The Developing Economies, XXIII-2 (June 1985)

DYNAMICS OF CROPPING PATTERN IN HARYANA: A SUPPLY RESPONSE ANALYSIS

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DEVELOPMENTAL policies for agriculture are designed not only to achieve a certain level of output but also to maintain a nutritionally desirable composition of output. This concern arose when the impressive agricultural production during the late sixties and seventies in India was accompanied by significant cropping pattern changes.[1] The compound growth rate of agricultural production in this country for the period 1967–79 has been estimated at 2.81 per cent per annum. But for the same period, production of cereals increased at the compound growth rate of 3.05 per cent; and production of pulses and oilseeds at 0.54 per cent and 1.62 per cent respectively. Among the cereals the annual growth rates for wheat and rice were 6.02 per cent and 2.64 per cent respectively and near zero for maize and *bajra* for the same period (i.e., 1967–79). In terms of per capita availability, the increase in pulses and oilseeds production has been less than the growth rate of population estimated at 2.01 per cent per annum during 1961–79. These changes in cropping pattern have been especially marked in the areas which have experienced the adoption of new farm technology which includes the use of high-yielding varieties of seeds, chemical fertilizers, pesticides, and improved farming practices. For example, the foodgrain production in Punjab and Haryana increased by 8.01 per cent and 5.33 per cent compound rate of growth, as compared to 2.77 per cent for all India during the period 1960–79. Among the cereals, rice and wheat grew at the compound growth rates of 12.47 and 8.93 per cent per annum in these states during 1959–79. On the other hand, pulses and oilseed decreased at the compound rate of 5.2 and 0.64 per cent respectively during 1960–79 in Haryana which is a key region for growing these crops.

The different rates of growth for individual crops indicate that their acreages have responded to the techno-economic changes made during this period. Price is considered the most critical economic factor in the area allocation decisions of farmers. A number of empirical studies are available which support the positive area and price relationship for different agricultural commodities in various regions of India and abroad [2]. But recently it has been observed that despite

This work was carried out at the Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi, for my M.Phil. dissertation during 1978–80. I am thankful to Prof. G. S. Bhalla for his useful comments on the final draft of this paper. I am also thankful to Drs. G. K. Chadha, Kusum Chopra, and H. S. Sidhu for their help at various stages of this work.

[1] See [6, 1979–80 edition, p. 8] [6, 1981–82 edition, p. 9].

the rise in relative prices of pulses and oilseeds, the proportionate acreage under them has either remained stagnant or in some cases declined [4]. On the other hand, the acreage under wheat and rice has expanded although their relative prices have remained stable or fallen in some cases [9] [14]. However, little emphasis has been given to the role of factors such as yield differentials which might represent the new technology. Irrigation and risk may also have emerged as important in recent periods. Unlike traditional farming, a farmer today has to incur a large variable cost on various constituents of new technology in addition to his own human and draught power. In earlier times of crop failure he was to lose or receive reduced wages for his family labor while under the new farm technology he may also lose the variable cost incurred on seeds, fertilizers, pesticides, etc. Under such conditions, the farmers' objective is not only to maximize profits but also to minimize losses to avoid disaster in case of crop failure.

This study attempts to analyze the cropping pattern changes in terms of varying responses of individual crops to price and non-price factors. Specifically, the study evaluates the responsiveness of acreage under twelve individual crops with respect to their (i) relative farm harvest prices, (ii) relative yield of individual crops, (iii) total irrigated area of the region, (iv) average rainfall received during the critical periods of a particular crop(s), and (v) risks arising from price and yield variations. The model also enabled us through its adjustment coefficient, to measure the degree of farmers' realization of various incentives available to them.

