables: lint production, mill consumption of lint, private consumption of cloth, the real lint price index, and the real textile price index. The other nine non-stochastic variables are exogenous, lagged endogenous, or constant and trend variables, as shown in Table 17. The data for the model are given in Appendix C and cover 25 years from 1955/56 to 1979/80 (plus 1954/55 for lagged variables). Prices and final consumption expenditure are in real terms which are useful for projections.

The model can be written in matrix notation to facilitate finding the reduced form which is necessary for projecting.

$$(6)\quad \beta Y_t + \Gamma X_t = U_t$$

Equation (6) is equivalent to equations (1) - (5) where β is a matrix of coefficients of current endogenous variables, Y_t is a vector of current endogenous variables, Γ is a matrix of coefficients of exogenous and lagged endogenous variables, X_t is the vector of these variables in the current period, and U_t is the error vector.

$$\beta = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -b_2/2 & 0 \\ 0 & 0 & 1 & 0 & -b_3 \\ 1 & -1 & 0 & 0 & 0 \\ 0 & k & -1 & 0 & 0 \end{bmatrix}$$

$$Y_t = \begin{bmatrix} \text{PROD} \\ \text{MILLCON} \\ \text{PRICON} \\ \text{PLINT} \\ \text{PTEX} \end{bmatrix}$$

$$\Gamma = \begin{bmatrix} -b_1 & -c_1 & 0 & 0 & 0 & 0 & 0 & -d_1 & -a_1 \\ -b_2/2 & 0 & -c_2 & 0 & 0 & 0 & -d_2 & 0 & a_2 \\ 0 & 0 & 0 & -c_3 & 0 & 0 & 0 & 0 & -a_3 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{bmatrix}$$

$$X_t = \begin{bmatrix} \text{PLINT } (-1) \\ \text{PGRAIN } (-1) \\ \text{PTEX } (-1) \\ \text{EXPEND} \\ \text{BALRAW} \\ \text{BALTEX} \\ \text{TIME} \\ \text{IRR } (-1) \\ 1 \end{bmatrix}$$

$$U_t = \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ 0 \\ 0 \end{bmatrix}$$

If β is invertible, (6) can be solved for current endogenous variables, i.e., the reduced form:

(7) $Y_t = \Pi X_t + V_t$

where $\Pi = -\beta^{-1}\Gamma$ and $V_t = \beta^{-1} U_t$.

Gauss-Jordan reduction techniques show the inverse exists:

$$\beta^{-1} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & -1 & 0 \\ k & 0 & 0 & -k & -1 \\ 2/b_2 & -2/b_2 & 0 & -2/b_2 & 0 \\ k/b_3 & 0 & -1/b_3 & -k/b_3 & -1/b_3 \end{bmatrix}$$

Examination of the $-\beta^{-1}\Gamma$ product matrix leads to the conclusion that each equation in the model is exactly identified. Indirect least squares (OLS estimation of each reduced-form equation) applied to an exactly-identified system yields an identical result as two-stage least squares (2SLS) or least-variance ratio estimation of the structural equations. Although the estimators of the structural parameters will be biased in expectation, they will be consistent (they converge to the true values in the probability limit). Moreover, some Monte Carlo studies 1/ indicate 2SLS estimators may be superior in terms of low bias to full-information maximum likelihood (FIML) or limited information single equation (LISE) approaches when exogenous variables are strongly correlated. Such correlation is present in the model at hand between time, the irrigated proportion of cotton, and real consumption expenditure, for example. In cases of mis-specification, 2SLS is also often superior to FIML and LISE as measured by root mean square error -- a combination of an estimator's bias and standard deviation.

For these reasons, indirect least squares (here equivalent to 2SLS) was adopted and the reduced form was estimated in double-log form (except for the BALRAW and BALTEX variables which had negative values). The estimates of the reduced-form equations are given in Appendix B where they are presented as a computer model for prediction. (Prediction with a simultaneous system requires iterative solutions of the reduced form for current endogenous values one period at a time.)

B. Elasticities

The elasticities of the structural form were derived from the reduced-form coefficients, and are presented in Table 18. The signs of the elasticities correspond to expectations. Note the price responsiveness of mill consumption to lint and especially to textile prices. The responsiveness should probably be viewed as a long-run adjustment in which most of the increase in cotton utilization requires new investment in plant and equipment.

Private cloth consumption has a highly negative price elasticity, suggesting cotton cloth consumption can at least be deferred or reduced considerably when prices are high. The expenditure elasticity, 0.405, is rather interesting to compare with cross-sectional estimates from various sources and National Sample Survey Rounds (NSS).

Table 19 shows that a simple time-series estimate of the expenditure elasticity (0.489) is somewhat higher but similar to the model value, whereas cross-sectional estimates are typically several times as large. However, the cross-sectional approaches rely on differences in expenditure between households, and assume a constant relationship between expenditure and quantity purchased. The range of quality differences for clothing and cloth are obviously vast in comparison with edible agricultural commodities. Wealthier households could double clothing expenditure with a

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1/ For example, R. Summers, "A Capital Intensive Approach to Small Sample Properties of Various Simultaneous Equation Estimates," Econometrica, Vol. 33, (1965) pp 1-41.

TABLE 18

Model Elasticities 1/

Definition	Value
Cotton Production	
Production w.r.t. lagged real lint price	0.074
Production w.r.t. lagged real foodgrains price	- 0.567
Production w.r.t. lagged irrigated proportion	0.421
Mill Consumption of Lint	
Consumption w.r.t. average of current and lagged real lint price	- 0.449
Consumption w.r.t. lagged real textile price	0.893
Private Consumption of Cotton Cloth (Total)	
Consumption w.r.t. current real textile price	- 0.688
Consumption w.r.t. total real private expenditure	0.405

1/ Elasticities for mill consumption and private consumption are derived from reduced-form parameters. The production equation is the same in reduced from as in the structural form, so the significance levels can be given. The direct price supply elasticity was not significant when estimated in real prices, although it was significant when estimated in nominal prices. The other supply elasticities were significant at 10% (cross-price) and 5% (irrigation). See text for comments on properties of model parameters.

2/ "w.r.t." is an abbreviation of "with respect to".

TABLE 19

Expenditure Elasticities of Cotton Cloth Demanded

Data Type and Time Period	Source	Value
Cross-Sectional, 1963 (mill-made)	Planning Commission a/	0.70-0.80
Cross-Sections loosely combined	R. Thamarajakshi	1.25
NSS 1970/71 Cross-Sectional	National Commission on Agriculture	1.86(rural) 1.64(urban)
NSS 1973-74 Cross-Sectional	Hitchings b/	1.82(rural) 1.68(urban)
1955-1979 Time-Series	Present Study/Simple Time Series c/	0.489
1955-1979 Time-Series	Present Study/Model	0.405

a/ Mill-made clothing.

b/ All clothing.

c/ Log-log form.

Sources: Planning Commission, Committee on National Resources, Study of Cotton in India, 1963, p.80.
Report of the National Commission on Agriculture, Demand and Supply, (1976), Appendix 10.2.
R. Thamarajakshi, Planning for Indian Agriculture: Performance, Perspective, and Policies.
Jon Hitchings, Part I of World Bank Staff Working Paper No. 500, (1981) p.13.

much smaller effect on square meters of cloth purchased than the quantity effect of doubling rice expenditures, for example, allowing quality substitution. If projections are made in terms of cloth or cotton weight (instead of m^2), the error in estimation is larger since more expensive clothing in India is often finer and actually weighs less. In addition, elasticities from NSS data for clothing also include expenditures on higher-priced blended and synthetic fabrics, which is another source of over-estimation. Therefore, while cross-sectional elasticities for clothing do reflect incremental expenditures, their bearing on physical quantities are much less reliable than time-series estimates. It is perhaps arguable that the difference between the two elasticities can be interpreted as a measure of quality substitution in clothing.

The supply equation in this model is the same in the structural as in the reduced form since output does not depend on current endogenous variables. When the equation was estimated in terms of nominal prices in the previous section, the own and cross-price (with respect to foodgrains) supply elasticities were equal in magnitude and opposite in sign: +0.284 and -0.282. When estimated with real prices, the supply effect depends almost entirely on the movement of foodgrains prices: the own-price elasticity is only slightly above zero. 1/ Two explanations are proposed for this apparent anomaly. First, the weight of foodgrains prices is much larger than cotton lint prices in the wholesale price deflator, and thus has a higher correlation with the deflator. Therefore, movements of real foodgrains imply larger adjustments in nominal terms (since they pull the deflator with them) than movements of real lint prices. By the same token, an erosion of real foodgrains prices, which can have large effects on farm income produces a much stronger shift into cotton (or other cash crops) than gains in real cotton prices.