A. *The Selected Region and Its Cropping Pattern*

The study is confined to the state of Haryana in India. The major analytical advantages of choosing this state are that the area is fairly homogeneous in farming type, it has adopted the new farm technology to a great extent, and it has recorded a phenomenal growth in agricultural production. The doubling of gross irrigated area, increase in the annual fertilizer consumption by a hundred fold, large-scale use of HYV of seeds, and a tenfold increase in the number of tractors during the period of study amply testify the changes in the farm technology of the state. The period of regression analysis for the study extends from 1960/61 to 1976/77, though for other purposes it was updated to 1978/79. The twelve crops examined are wheat, rice, *jowar, bajra,* maize, barley, gram, sugarcane, groundnut, rapeseeds and mustard seeds, American cotton, and Desi cotton. The crops included in the study account for 90 per cent of the area under cultivation in the state. The secondary sources used for collecting the time-series data for the study are the publications of the Directorate of Economics and Statistics, the Ministry of Agriculture in the government of India and the Economic and Statistical Organisation of the government of Haryana.[2]

[2] The main publications used for collecting secondary data are: India, Government of Haryana, Economical and Statistical Organization, *Statistical Abstracts, 1966/67 to 1978/79;* India, Ministry of Food, Agriculture, Community Development and Cooperation, Directorate of Economics & Statistics, *Farm (Harvest) Prices of Principal Crops, 1954–55 to 1965–66* (1969); India, Ministry of Agriculture & Irrigation, Directorate of Economics and Statistics, *Farm (Harvest) Prices of Principal Crops in India, 1965–66 to 1970–71*

One feature of cropping pattern in Haryana has been the increasing share of foodgrains over the period of study. The total cropped area (TCA) of the state increased from 4.45 million hectares during 1961–65 to 5.41 million hectares during 1976–78. But this increase in area was not proportionately shared by all crops as it is evident from the percentage share of individual crops (Table I). Highest increase in area was recorded by cereals and among them the major share goes to wheat and rice. The percentage share of wheat and rice in TCA increased from 19 per cent in 1961–65 to 33 per cent in 1976–78 as compared to the increase in percentage share of all cereals from 47 per cent to 57 per cent over the same period. Pulses and oilseeds registered a decline in their percentage shares in TCA to such an extent that their absolute areas have also decreased. The other crops which recorded appreciable change in their percentage shares are *jowar* (decreased), cotton (both American and Desi varieties) and potatoes (increased). Secondly as we observe from Table I, the changes in the cropping pattern started earlier than the green revolution. The highest declines in the acreage under gram and rapeseed/mustard seed occurred between 1961–65 and 1966–70. During the same period, wheat, rice, and cotton recorded the highest increase in acreages. This period was also accompanied by a marked increase in the irrigated area. The percentage of gross irrigated area in TCA increased from 26 per cent in 1960/61 to 39 per cent in 1966/67 [13]. This increase in irrigated area further continued but with a declining rate, as in 1976/77 the percentage of irrigated area in TCA was only 50 per cent after a lapse of ten years [13]. This indicates that increase in irrigation may be an important factor in explaining changes in the acreage under major crops like wheat, rice, gram, etc.

B. *Analytical Framework*

To measure the magnitudes and nature of various supply shifters, the acreage supply equations have been estimated with Marc Nerlove's partial adjustment adaptive expectational model [12]. This model has been extensively used over the last two decades. And in spite of some structural and estimational problems [8], the model is still regarded as the best available approach for this type of study. The essential features of the model are as follows:

(a) The farmer desires the acreage to be planted under different crops on the basis of expected future price which is taken as the weighted moving average of past prices, the weights decline exponentially as one goes back in time.

(b) The farmer partially adjusts the current planted area to the desired area in the current production year due to techno-economic and institutional constraints, i.e., full adjustment to the desired area is spread over a number of years.

C. *The Model*

The comprehensive (including the additional variables) Nerlovian model used in the study is as follows:

(1975); idem., *Farm (Harvest) Prices of Principal Crops in India, 1970–71 to 1974–75* (1978); idem., *Agricultural Situation in India* especially August issues for farm (harvest) prices after 1974–75.

TABLE I
AREA UNDER DIFFERENT CROPS IN HARYANA

(1,000 ha)

	1961–65	1966–70	1971–75	1976–78
1. Rice	173	230	291	388
	(3.89)	(4.85)	(5.67)	(7.17)
2. *Jowar*	292	242	180	167
	(6.57)	(5.11)	(3.50)	(3.09)
3. *Bajra*	747	893	933	901
	(16.81)	(18.84)	(18.17)	(16.65)
4. Maize	99	103	121	103
	(2.23)	(2.17)	(2.36)	(1.90)
5. Wheat	670	926	1,192	1,402
	(15.07)	(19.54)	(23.21)	(25.90)
6. Barley	95	181	159	97
	(2.14)	(3.82)	(3.10)	(1.79)
7. Total cereals	2,081	2,577	2,877	3,061
	(46.82)	(54.37)	(56.02)	(56.55)
8. Gram	1,409	1,092	1,033	1,079
	(31.70)	(23.04)	(20.11)	(19.93)
9. Total pulses	1,467	1,199	1,134	1,150
	(33.00)	(25.30)	(22.08)	(21.25)
10. Rapeseed & mustard seed	196	152	175	133
	(4.41)	(3.21)	(3.41)	(2.46)
11. Groundnut	5.72	12.70	9.28	9.10
	(0.13)	(0.27)	(0.18)	(0.17)
12. Total oilseeds	205	167	189	145
	(4.61)	(3.52)	(3.68)	(2.68)
13. Cotton, Desi	71	100	136	275
	(1.60)	(2.11)	(2.65)	(5.08)
14. Cotton, American	83	105	115	
	(1.87)	(2.22)	(2.24)	
15. Sugarcane	141	151	142	185
	(3.17)	(3.19)	(2.76)	(3.42)
16. Potato	2.95	3.96	8.84	11.00
	(0.07)	(0.08)	(0.17)	(0.20)
17. Total	4,051	4,303	4,602	4,827
	(91.14)	(90.78)	(89.60)	(89.17)
18. All crops	4,445	4,740	5,136	5,413
	(100)	(100)	(100)	(100)

Note: Figures in parentheses are percentages of total cropped area.

$$A^*_t = a_0 + a_1 P^*_t + a_2 Y_{t-1} + a_3 CV_p + a_4 CV_y + a_5 R_s + a_6 I_t + a_7 D + V_t, \quad (1)$$
$$A_t - A_{t-1} = B(A^*_t - A_{t-1}) + Z_t, \quad 0 < B < 1, \quad (2)$$
$$P^*_t = \phi P_{t-1} + (1-\phi)\phi P_{t-2}, \quad 0 < \phi < 1, \quad (3)$$

where B and ϕ are the adjustment and expectation coefficients respectively.

As usual we have assumed expectational coefficient of price equal to unity and hence $P^*_t = P_{t-1}$. Now substituting P_{t-1} for P^*_{t-1} in equation (1) and consequent value of A^*_t in the equation (2). We obtain the following estimating equations:

$$A_t = C_0 + C_1P_{t-1} + C_2Y_{t-1} + C_3CV_p + C_4CV_y + C_5R_s + C_6I_t + C_7D + C_8A_{t-1} + U_t, \quad (4)$$

where $C_0 = a_0B$, $C_1 = a_1B$, $C_2 = a_2B$, $C_3 = a_3B$, $C_4 = a_4B$, $C_5 = a_5B$, $C_6 = a_6B$, $C_7 = a_7B$, $C_8 = 1 - B$, and $U_t = BV_t + Z_t$.

Variables are denoted as follows:

A^*_t = Desired area under the crop concerned which will be different from planned area in the period due to the partial accounting of farmers' expectations in the planning.

t = tth production period.

A_t = The actual area planted in 1,000 hectares under the crop concerned which is used as dependent variable.