A second consideration is that since substantial portions of foodgrain production are not marketed, production is less responsive to nominal price movements. (Rice, wheat and sorghum will be grown as staples even when prices are depressed). Cotton area is likely to adjust more to year-to-year nominal or real price configurations since it is not consumed on the holding. The stronger role of foodgrains prices on cotton production when cast in real terms rather than nominal terms is not especially paradoxical for these reasons.

The gap between the elasticities estimated in real and nominal terms can be narrowed somewhat by deflating the price data by a wholesale

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1/ The irrigation elasticities are nearly equal in both estimation cases, as are the sum of the absolute values of the price elasticities. In the real price case, R^2 (adjusted) = 0.65, F(3,21) = 16.18, DW = 2.60.

price index (WPI) which exludes foodgrains and cotton lint. These commodities have weights of 12.922% and 2.246% in the WPI, respectively. After deflation by the adjusted WPI, 1/ the own price elasticity was elevated to 0.138, and the cross-price elasticity with foodgrains was reduced (in absolute value) to -0.469. Excluding cotton textiles from the WPI, with a weight of 8.102%, yielded elasticities of 0.148 and -0.473. It might be argued that the most informative weights would reflect the expenditure patterns of cotton farmers which may be tilted more to foodgrains than the national norm. If such weights were available, the own-price elasticity of supply, in real terms, might rise incrementally.

Due in part to the simultaneous structure of the model, the shift in emphasis in favor of the direct elasticity and away from the cross-price elasticity, which is occasioned by the adjusted WPI, had a limited effect on the projections. The base case production projection for 1990/91 was altered by 2% (see case five in Table 20), and cloth consumption by 2.3%, after incorporating these modifications which included adjustment of the WPI for cotton textile prices.

C. Projection Results for 1990/91

Actual values of the variables for 1979/80 are given in row one of Table 20. Initialized values of exogenous variables (based on trend fits) appear in row two, and are the basis of model projections. As a type of calibration or reference point, straight growth-rate projections (which do not start with the initialized values) can be compared with the model base case (cases 3 and 4). The external assumptions for each set of projections are given in the first five columns of the table. (The main departure of the model base case from historical growth rates for exogenous variables is for total expenditure, set at 3.5% per year, in keeping with recent experience and other projection work). The model base predicts lower production and limit prices in 1990/91 than present growth rates imply, and slightly higher private cloth consumption. The exogenous changes in the trade balance for lint was chosen in the base case to model the starting assumption that net trade would become almost zero. 2/

1/ The adjusted WPI is given by:
$WPI' = (WPI - 0.12922\ P_G /100 - 0.02246\ P_L /100)\ 1.1788$
where P_G is the nominal price index for foodgrains and P_L is the nominal price index for cotton lint. Multiplications is by 1.1788 since $1/(1-0.1299-0.02246) = 1.1788$, which lets WPI = 100 in the base year. A similar procedure purges WPI of cotton textile prices.

2/ BALRAW = 3.1 thousand tons by 1990/91 under the first assumption.

TABLE 20

PROJECTION RESULTS GIVEN ALTERNATIVE HYPOTHESES

CASE NO.	CASE DESCRIPTION (Departure from base case)	CHANGE RATE OF EXOGENOUS PARAMETERS a/ FOODGRAINS Real Price Index	CHANGE RATE OF EXOGENOUS PARAMETERS a/ TRADE b/ Textiles (+ =	TRADE b/ Lint Exports)	IRRIGATION Proportion cotton area	EXPENDITURE Total	ENDOGENOUS VARIABLES PRODUCTION Cotton Lint	CONSUMPTION Mills (Lint)	CONSUMPTION Private (Cloth) Total	CONSUMPTION Private (Cloth) Per Capita c/	REAL PRICE INDEX Cotton Lint	REAL PRICE INDEX Cotton Textiles	EXOGENOUS VARIABLES REAL PRICE INDEX Foodgrains (Lagged)	NET COTTON TRADE BALANCE b/ Textiles (+ =	NET COTTON TRADE BALANCE b/ Lint Exports)	Irrigated Proportion (Lagged)	Private Consumption Expenditure (1970/71 Prices)
		(%/yr)	(Million m²/year)	(1,000 tons/yr)	(% / yr)	(% / yr)	(1,000 tons)	(1,000 tons)	(Million m²)	(m²)	(1970/71 = 100)		(1970/71=100)	(Million m²)	(1,000 tons)	(%)	(Billion Rs)
	Variable Names						PROD	MILLCON	PRICON		PLINT	PTEX	PGRAIN(-1)	BALTEX	BALRAW	IRR(-1)	EXPEND
	1979/80																
1	Actual Values						1,309	1,174	7,963	12 10	75 8	90 6	92 9	779	135 2	28 3	352 5
2	Initialized Values (Exogenous Variables)	-	-	-	-	-	-	-	-	-	-	-	98 7d/	1,131d/	-29 9d/	28 3	352 5
	1990/91																
3	Growth Rates Only e/ (without model)	0 08	+0 06	+7 0	4 97	2 78	1,506	1,411	9,459	11 52	87 6	73 3	99 5	1,131	47 8	46 0	503 2
4	Model Base Case e/	0 08	+0 06	+3 0	4 97	3 5	1,437	1,434	9,554	11 63	77 8	74 2	99 5	1,131	3 1	46 0	514 6
5	Moderate Drop Food-grain Prices	-1	-	-	-	-	1,530	1,527	10,248	12 48	79 3	78 1	89 3	1,131	3 1	46 0	514 6
6	Faster Drop Foodgrain Prices	-2	-	-	-	-	1,632	1,620	10,939	13 32	80 7	82 0	80 7	1,131	3 1	46 0	514 6
7	Cotton Lint Imports	-	-	-20 0	-	-	1,429	1,679	11,381	13 86	71 8	73 1	99 5	1,131	-249 9	46 0	514 6
8	Cotton Textile Imports	-	-100 0	-	-	-	1,438	1,435	10,659	13 14	78 4	74 0	99 5	31	3 1	46 0	514 6
9	Moderate Drop Foodgrain Prices Textile Export Promotion	-1	+50 0	-	-	-	1,530	1,527	9,695	11 80	79 0	78 2	89 3	1,681	3 1	46 0	514 6
10	Moderate Drop Foodgrain Prices - Cotton Lint Export Promotion	-1	-	+15 0	-	-	1,531	1,395	9,263	11 28	79 1	78 4	89 3	1,131	135 1	46 0	514 6
11	Faster Drop Foodgrain Prices - Rapid Expen-diture Growth - Cotton Lint Export Promotion	-2	-	+20 0	-	5 0	1,640	1,450	9,673	11 78	94 3	78 7	80 7	1,131	190 1	46 0	602 9
12	Faster Drop Foodgrain Prices - Rapid Expen-diture Growth - Slower Irrigation Expansion - Cotton Lint Export Promotion	-2	-	+20 0	2 5	5 0	1,470	1,280	8,404	10 23	81 9	78 3	80 7	1,131	190 1	36 2	602 9
13	Faster Drop Foodgrain Prices - Rapid Expen-diture Growth - Slower Irrigation Expansion Cotton Lint Imports	-2	-	-20 0	2 5	5 0	1,467	1,721	11,687	14 23	82 5	77 5	80 7	1,131	-249 9	36 2	602 9
14	Faster Drop Foodgrain Prices - Cotton Lint Export Promotion - Cotton Textile Export Promotion	-2	+25 0	+15 0	-	-	1,623	1,487	9,677	11 78	80 4	82 2	80 6	1,406	135 1	46 0	514 6

a/ Continuous growth rates for foodgrains price index (1970/71 = 100), irrigation (growth rate of percent of cotton area under irrigation), and total private consumption expenditure in constant 1970/71 prices

b/ The cotton lint trade balance represents net imports or exports, changes in domestic stocks and a 3% allowance for losses in storage and processing of pressed bales The loss is mostly in spinning The cotton textile trade balance approximates the square meter (m²) equivalent of net imports or exports of mill-made, handloom and powerloom cotton cloths cotton yarns, made-up items, other cotton manufactures and changes in stocks (see text)

c/ Per capita consumption of cotton cloth in square meters assumes that 80% of blended fabrics are cotton and that the population is 658 1 million in 1979/80 (which reconciles total with per capita consumption in the Handbook of Statistics on the Cotton Textile Industry, p 34), and 821 3 million in 1990/91

d/ These initialized values for the projection model are based on trend fits for 1979/80

e/ The "Growth Rates Only" projections do not start from 1979/80 actual values or from "initialized" values, but simply extrapolate historical trends Model projections begin with "initialized" values

The exogenous irrigation variable continues to grow at an historical rate of 4.97%/year (that is, a growth rate in the 28% irrigated in 1979/80 equal to an absolute increase of 1.4%/year). The irrigated proportion would be 46% in 1990/91 under these assumptions: an increase of 18% over the present. If a further 18% of cropped cotton area were brought under irrigation in the decade of the 1990's, 64% would be irrigated by year 2000. This is one per cent less than proposed by the National Commission on Agriculture. 1/

Now suppose there is a moderate drop of real foodgrains prices equalling 1% per year. The foodgrains price index would be 89.3 in 1990/91. The real foodgrains price index has been 85.4 for 1979/80 and 84.3 for 1980/81, so a sustained level in the range of 90 may not be unattainable. The effect of falling foodgrain prices is shown in Case 5 of Table 20. Compared with the base situation, production of cotton rises 90 thousand tons, and lint prices rise 1.5% relative to inflation. The freed income from lower foodgrain prices diverts expenditure into textiles which increases consumption by nearly a square meter per capita. The heightened demand pushes real textile prices up four index points.

A faster drop in foodgrains prices, equalling 2% per year, would raise cotton production, cloth consumption and lint and textile prices even higher, but leave the foodgrain price index at 80.7 in 1990/91 which is probably unrealistic (Case 6). In this scenario, per capita cotton cloth consumption would be 13.3 square meters using a revised population projection of 821.3 million.

Table 20 presents projections utilizing eight other sets of assumptions to illustrate policy alternatives. Before turning to these results, a few comments on the simpler projection cases are in order.

One of the first reactions to Table 20 is likely to be that per capita cloth consumption is quite low in most cases compared with other projections, and especially in view of declining real cotton textile prices. However, Table 21 demonstrates that both consumption per capita and real prices have been falling fairly steadily for the last twenty years. The growth rate in textile prices given in Table 17 is - 1.53%/year, which is significant with 99% confidence. Although consumption of blended fabrics is growing, the cotton cloth figures in Table 21 have been adjusted to include 80% of the blended fabrics, which is a typical cotton proportion. However, the adjustment does not reverse the decline. Consumption was 12.10 m^2/capita in 1979/80 and only

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1/ Commercial Crops, Part VI, (Delhi, 1976), p. 179. The projection for cotton is 7.5 million hectares irrigated out of 11.5 million total, or 65% by A.D. 2000.

TABLE 21

Per Capita Woven Cloth Availability

	Man-Made Fiber	Blended/Mixed Fabrics	Cotton Cloth and Cotton Blended a/	Cotton Textile Real Price Index b/
	(square meters)			(1970/71=100)
1960	1.20	-	13.80	120.3
1961	1.15	-	14.76	119.9
1962	1.17	-	14.35	119.9
1963	1.24	-	14.69	117.1
1964	1.63	-	15.22	107.4
1965	1.73	n.a.	14.72	104.0
1966	1.65	n.a.	13.95	97.5
1967	1.74	n.a.	13.57	91.3
1968	1.90	n.a.	14.37	93.5
1969	1.79	0.20	13.76	94.8
1970	1.71	0.28	13.77	100.0
1971	1.72	0.45	12.74	103.9
1972	1.59	0.36	13.45	97.6
1973	1.46	0.44	12.37	97.2
1974	1.36	0.36	13.15	92.1
1975	1.37	0.61	13.04	84.4
1976	1.58	0.97	12.09	89.2
1977	1.86	2.32	11.31	95.5
1978	2.27	2.73	12.26	97.6
1979	1.98	2.54	12.10	90.6

a/ Pure cotton cloth plus 80% of blended/mixed fabric quantity gives an approximate total cotton equivalent.

b/ Wholesale price index, financial years (1960=1960/61 for example). Includes cotton yarn, mill, handloom and powerloom cloth, and khadi.

Sources: Handbook of Statistics on Cotton Textile Industry, Indian Cotton Mills Federation (Bombay, 1980) p.34;
Wholesale Price Statistics, Economic and Scientific Research Foundation.

10.2 m^2/capita on a pure cotton basis. This is down from 14.5 m^2/capita of pure cotton fabric in the 1950s and 1960s. Although textile prices were dropping, the trend in consumption was also negative at about -1% per year, again significant at 99% confidence. Of course, pure man-made fibers add two square meters per capita to total consumption, and improvements in quality may mean the cotton fabrics, as well as the blends, require less frequent replacement. Thus it does appear inconsistent that the model base case shows further declines in prices and consumption, albeit less than implied by extrapolations of trends. Other projections should be examined with these factors in mind.

D. Comparison of Projections

Projections from the model for various cases are reported in Appendix A for 1985/86. Some of these projections are reproduced in Table 22 along with other forecasts for comparison. One of the demand projections of the Central Institute for Cotton Research simply assumes a 2% growth rate for cloth requirements on a base of 13.7m^2/capita. Cotton cloth consumption has not been this high since 1970. Combined with a low population estimate of 682 million in 1983/84, 1/ the resultant forecast is 16.4m^2/capita. However, this high estimate should be considered more of a proposal than a projection. A second estimate from the Central Institute for Cotton Research, presented on the same page, is 19.96m^2/capita in 1985. This value is apparently taken from the National Commission on Agriculture (NCA) and used to derive production requirements. These "requirements" cannot be interpreted as a supply projection. The reported production target of two million tons lint necessitates a 5.2% compound growth rate in yield (since the cultivated area is presumed to remain stable in the Institute's work, as it has for two decades) compared with a 2.4% yield growth rate realized over the last ten years. The target is unlikely to be achieved.

The projection of 19.96m^2/capita by the National Commission on Agriculture seems unacceptably high for three reasons. First, the cross-sectional elasticities which were used express the willingness to spend more on clothing, and since the scope for quality substitution (improvement) is enormous, they greatly overstate the tendency to consume more cloth measured in m^2, and especially if measured by weight. The elasticities also include expenditures on higher-priced blended and man-made fibers. These points were discussed above. Secondly, 1961/62 was taken as the base year for consumption, which ignores the sharply

1/ Provisional census figures are 684 million in February, 1981.

TABLE 22

Comparisons of Supply and Demand Projections

Source	Projection Year	Cotton Lint Production (1,000 tons)	Cotton Cloth Consumption (1,000 tons)	Cotton Cloth Consumption (m²/capita)	Population (millions)
Central Institute for Cotton Research (1980)	1983/84	-	1,615a/	16.40a/	682
Central Institute for Cotton Research (1980)	1985	2,057b/	-	19.96	
National Commission on Agriculture (1976) (Low Case for Supply and Demand; Demand from cross-sectional data)	1985	2,070	1,453f/	19.96f/	725.6
R. Thamarajakshi (Cross-Sectional)	1983/84	-	1,299	15.74c/	701.3
Hitchings - Cross-Sectional (1981) (3.5% Expenditure Growth; No Income Redistribution)	1984/85 (1985/86)	-	1,050d/ (1,101)	14.11e/	744.2
Present Study - Time Series, Simultaneous Model					
A. Base Case	1985/86	1,299	1,159	11.57	746.1
B. Moderate Drop Foodgrains Prices (Case 5)	1985/86	1,340	1,201	11.99	746.1
C. Faster Drop Foodgrains Prices and Rapid Expenditure Growth and Slower Irrigation Expansion and Cotton Lint Imports (Case 13)	1985/86	1,315	1,313	13.11	746.1

a/ Simply assumes 2% growth rate. The implicit conversion factor is 6.9 m^2/kg if all cotton were used for cloth.
b/ Appears to be working backwards from NCA figure of 19.96 m^2/capita.
c/ The conversion factor used in the study was 8.5 m^2/kg.
d/ Includes all clothing in elasticities, but cotton only in the projection base. The figure in parentheses is adjusted for 1985/86.
e/ The study used a conversion factor of 10 m^2/kg rather than 7.45 m^2/kg used here. See comparisons in text for 1989/90.
f/ Uses a base level of consumption from 1960/61, and a conversion factor of 10 m^2/kg.