P_{t-1} = The ratio of farm harvest price of the crop concerned to its competing crop(s) which will henceforth be called relative price. (The competing crop(s) for individual crop are: wheat for gram, barley, and rapeseed/mustard seed; gram for wheat; maize and wheat for sugarcane;[3] maize for rice; rice for maize; *bajra* for *jowar*; *jowar* for *bajra*; maize and *bajra* for groundnut; American cotton for Desi cotton; and Desi cotton for American cotton. The competing crop(s) were selected keeping in view the extent of area occupied, season, and nature of crop.)

Y_{t-1} = Ratio of the yield of crop concerned to the yield of its competing crop(s).

CV_p = Coefficient of variations of the prices of the crop concerned for the years t-1, t-2, and t-3, used as a measure of price risk.

CV_y = Coefficient of variation of the yields of crop concerned for the years t-1, t-2, and t-3 used as a measure of yield risk.

R_s = Rainfall of the sowing-season for the crop concerned in millimeters.

I_t = Irrigated area under all crops in 1,000 hectares. Ratio of gross irrigated area and total cropped area was also tried as alternative variable.

D = Dummy variable to pick up the effect of left out variables of new technology. Thus the dummy will specify the constant terms for the two periods, i.e., 1960–67 and 1967–76.

In the final estimated acreage supply equation, only those variables are included which significantly increased the explanatory power of equation.

The short-run elasticity of acreage with respect to independent variable, i.e.,

[3] The competing crop(s) for each crop concerned have been selected keeping in view the spread of their areas over the state and their percentage share in the total cropped area of the state. Sugarcane is an annual crop, therefore combined yield of maize and wheat was used for deflating the yield of sugarcane while for deflating price, price of dominant market crop, i.e., wheat, was used.

TABLE

ESTIMATED FARMER'S ACREAGE

Variables	Wheat	Rice	Maize	*Jowar*	*Bajra*	Barley
Constant	−158.01	4.91	100.56	762.50	1,011.99	−173.32
P_{t-1}	260.34*** (3.38)	—	—	—	−147.72** (2.30)	97.01* (2.06)
Y_{t-1}	47.88* (1.95)	—	−30.42 (−1.41)	—	−58.57*** (−3.08)	194.48*** (3.10)
I_t	0.37*** (9.42)	0.03 (1.02)	0.02** (2.83)	−0.16*** (−4.46)	0.03 (0.76)	—
R_s	—	0.02* (1.90)	—	—	—	0.67* (2.09)
CV_p	−6.03*** (−5.93)	—	—	−0.80* (1.62)	—	—
CV_y	3.18 (1.41)	1.19* (1.83)	—	−0.87 (−1.32)	1.25 (1.15)	—
Dummy	116.21*** (3.34)	22.15* (1.92)	—	—	95.80** (2.24)	60.01** (2.84)
A_{t-1}	—	0.58** (2.28)	—	−0.73* (2.09)	—	0.31 (1.75)
R^2	0.99	0.98	0.51	0.92	0.85	0.79
d-statistics	2.32	1.06	2.34	2.29	1.99	2.36

Notes: Figures in the parentheses are *t*-ratios.

[a] Proportion of gross irrigated area to total cropped area was used in place of total irrigated area as it was more significant.

[b] Data relates to Hissar District only which produces more than 80 per cent of the total cotton in Haryana.

$(dA/dX)(\bar{X}/\bar{A})$, where X is independent variable, was calculated by multiplying the coefficient of each independent variable with the ratio of average of that variable and area over the period of study. The long-run elasticity was obtained by dividing short-run elasticity by the coefficient of adjustment.

D. *Empirical Results*

Acreage supply equations including only suitable[4] explanatory variables are shown in Table II for each of the twelve crops. There are seventeen time-series observations for each crop for the period 1960 to 1976/77. All the estimated relationships are in simple linear form and show a good fit to data.[5] The co-

[4] In final estimating equations of various crops, only those variables were retained which entered significantly in step-wise regressions analysis. Some alternative variables such as a proportion of total irrigated area in the total cropped area for total irrigated area and coefficients of variations of preceding three-years relative price and yield for CV_p and CV_y were also tried. All the equations given in Table II were also estimated without dummy variable. Finally the statistically better equations are presented in Table II.