Sources: "Cotton at a Glance," Chokhey Singh (ed.), Central Institute for Cotton Research (Nagpur, 1980) p. 39. Figures also reported in "Objectives and Progress," Bulletin No. 1, p. 3.
Demand and Supply, Part III of the Report of the National Commission on Agriculture, (Delhi, 1976), Tables 10.8, 10.9, and 11.16, and Appendix 10.8.
Part I of India: Papers on Demand and Supply Prospects for Agriculture, World Bank Staff Working Paper No. 500, (1981), Table 4A.
"Planning for Indian Agriculture: Performance, Perspective, and Policies," R. Thamarajakshi,(undated), p. 17.

downward trend that has persisted for a quarter of century. 1/ Thirdly, the population estimate appears too low in light of the 1981 census. However, when million m^2 was converted to tons using $10.0m^2/kg$, the projection of the weight of cloth demanded in 1985 coincided more with other studies. 2/

The NCA "low" supply estimate assumes a 12.5% increase in cotton area by 1985 (although no trend is detected and no expansion is expected), a 7.2% compound growth rate in yields (or 42% total over the period), and rapid irrigation equal to 44% of the total cotton area by 1985. 3/ Trend increases, used in the present model indicate the irrigated proportion would reach 36% in that year. The NCA low estimate seems to be far too optimistical.

Thamarajakshi's projection in per capita terms also suffers from the over-estimation tendency of cross-sectional elasticities and a low population estimate. The weight of cloth is also taken to be less, at $8.5m^2/kg$. If the $7.45m^2/kg$ conversion factor and a 746.1 million population figure are applied to the weight projection of 1,299 thousand tons of cloth (see Table 22), this alone lowers the per capita estimate to $12.97m^2$.

Hitchings' cross-sectional projection, based on NSS survey data from 1973/74, also has high cross-sectional elasticities, but the base consumption level was found from conservative estimates of raw cotton production and utilization data. The base was 6% lower than direct estimates of cloth for 1973/74. 4/ The implicit conversion was $10m^2/kg$ which results in the projection of cloth weight for 1984/85 being lower while square meters per capita are higher than in the present study. The cross-sectionally derived projection in terms of weight, and adjusted to 1985/86 (shown in parentheses) is 5% lower than the base case for the simultaneous model: 1.101 versus 1.159 million tons. 5/

The higher elasticities in the the cross-sectional data cause the projection to be 7% above the simultaneous forecast by 1990/91: 1.37

1/ See page 7 of Demand and Supply.

2/ The projection was actually done in terms of square meters.

3/ Tables 11.6, 11.8 and 11.15.

4/ See footnote 14, page 8 of that paper.

5/ The adjustment is made by applying the instantaneous growth rate between 1979/80 and 1984/85 for one year.

versus 1.28 million tons for the base case. 1/ However, the base case of the model is considered a less-likely alternative than the assumption of moderately falling foodgrains prices from a trend-fitted, initialized index level of 98.7. The model projection under this scenario is almost identical, being 1.375 million tons. 2/

The Sixth Five-Year Plan calls for production of 1.56 million tons of lint in 1984/85 which is 16% higher than the model projection for the following year, assuming a drop in foodgrain prices. 3/ The feasibility of the Plan's target for cotton is discussed in the final section of this study.

All of the cross-sectional projections reported in Table 22 which express demand for cotton cloth in m^2/capita seem improbably high given the present levels and well-established trends. The NCA and Central Institute demand forecasts are likely to err on the high side, even when measured by weight. However, a reasonable degree of concurrence exists with Hitchings' study of the consumption outlook in weight terms, despite the inherent short-comings of cross-sectional expenditure elasticities for clothing.

Returning now to Table 20, cases six, seven, and eight illustrate three scenarios for reversing the trend of declining per capita consumption of cotton cloth, and increasing the level by a square meter or more over ten years: (1) rapidly falling foodgrains prices, (2) cotton lint imports, or (3) a reduction of cotton textile exports. Real foodgrain prices falling by 2% per year may not be too likely. The change rate in the lint trade balance, necessary to achieve consumption levels of 13.86m^2/capita by 1990/91, would be 20 thousand tons per year, assuming no change in foodgrains prices, and the other exogenous conditions. 4/ The raw lint "balance", approximately equal to the net trade balance adjusted for spinning losses, would then be about a quarter of a million tons in 1990/91. Unfortunately, the model does not capture the demand effects of price changes induced by lint imports at higher world prices, although it has been shown that imported lint is considerably more costly (Table 14),

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1/ Hitchings' projection of 1.31 million tons was advanced one year by the growth rate. The simultaneous model forecast was 9.554 billion m^2 (base case, see Table 20), which can be divided by 7.45 m^2/kg.

2/ Converting 10.248 billion m^2.

3/ Sixth Five-Year Plan, 1980-85, Planning Commission, Government of India, p. 120.

4/ That is, the net import series 20 thousand, 40 thousand, 60 thousand, etc., increasing each year and beginning with an initialized balance in slight deficit.

and that textile demand is quite price responsive (Table 19). The third possibility for raising domestic consumption would be a reduction of cotton textiles, yarn, and other net exports manufacured from cotton, which presently stand at around a billion m^2 equivalent on a fitted trend basis. A net export reduction of 100 million m^2 per year cloth equivalent, 1/ made up from all sources and diverted to domestic consumption would raise per capita availability by a square meter and leave net trade in textiles and yarn at about zero in 1990/91.

Cases 9 and 10 in Table 20 show that modest export growth at the rate of an incremental 50 million m^2 of textiles or 15 thousand tons of lint each year (30 thousand in the second year, etc.) are compatible with trends in domestic consumption provided foodgrain prices fall at the rate of 1%/ year from trend levels. However, these export goals do not allow for a reversal of the declining level of per capita cotton cloth consumption.

Case 11 illustrates that if a similar lint export goal 2/ coincides with a rapid expenditure growth rate of 5%, a faster drop in foodgrains prices would be needed to spur production to maintain trend-projected levels of domestic consumption. In this scenario, production would reach 1.64 million tons lint in 1990/91. It is estimated that the real lint price index would be 94.3.

Production is heavily dependent on irrigation. This is demonstrated by Case 12 which adds the assumption of slower irrigation expansion to the conditions of Case 11. The result is a sharp fall in production and consumption. Reversing the direction of the lint trade balance to 20 thousand tons net imports on an incremental basis (year over year), pushes consumption back up despite slower irrigation growth (Case 13). It is surprising that faster total expenditure growth (economy-wide) only moves real textile prices five to six index points above trend and base case levels for 1990/91. Although allowances can be made for the fact that changes in average quality, (which would account for some of the additional cloth expenditures), should not be reflected in a price index, the textile price effect of assuming rapid economic expansion may well be underestimated.

Finally, Case 14 illustrates that pursuing the goals of both cotton textile and lint export promotion are feasible within consumption trends only if foodgrains drop rapidly in prices, and again, the declining consumption trend is not reversed.

1/ A 100 million^2 reduction the first year, 200 million m^2 the second, and so on.

2/ An incremental 20 thousand tons per year in this case.

The cases shown in Table 20 represent only a few of many possible choices of exogenous assumptions. They were selected partly to portray the behaviour of the model and the effects of changing key parameters or policy objectives, rather than to illustrate only the more likely scenarios. Two of the model's prominent weaknesses are the heavy reliance on trends in exogenous variables, except when changed by assumption, and the failure to incorporate the effects of trade balances on real prices in a more direct manner, especially given higher world lint prices. The model obviously does not represent any of the adjustments to improved profitability that may be derived from agricultural research or altered cultivation practices as discussed in Section V.

Estimating the model in real prices may have understated the responsiveness of farmers to cotton price movements, and placed too much weight on the foodgrain sector. As discussed above, there seems to be a symmetric but opposite cotton production response to cotton or foodgrains price movements when measured in nominal terms. According to these elasticities, outside the model, giving farmers access to higher world prices through lint exports ought to significantly stimulate production. However, some arguments were advanced as to why real foodgrain prices might play a larger role in the supply of cotton over the long term than nominal foodgrain prices.

There appear to be strong grounds for dismissing most of the cross-sectional projections which forecast very high per capita cotton cloth consumption. Several of these projections are flawed either by weak methodology, cross-sectional bias in expenditure elasticities inherent to the commodity and heightened by aggregation with non-cotton cloth, or out-of-date population forecasts. They radically contravene trends and are not supported by the fuller, simultaneous estimation procedure used here.

The likelihood of various trade balance assumptions that were experimented with largely depend on policy choices. The importance of irrigation was demonstrated in Section III, and again when comparing Cases 11 and 12 in Table 20. The irrigation assumptions used in most of the projections may prove too sanguine. The expansion of irrigated cotton is, of course, critically influenced by new irrigation projects, external aid flows, and by the type of genetic or agronomic break-through that would alter relative profitability between crops. Given that a modest drop in foodgrain prices is in keeping with recent experience, Case 5 may offer the most likely outlook, although a reduction in textile exports might accompany accelerated expenditure growth. This projection case forecasts net lint trade in 1990/91 at about zero, production at 1.53 million tons of lint, and a slight increase in cotton cloth consumption to 12.5 m^2 per capita.

SECTION VIII

PRODUCTION OUTLOOK

The Sixth Five-Year Plan calls for the production of 1.56 million tons of lint (9.2 million bales) in 1984/85--a 25% increase over 1979/80, implying a growth rate of 4.6%. 1/ This is significantly above the model's projection of 1.35 million tons by 1985/86 assuming a moderate drop in foodgrains prices (Appendix A), and requires a growth rate 2% higher than over the last decade, i.e., almost double.

The Plan's trade outlook for 1984/85 is 51 thousand tons of lint exported--3% of the production target. 2/ About 14 thousand tons were imported in 1979/80 or 8 thousand tons net. The trend value for 1985/86 is 12 thousand tons net lint imports, which is used in the projection model. Both amounts are quite small and represent approximate self-sufficiency. The expansion of production is expected to come entirely from improved yields, although this is not stated explicitly in the Sixth Plan document. The National Commission on Agricultural visualizes no change in cotton area over the next twenty years. This outlook is echoed by the Directorate for Cotton Development and the Central Institute for Cotton Research. It is almost invariably concurred with by university researchers, district agricultural officers, seed farm and cotton project

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1/ Sixth Five-Year Plan 1980-85, Planning Commission, Government of India, p. 120.

2/ Ibid., p. 155.

personnel, and other agriculture and cotton specialists. The flat area trend of the last two decades is expected to continue. 1/

The required growth rate of 4.6% can therefore be interpreted as the yield growth rate necessary to achieve the Plan's target. The yield growth rate over the last ten years was 2.4%. Section III of this study (see Table 3) derived statistics which indicated 57% of the past yield growth rate is associated with an increased proportion of cotton under irrigation within States, while an additional 24% has come from shifts in total cotton area between States. Most of these shifts were away from States where cotton is grown under rainfed conditions and in favor of States where cotton is predominantly irrigated.

The Sixth Plan expects an additional 8.0 million hectares to be irrigated by 1984/85 for all crops. 2/ This is a 15% increase over 52.6 million hectares irrigated in 1979/80 (utilized irrigation). 3/ Cotton's share of the total irrigated area has remained virtually unchanged at 3.5% over a recent ten-year period (Section III, Table 4). Cotton's relative profitability will determine whether this pattern holds for the future. Assuming for the moment that it does, the planned increase in irrigation would result in 33% of all cotton being irrigated in 1984/85, which implies a change in proportion of just under 1%/yr. 4/ This is approximately in keeping with historical trends, as a footnote above suggests, and nearly coincides with the assumption of the supply/demand

---

1/ For example, there is a directive in Maharashtra to augment the land area devoted to forestry. No area expansion of cotton is foreseen. Horticultural crops tend to occupy the new and limited irrigated areas. Rainfed land allocations have remained nearly fixed at 50% cotton and 50% sorghum. Low cotton prices have recently caused land in Gujarat to be diverted away from cotton to pulse and oilseed crops. ("Present Status of Cotton Development and Future Prospects in Gujarat," G. B. Kasad, (Ahmedabad, 1980)). Sugarcane has been competing irrigated land away from cotton in Gujarat. Plant scientists have recommended reductions in cotton area to hold down the high production costs of improved practices. Profits are greater, they argue, when more labor, seed, and chemical inputs are concentrated on smaller plots. Reductions in cotton area are recommended in a study of optimal water use in Haryana (see below in this section).

2/ The Sixth Five-Year Plan, 1980-85, p. 155.

3/ Ibid., p. 148. This increase compares with a 31.5% increase between 1966/67 and 1976/77 (see Table 4).

4/ 1.15 x 28.7% irrigated in 1979/80.

projections that 36% of cotton would be irrigated in 1985/86 (see Appendix A).

However, the Plan's outlook for irrigation does not generate the required 4.6% yield growth rate. The change in irrigated proportion alone would result in an estimated yield growth rate of 1.64%. 1/ Historically, the irrigation-independent yield growth rate has been about 0.38%, for a total of 2.02%. The 0.38% includes the yield growth rate for irrigated cotton after any change in irrigated proportion is removed. Therefore, a reasonable conclusion is that the Plan's target will not be achieved unless the profitability of irrigated cotton increases vis-a-vis other irrigated crops, boosting cotton's share of the total irrigated area. The irrigation-independent yield growth rate might improve to 1% or above owing to progress in research and cultivation practices of the sort discussed in Section V. However, it seems unlikely that it would jump eightfold to 3% which would be necessary to close the gap between 4.6% and 1.64%.

Just under half of the cotton area is planted with improved or hybrid seeds. There is considerable potential for expanding the use of superior varieties. Net returns can be raised through more effective pest management, higher germination rates, earlier sowing in some cases, and genetic improvements in ginning percentage and fiber length and strength which make lint more valuable. Rendering gossypol inactive in cotton seed glands would make seed oil available for human consumption without expensive processing, and would enhance profitability.

Although net returns are usually higher for improved or hybrid varieties, and for irrigated conditions, the ratios of the value of output to the value of inputs often does not increase. Proper cultivation of superior varieties places considerably more capital at risk: production costs for H-4 in Maharashtra were triple the costs for other varieties (Table 11), and irrigated varieties in Gujarat similarly cost three times as much to produce as rainfed varieties (Table 10).

Trends in profitability could not be detected in Maharashtra or Punjab from available data. Output-to-input value ratios bounced around with yield in the former case, while being dominated by price fluctuations in the Punjab. Cotton in Gujarat has had difficulty competing with sugarcane for irrigated area. Some specialists have recommended reducing the cotton area in Gujarat to concentrate costly inputs on smaller plots.

1/ See the generalized least squares regression of Section III. The effects of area shifts are already included in this application of the regression.

A study of relative profitability in Haryana had American cotton tied with groundnut in fourth place after chilies, basmati rice, and arhar. 1/ A sizeable linear programming model for the Siwani canal system in Haryana had a reduction in cotton area from 1,330 hectares to 1,183 hectares as an optimal solution, when allowing water to be reallocated between regions and crops. 2/ Punjab, Haryana, and Gujarat account for about 60% of irrigated cotton area.

It is difficult to argue that the relative profitability of irrigated cotton will undergo a radical transformation within the context of existing policy. Nominal protection coefficients indicate, however, that export limitations result in farmers receiving only 50-70% of the properly-adjusted world price that would be available if there were no trade restrictions or other distortions (Tables 15 and 16). The estimates of distortion in this study, if accepted, would imply that several World Bank appraisal reports have over-estimated the financial returns, but under-estimated the economic returns from cotton cultivation.

Export quotas continue to be set with an eye to holding down cotton prices to mills and consumers. "The rise in prices of cotton from November 1980 persuaded the Commerce Ministry to decide on May 20 against fresh commitment of cotton for export in the current season." 3/ The disincentive effects of quotas are aggrevated by a regressive tariff that has a perverse impact on income distribution. Real cotton textile prices have been falling, 4/ but given the negative protection offered to cotton producers, declining world prices, more rapidly-declining domestic raw cotton prices, the high cost of inputs for improved varieties, and the planned rate of irrigation expansion, planners should not be surprised if production falls short of the targets.

1/ Net returns in 1979, adjusted for the rental value of land, interest on working capital and owned inputs were (Rs/ha): chilies 2,709, basmati rice 1990, arhar 1,390, groundnut 1,016, American cotton 1,014, Desi cotton 736, guara grain 632, jowar 572. Package of Practices for Karif Crops, 1980, "Economics of Important Karif Crops in Haryana 1979," (Haryana Agricultural University, Hissar, 1980), p. xvii-xlix.

2/ Optimum Allocation of Irrigation Water of Siwani Canal Haryana, B. S. Panghal and I. J. Singh, (Haryana Agricultural University, Hissar, 1980).