[5] Serial correlation of estimated equations has been tested by Durbin-Watson d-statistics [9, p. 252]. Most of the values of *d*-statistics give nonconclusive inference regarding

II
RESPONSE FUNCTIONS

Gram[a]	Rapeseed & Mustard Seed	Groundnut	Sugarcane	Cotton[b]	
				American	Desi
1,214.57	12.66	2.58	142.28	90.61	70.81
241.92**	85.07**	2.15*	50.56***	54.29**	—
(2.20)	(2.30)	(1.94)	(4.13)	(2.31)	
—	−152.02	1.32*	37.16**	18.70	32.22
	(−1.026)	(1.90)	(2.25)	(1.64)	(1.43)
−2,089.28***	—	−0.01**	0.01	0.101*	0.12**
(−3.37)		(2.30)	(0.95)	(1.95)	(2.61)
1.44***	0.29**	—	—	−0.19	—
(4.98)	(2.24)			(−1.31)	
−4.78	—	0.09**	—	—	—
(−1.52)		(2.52)			
—	−2.47**	−0.15***	—	—	—
	(−2.28)	(−3.26)			
104.36	—	—	—	—	—
(1.10)					
—	—	0.12***	1.07***	0.37	0.45*
		(7.32)	(4.53)	(1.66)	(1.89)
0.91	0.56	0.92	0.84	0.81	0.90
2.15	2.53	2.49	1.62	2.13	1.72

* Significant at 10 per cent level.
** Significant at 5 per cent level.
*** Significant at 1 per cent level.

efficients of multiple determination $\bar{R}^2$ (adjusted for degrees of freedom) are above 0.8 for all crops except maize and rapeseed/mustard seed. The short-run and long-run elasticities of acreage with respect to price, yield, irrigation, and rainfall variables were computed from their coefficients (Table III). Main results of the study are discussed below.

E. *Adjustment Behavior*

As our model is based upon Nerlove's partial adjustment hypothesis, it will be interesting to know how far the estimated equations for actually planted area support this argument. Out of the twelve crops studied, lagged dependent variable (A_{t-1}) entered significantly in the equations of seven crops. The adjustment

presence of serial correlation except for the equations of rice and sugarcane in which serial correlation is indicated. Durbin's h-statistics [9, p. 313] was also computed for the equation in which lagged dependent variable entered significantly and computation of h-statistics was possible. The values of h-statistics ($<\pm 1.645$) indicated no serial correlation in the equations of barley, groundnut, and American cotton and serial correlation was indicated in case of sugarcane. For the remaining equations either the test was not applicable or the value of h-statistics was not defined.

coefficient obtained for these crops are in the range of -0.067 for sugarcane to 1.73 for *jowar*. Thus both the extreme values of this range are outside the assumed range of zero to one. Hence *jowar* indicates overadjustment to the desired change in area. However, we know from the time-series data that *jowar* has recorded continuous decline in its area and so the actual decline in area was always more than desired. It may be possible as we have taken *bajra* as a competing crop for *jowar* whereas in actual practice, the high-yield crops like maize or rice may have compelled. Crops for which A_{t-1} did not enter significantly, the adjustment coefficients are considered unity, i.e., these crops show full adjustment to the desired changes. The crops showing full adjustment are wheat, gram, maize, *bajra,* and rapeseed/mustard seed. This points out that farmers of Haryana are not significantly influenced by institutional and technological constraints while expanding or contracting area under these five crops which cover about two-thirds of total cropped area in the state.