3/ Economic and Political Weekly, July 11-18, 1981, p. 1169.

4/ The index was 90.6 in 1979/80 on a 1970/71 base of 100.

A supply elasticity estimate based on nominal prices was around 0.3. A trade policy oriented more toward production incentives could be expected to boost output. However, the cross-price elasticity with foodgrains became dominant when prices were cast in real terms for the supply/demand model. It was contended that most projections based on cross-sectional data over-estimate future per capita consumption. The model indicated that reversing the declining consumption trend in cotton cloth per capita (cotton in blends included) and in fact raising it one square meter by 1990/91 (about 10%), would probably require: (1) a rapid drop in real foodgrain prices equal to 2%/year; (2) net lint imports of a quarter million tons in 1990/91; or (3) a drop in projected net cotton textile exports from 1.1 billion square meters cloth equivalent, to virtually nil. 1/ (See Table 20 for details).

Allowing per capita consumption of cotton cloth and cotton in blended fabrics to continue the downward drift at about the historical rate (reaching 11.3 to 11.8 m^2/capita by 1990/91) would accommodate yearly increments in net cotton textile exports of 50 million square meters equivalent, or 15 thousand tons of lint. (The increments would accumulate so that in year two the change would be 100 million square meters, for example). Even these modest export possibilities would require the stimulative effects on cotton production of a gentle drop in real foodgrain prices, although relaxing export quotas would provide some price stimulation.

1/ These scenarios were associated with cotton cloth consumption ranging from 13.14 to 13.86 m^2/capita in 1990/91 compared with 12.10 m^2/capita in 1979/80. Blended fabrics are included. The trade balance includes adjustments in stocks and losses in spinning and processing.

APPENDICES

A. Projections for 1985/86 Given Alternative Hypotheses

B. The Projection Model

C. Time-Series Data

APPENDIX A

Projections for 1985/86 Given Alternative Hypotheses (Cases 4,5,6,9 & 13)
(See Tables 17 & 20 for notes and definitional details)

	ENDOGENOUS VARIABLES							EXOGENOUS VARIABLES			
	LINT PRODUCTION	MILL CONSUMPTION	PRIVATE CLOTH CONSUMPTION		REAL PRICE INDICES			NET TRADE BALANCE b/ (+ = EXPORT)		IRRIGATED PROPORTION c/	PRIVATE CONSUMPTION EXPENDITURE d/
			TOTAL	PER CAPITA a/	LINT	COTTON TEXTILES	FOODGRAINS	TEXTILES	LINT	(Lagged)	
	(1,000 tons)	(1,000 tons)	(million m^2)	(m^2)	(1970/71=100)	(1970/71=100)	(1970/71=100)	(million m^2)	(1,000 tons)	(%)	(billion Rs.)
1985/86 Model Base Case	1,299	1,311	8,634	11.57	76.4	80.4	99.1	1,131	-11.9	36.1	433.3
Moderate Drop Foodgrain Prices (-1% per year)	1,340	1,353	8,948	11.99	77.7	82.6	93.9	1,131	-11.9	36.1	433.3
Faster Drop Foodgrain Prices (-2% per year)	1,382	1,393	9,251	12.40	78.9	84.7	89.2	1,131	-11.9	36.1	433.3
Moderate Drop Foodgrain Prices (-1% per year) and Textile Export Promotion (Continual Increase 50 million sq. meters/yr.)	1,341	1,353	8,645	11.59	77.6	82.6	93.9	1,431	-11.9	36.1	433.3
Faster Drop Foodgrain Prices (-2% per year) and Rapid Expenditure Growth (5% per year) and Slower Irrigation Expansion (2.5% per year) and Cotton Lint Imports (Continual Increase 20,000 tons/yr.)	1,315	1,465	9,784	13.11	79.9	82.1	89.2	1,131	-149.9	32.0	472.4

a/ Assumes population of 746.1 million in 1985/86.
b/ Includes stock adjustments, extra-factory lint consumption (for lint), yarn equivalent, finished items, and powerloom and handloom exports (for textiles).
c/ Proportion of gross cropped cotton area under irrigation.
d/ Total; final; real prices based on 1970/71.

APPENDIX B

THE PROJECTION MODEL

```
100 PTEXREALL=90.56
110 IRRL=28.3
120 INDGRAL=98 72
130 INDCOTL=88.5
132 BALRAWC=-29.9
134 BALTEXC=+1131
136 TOTEXPC=35251
140 FOR T = 26 TO 36 DO BEGIN
170 BALTEXC=BALTEXC+0.06
180 BALRAWC=BALRAWC+3
190 TOTEXPC=TOTEXPC*(1.035)
200 MPRODC=EXP(7.94332+0.074532*LN(INDCOTL)-0.56683*LN(INDGRAL) &
210 +0 42072*LN(IRRL))
220 MMCONC=MPRODC-BALRAWC
230 CLOTHC=7.45*MMCONC-BALTEXC
240 INDCOTC=EXP(13.6623+0.594489*LN(INDCOTL)-0.842757*LN(INDGRAL) &
250 - 1.7858*LN(PTEXREALL)+0.0000245*BALRAWC &
260 - 0.041687*T + 0.314305*LN(IRRL))
270 PTEXREALC= EXP(10.3817 +0.132605*LN(INDCOTL)-0.45252*LN(INDGRAL) &
280  -0 404918*LN(TOTEXPC)+0.0000226*BALRAWC+0.00000272*BALTEXC &
290 - 0 04705*LN(IRRL))
295 IF T NEQ 31 AND T NEQ 36 THEN GO TO 330
300 DISPLAY T,"MPRODC",MPRODC,"MMCONC",MMCONC,"CLOTHC",CLOTHC,"INDCOTC"
310 DISPLAY INDCOTC,"PTEXREALC",PTEXREALC,"INDGRAL",INDGRAL,"IRRL",IRRL
320 DISPLAY "BALTEXC",BALTEXC,"BALRAWC",BALRAWC,"TOTEXPC",TOTEXPC
325 SKIP 3
330 INDCOTL=INDCOTC
340 PTEXREALL=PTEXREALC
342 INDGRAL=INDGRAL*1.000778
344 IRRL=1.0497*IRRL
350 END
```

This projection model (program HITCH.CPROJ6) contains the reduced-form estimates of the structural model discussed in Section VII. However, the variable names are those given in Appendix C with the suffix "C" for current and "L" for lagged. The variable "TOTEXPC" in the program is the same as "TOTEXP70" in Appendix C, and the "EXPEND" variable in the text times one hundred. (The units of TOTEXPC are 100 billion Rs.) The time variable "T" in line 140 begins with 1955/56, so T=26 in 1980/81.

APPENDIX C

TIME-SERIES DATA

	MPROD	MMCON	CLOTHPCAP* POP	CLOTHPCAP	INDCOT	INDGRA	PTEXREAL	BALTEX	BALRAW	IRR	TOTEXP70/ 100	PRAW	PGRA	IM
1954	756.50				104.4	84.9	127 906977			8 7	194 620000	44.9	36 5	
1955	710 60	901 00	5665 1500	14.50	104 7	86.3	131.617647	1047 3000	-190 400000	9.1	197.280000	42 7	35 2	5 40
1956	836.40	929 90	5848 9902	14 71	104 7	96.8	127 956989	1078 7618	-93.500000	9 5	203 990000	48 7	45 0	5 50
1957	843 20	935 00	5882 2150	14.50	97 5	98 1	123 799582	1083 5350	-91 800000	10.0	195.650000	46 7	47 0	3 70
1958	829 60	952 00	5914 2048	14 28	87.8	102 8	113 855422	1178 1952	-122 400000	11 0	207 610000	43 7	51.2	4.10
1959	625 60	969 00	5805 2064	13 72	90.1	95 2	115 473888	1413 8436	-343 400000	12 0	206 880000	46 6	49 2	8.10
1960	952 68	986 00	6000 2400	13 80	89.3	89 5	120 325679	1345 4600	-33 320000	12 9	217 207232	49 2	49 3	8 00
1961	824 50	1023 74	6551 9640	14.76	86 6	87.7	119 927536	1074 8990	-199 240000	12.9	217 788000	47 8	48 4	7 10
1962	941.12	1020.68	6520 6400	14 35	87.1	89.0	119 895288	1083 4260	-79 560000	15 3	222 561187	49 9	51 0	8 90
1963	976 99	1094 63	6832 3190	14 69	87 5	91.5	117 077176	1322 6745	-117 640000	14 9	229 657446	53 3	55 7	6 86
1964	1021 87	1146 82	7246.2420	15.22	82 7	104 3	107 407407	1297 5670	-124 950000	15 1	250 292959	55.8	70.4	9 82
1965	824.84	1047.71	7173 0560	14 72	78 1	102 6	103 988996	632 3835	-222 870000	16 4	244.394434	56.8	74.6	5.57
1966	895.22	1037 34	6958 2600	13 95	73 5	106 8	97 463768	769.9230	-142 120000	16 5	253 015209	60.9	88.4	8.28
1967	982 09	1109.76	6927.4850	13.57	73 7	119 5	91.341991	1340 2270	-127 670000	16 1	269.984524	68.1	110.4	8.24
1968	925.99	1115 88	7509.7620	14 37	80 9	106 5	93 537788	803 5440	-189 890000	16.5	280.656136	73 9	97.2	4.54
1969	945.88	1140 82	7360.2240	13 76	92.0	106.2	94 831224	1183.5850	-200.940000	19.5	290 710682	81.7	100.7	9 64
1970	809.71	1065 39	7541.8290	13 77	100.0	100.0	100 000000	395.3265	-255 680000	20 6	298.380000	100 0	100.0	9.10
1971	1181.50	1144.61	7135.6740	12.74	102.0	97 9	103 882576	1391 6705	36 890000	24 4	307.040000	107.8	103 4	7.90
1972	974.95	1167.39	7688 0200	13.45	78 8	102.8	97 590361	1009 0355	-192.440000	25.9	300.700000	91.6	119 5	4 68
1973	1072.53	1237.26	7216.6580	12.37	99.0	101.6	97 136722	2000.9290	-164.730000	24 8	308.800000	138 3	141 9	1.88
1974	1216.52	1208.70	7832 1400	13 15	96 5	111 9	92 109777	1172 6750	7 820000	23 9	310 880000	168.8	195 8	1 15
1975	1011 50	1282.65	7929.6240	13 04	78 8	100 6	84 393064	1626 1185	-271.150000	25 3	334 540000	136 4	174 1	1 66
1976	992 63	1147.84	7500.6360	12 09	111.8	86.5	89 184598	1050 7720	-155 210000	25 9	331 890000	197 5	152.7	6.22
1977	1231.31	1124.72	7144.5270	11.31	103.9	91 7	95 532831	1234 6370	106 590000	26 7	360 020000	193 0	170.4	6.16
1978	1352 86	1186.77	7894.2140	12.26	90.9	92.9	97 631862	947.2225	166 090000	28.3	378.450000	168.6	172 6	0.85
1979	1308.66	1173.51	7963.0100	12 10	75 8	85 4	90 579044	779 6395	135.150000	28.7	352 510000	164.4	185.1	0.85

	EX
1955	6 40
1956	3 12
1957	3 10
1958	4 20
1959	2 10
1960	3 07
1961	3.48
1962	3.49
1963	2.85
1964	2 53
1965	1 93
1966	2.59
1967	2.44
1968	2 01
1969	2 19
1970	2 00
1971	2 47
1972	1.84
1973	3 66
1974	0.97
1975	4.27
1976	0.39
1977	0.10
1978	0.46
1979	0.38

Definitions and Units

MPROD	Cotton production, pressed bales of lint, 1,000 metric tons
MMCON	Mill consumption of lint, 1,000 metric tons
CLOTHPCAP*POP	Total private consumption of cotton cloth, and cotton equivalent of blended cloth, million sq. meters, "cloth per capita times population"
CLOTHPCAP	Cotton cloth per capita, including cotton component of blended-fabric cloth, sq. meters
INDCOT	Deflated wholesale raw cotton price index, financial years, 1970/71 = 100
INDGRA	Deflated wholesale foodgrains price index, financial years, 1970/71 = 100
PTEXREAL	Deflated wholesale cotton textiles price index, financial years, 1970/71 = 100
BALTEX	Adjusted trade and utilization balance of cotton textiles, see text, million sq. meters
BALRAW	Adjusted trade and utilization balance of cotton lint, see text, 1,000 metric tons
IRR	Percent of cultivated cotton area under irrigation
TOTEXP70/100	Total real private consumption expenditure in billion Rs., and 1970/71 prices
PRAW	Nominal wholesale cotton lint price index, 1970/71 = 100
PGRA	Nominal wholesale foodgrains price index, 1970/71 = 100
IM	Raw cotton imports, 100,000 bales of 170 kg.
EX	Raw cotton lint exports, 100,000 bales of 170 kg.

See Notes on following page.

Notes for Appendix C

The variable names given in the table are those found in a particular datafile (H.COTTON). As shown in the column headings, two of the variables require transformations for the units to match the definitions indicated. Some of the variables were renamed for clarity when the model was being presented in the text (see Table 17, for example). These variable names are matched below.

TEXT NAME	DATAFILE NAME
PROD	MPROD
MILLCON	MMCON
PRICON	CLOTHPCAP*POP
PLINT	INDCOT
PTEX	PTEXREAL
PGRAIN	INDGRA
EXPEND	TOTEXP70/100

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This study, based on an agricultural survey of 8,000 farms, assesses the extent and root causes of pervasive rural poverty in northeast Brazil. The authors review a number of policy and project options; they conclude that courageous land reform is the only effective means of dealing with the problem.

The Johns Hopkins University Press, 1982. 288 pages.

LC 81-47615. ISBN 0-8018-2581-4, $25.00 (£17.50) hardcover.

Agricultural Extension: The Training and Visit System
Daniel Benor and James Q. Harrison

Describes the Training and Visit System of extension developed by Daniel Benor and introduced in a number of projects assisted by the World Bank in developing countries.

May 1977. 55 pages (including annex). English, French, and Spanish.

Stock Nos. PM-7701-E, PM-7701-F, PM-7701-S. $3.00 paperback.

Agricultural Land Settlement
Theodore J. Goering, coordinating author

Examines selected issues related to the World Bank's lending for land settlement, and gives estimates of the global rate of settlement and the world's ultimate potentially arable land.

A World Bank Issues Paper. January 1978. 73 pages (including 4 annexes). English, French, and Spanish.

Stock Nos. PP-7801-E, PP-7801-F, PP-7801-S. $5.00 paperback.

Agricultural Price Management in Egypt
William Cuddihy

World Bank Staff Working Paper No. 388. April 1980. x + 164 pages (including annex, bibliography).

Stock No. WP-0388. $5.00.

Agricultural Price Policies and the Developing Countries
George Tolley, Vinod Thomas, and Chung Ming Wong

This book first considers price policies in Korea, Bangladesh, Thailand, and Venezuela, bringing out the consequences for government cost and revenue, farm income, and producer and consumer welfare. Other effects, including those on agricultural diversification, inflation, economic growth, and the balance of payments are also discussed. The second part of the book provides a methodology for estimating these effects in any country. Operational tools for measuring the effects on producers, consumers, and government are developed and applied.

The Johns Hopkins University Press, 1982. 256 pages.

LC 81-15585. ISBN 0-8018-2704-3, $25.00 (£17.50) hardcover.

Agricultural Project Analysis: Case Studies and Exercises

Case studies and exercises on agricultural project preparation and analysis, developed for, and used in, EDI's rural development and rural credit courses.

World Bank (EDI), 1979, v.1—viii + 711 pages. v.2—iv + 113 pages. v.3—iv + 157 pages. (Available from ILS, 1715 Connecticut Avenue, N.W., Washington, D.C. 20009, U.S.A.)

$9.00 paperback.

Agricultural Research

Points out that developing countries must invest more in agricultural research if they are to meet the needs of their growing populations. States that studies in Brazil, India, Japan, Mexico, and the United States show that agricultural research yields a rate of return that is more than two to three times greater than returns from most alternative investments and cites some of the successes of the high-yielding varieties of rice and wheat that were developed in the mid-1960s. Discusses the World Bank's plans to expand its lending for agricultural research and extension, particularly for the production of food and other commodities that are of importance to low-income consumers, small farmers, and resource-poor areas.

Sector Policy Paper. June 1981. 110 pages (including annexes). English, French, and Spanish.

Stock No. PP-8101-E, PP-8101-F, PP-8101-S. $5.00 paperback.

A Development Model for the Agricultural Sector of Portugal
Alvin C. Egbert and Hyung M. Kim

Spatial mathematical programming is used to develop comprehensive and quantitative methods to suggest development strategies in Portugal's agriculture sector.

The Johns Hopkins University Press, 1975. 110 pages (including bibliography).

LC 75-26662. ISBN 0-8018-1793-5, $6.50 (£4.00) paperback.

Economic Aspects and Policy Issues in Groundwater Development
Ian Carruthers and Roy Stoner

Examines a wide range of economic and policy issues related to development of groundwater for irrigation.

World Bank Staff Working Paper No. 496. October 1981. 110 pages (including annex, bibliography).

Stock No. WP-0496. $5.00.

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Economic Return to Investment in Irrigation in India
Leslie A. Abbie, James Q. Harrison, and John W. Wall

Reports on an investigation into the efficiency of investment in surface and groundwater irrigation in India.

World Bank Staff Working Paper No. 536. 1982. 52 pages.

ISBN 0-8213-0083-0. $3.00.

Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis
Maxwell L. Brown

Clarifies the relation between simple farm income analysis and the broader field of agricultural project analysis and emphasizes the more practical aspects of project preparation and gives guidance to those responsible for planning in agriculture.

EDI Series in Economic Development. The Johns Hopkins University Press, 1980. 154 pages.

LC 79-3704. ISBN 0-8018-2386-2, $15.00 (£10.50) hardcover; ISBN 8-8018-2387-0, $6.50 (£4.50) paperback.

Spanish: Presupuestos de fincas. *Editorial Tecnos, 1982.*

ISBN 84-309-0886-2, 725 pesetas.

Fishery

Highlights the importance of fisheries to the economies of developing countries and recommends that the World Bank provide assistance to those countries that have the fishery resources and are willing to develop them further.

Sector Policy Paper. December 1982.

ISBN 0-8213-0138-1. $5.00 paperback.

Food Security in Food Deficit Countries
Shlomo Reutlinger and Keith Knapp

World Bank Staff Working Paper No. 393. June 1980. 39 pages (including appendix, references).

Stock No. WP-0393. $3.00.

Forestry
Graham Donaldson, coordinating author

Examines the significance of forests in economic development and concludes that the World Bank should greatly increase its role in forestry development, both as a lender and adviser to governments.

Sector Policy Paper. February 1978. 63 pages (including 7 annexes). English, French, and Spanish.

Stock Nos. PP-7804-E, PP-7804-F, PP-7804-S. $5.00 paperback.

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Improving Irrigated Agriculture: Institutional Reform and the Small Farmer
Daniel W. Bromley

A model of farmer interdependence is developed to provide suggestions for improving existing irrigation systems, as well as for designing new ones.

World Bank Staff Working Paper No. 531. 1982. 96 pages.

ISBN 0-8213-0064-4. $3.00.

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Increasing Agricultural Productivity
(Proceedings of the Third Annual Agricultural Sector Symposium)
Ted J. Davis, editor

These proceedings are the third in a series of records of Agricultural Sector Symposia presented at the World Bank each January since 1980. Contains the papers presented by the speakers, chairpersons' statements, and summaries of the discussions prepared by the rapporteurs.

1982. 307 pages (including index). ISBN 0-8213-0099-7. $15.00.

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India: Demand and Supply Prospects for Agriculture
James Q. Harrison, Jon A. Hitchings, and John W. Wall

Contains four papers that report on the World Bank's economic work in the agricultural sector in India and the implications of this development both for foodgrains and for other major agricultural commodities. Focuses on the demand for agricultural commodities through the year 2000, the foodgrain economy, the vegetable oil economy, and the sugar economy.

World Bank Staff Working Paper No. 500. October 1981. 133 pages (including 5 appendixes, references, annex).

Stock No. WP-0500. $5.00.

Agricultural Research and Productivity
Robert E. Evenson
and Yoav Kislev

Examines the role of scientific research and technological change in increasing agricultural productivity.

Yale University Press, 302 Temple Street, New Haven, Connecticut 06520, U.S.A. 1975. xi + 204 pages (including 10 appendixes, references, index).

LC 74-15210. ISBN 0-300-01815-0, $15.00 hardcover; ISBN 0-300-01877-0, $3.95 paperback.

Spanish: Investigación agrícola y productividad. *Editorial Tecnos, 1976. ISBN 84-309-0641-X, 420 pesetas.*

Agroindustrial Project Analysis
James E. Austin

Provides and illustrates a framework for analyzing and designing agroindustrial projects.

EDI Series in Economic Development. The Johns Hopkins University Press, 1981. 224 pages (including appendixes, bibliography, and index).

LC 80-550. ISBN 0-8018-2412-5, $16.50 (£10.00) hardcover; ISBN 0-8018-2413-3, $7.50 (£4.25) paperback.

French: L'Analyse des projets agroindustriels. Economica, 1982. ISBN 2-7178-0480-3, 49 francs.

Spanish: Análisis de proyectos agroindustriales. *Editorial Tecnos, 1981. ISBN 84-309-0882-X, 600 pesetas.*

Argentina: Country Case Study of Agricultural Prices, Taxes, and Subsidies
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World Bank Staff Working Paper No. 386. April 1980. 72 pages (including 3 annexes).

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The Johns Hopkins University Press, 1983. 632 pages.

LC 80-29366. ISBN 0-8018-2585-7, $35.00 (£24.50) hardcover.

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Building National Capacity to Develop Water Users' Associations: Experience from the Philippines
Frances F. Korten

Over a five-year period, the National Irrigation Administration (NIA) of the Philippines has been building its capacity to develop water users associations on small-scale irrigation systems. This paper details the changes that have been made within the agency as a result of the development of these associations prior to the construction of the physical system and the involvement of association members in the planning and construction stages. It also examines the nature of the learning process that has led to these changes and discusses the implications for donor support of other small-scale irrigation programs and more generally for programs involving village-level work.

World Bank Staff Working Paper No. 528. July 1982. v + 69 pages (including references).

ISBN 0-8213-0051-2. $3.00.

Casos y Ejercicios Sobre Proyectos Agrícolas
Edited by Orlando T. Espadas

Three case studies prepared in conjunction with the EDI's Agricultural Projects Courses in Spanish and intended primarly for teachers of project analysis.

World Bank (EDI), March 1974; revised January 1975. 480 pages (Available from ILS, 1715 Connecticut Avenue, N.W., Washington, D.C. 20009, U.S.A.)

$5.00 paperback.

The Design of Organizations for Rural Development Projects—a Progress Report
William E. Smith,
Francis J. Lethem, and
Ben A. Thoolen

World Bank Staff Working Paper No. 375. March 1980. 48 pages. English and French.

Stock No. WP-0375-E, WP-0375-F. $3.00.

The Design of Rural Development: Lessons from Africa
Uma Lele

Analyzes new ways of designing rural development projects to reach large numbers of low-income subsistence populations. The paperback reprinting in 1979 contains a new chapter by the author updating her findings.

The Johns Hopkins University Press, 1975; 3rd printing, 1979. 260 pages (including glossary, appendix, maps, bibliography, index).

ISBN 0-8018-1769-2, $9.95 paperback.

French: Le développement rural: l'expérience Africaine. *Economica, 1977. ISBN 2-7178-0006-9, 39 francs.*

Some Aspects of Wheat and Rice Price Policy in India
Raj Krishna and G. S. Raychaudhuri

World Bank Staff Working Paper No. 381. April 1980. 62 pages (including 2 appendixes, 6 tables, bibliography).

Stock No. WP-0381. $3.00.

A System of Monitoring and Evaluating Agricultural Extension Projects
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World Bank Staff Working Paper No. 272. December 1977. vi + 115 pages (including 9 annexes, bibliography).

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In the ten years since its publication, the first edition has been accepted widely as a standard reference and text. The methodology reflects the best of contemporary practice in government agencies and international development institutions concerned with investing in agriculture and is accessible to a broad readership of agricultural planners, engineers, and analysts.

This revision adds a wealth of recent project data; expanded treatment of farm budgets and the efficiency prices used to calculate the effects of an investment on national income; a glossary of technical terms; expanded appendixes on preparing an agricultural project report and using discounting tables; and an expanded, completely annotated bibliography.

EDI Series in Economic Development.

The Johns Hopkins University Press. July 1982. 528 pages (including appendixes and glossary/index).

LC 82-15262. ISBN 0-8018-2912-7, $37.50 (£22.50) hardcover; ISBN 0-8018-2913-5, $13.50 (£8.75) paperback.

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