F. *Price Response*

Columns two and three of Table III and row two of Table II show that of the major crops, *bajra* is the only crop whose area bears negative relationship with its previous year's relative price. Perhaps *bajra* is cultivated only for subsistence requirements (especially for animal fodder) and when prices of this coarse grain rise, the prices of other grains like maize and rice, etc., rise much more and farmers may decrease area from *bajra* and give more to other crops. In western Haryana where maize and rice are not cultivated; *guara,* a remunerative fodder crop, may take area from *bajra.* The negative response of *bajra* acreage to prices is supported by Batra [3] in Gujarat but Acharya [1] has obtained positive price elasticity for Rajasthan (see Appendix Table I). But Acharya's results do not refute our argument because the importance of a crop differs from region to region and over different periods. In Rajasthan *bajra* may not only be a subsistence crop but also an important market crop.

Acreage under rice, *jowar,* maize, and Desi cotton do not show significant relationship with price changes. All other crops have positive short-run elasticities varying from medium magnitudes 0.25 to 0.44 in the cases of wheat, groundnut, and sugarcane to as high as 0.58 to 1.05 in the cases of barley, American cotton, and rapeseeds/mustard seeds. The corresponding long-run elasticities (column three of Table III) range from 0.25 to 1.30. Exceptionally high magnitude (-6.29) of long-run elasticity of sugarcane is obtained due to low value of coefficient of adjustment.

On comparing crop-wise elasticities to price changes, it is observed that the cash crops, e.g., rapeseed/mustard seed, American cotton, sugarcane, and groundnut are more responsive than food crops. Among the food crops the elasticity of barley is higher than that of wheat, etc. The elasticity of barley is comparable to that of Punjab and Rajasthan, though the study periods were different (Appendix Table I). Nowadays, barley is being substituted by wheat in consumption but due to its demand from the beer industry, farmers may produce it for market. The price elasticities for wheat, American cotton, and gram for Haryana are

TABLE III

COEFFICIENTS OF ADJUSTMENT AND SHORT-RUN AND LONG-RUN ELASTICITIES

Crop	Coefficient of Adjustment	Acreage Elasticity with Respect to							
		Rrice		Yield		Irrigated Area		Rainfall	
		SR	LR	SR	LR	SR	LR	SR	LR
1. Wheat	1.00	0.25***	0.25***	0.13**	0.13*	0.94***	0.94***	—	—
2. Gram	1.00	0.26**	0.26**	—	—	−0.96***	−0.96***	0.43***	0.43***
3. Barley	0.69	0.58*	0.84*	0.94***	1.36***	—	—	0.16*	0.23*
4. Rapeseed & mustard seed	1.00	1.05**	1.05**	−0.31	−0.31	—	—	0.58**	0.58**
5. Sugarcane	−0.07	0.44***	−6.29***	0.41**	−5.84**	0.09	−1.28	—	—
6. Rice	0.42	—	—	—	—	0.24	0.58	0.06*	0.15*
7. Maize	1.00	—	—	−0.21	−0.21	0.29**	0.29**	—	—
8. *Jowar*	1.73	—	—	—	—	−1.33***	−0.77***	—	—
9. *Bajra*	1.00	−0.20**	−0.20**	−0.15***	−0.15***	0.08	0.08	—	—
10. Groundnut	0.88	0.40*	0.46*	0.28*	0.32*	−0.56**	−0.63**	—	—
11. Cotton, American	0.61	0.79**	1.30**	0.26*	0.42*	—	—	—	—
12. Cotton, Desi	0.54	—	—	0.46**	0.87**	1.44**	2.69**	—	—

Note: SR=Short-run, LR=Long-run
* Significant at 10 per cent level.
** Significant at 5 per cent level.
*** Significant at 1 per cent level.

higher than those of Punjab and Rajasthan obtained in earlier studies (Appendix Table I). The elasticity of groundnut acreage is approximately equal to Punjab. The insignificant response of rice to price changes in our study is in line with many other studies [9] [14] related to Punjab and other rice-producing states. The price elasticity of sugarcane in Haryana was higher than that of Punjab but was lower as compared to Bihar and Tamil Nadu (Appendix Table I, note c).

G. *Yield Response*

Of the twelve crops, acreage under wheat, barley, sugarcane, groundnut, and cotton (both varieties) positively responded to yield changes while *bajra* acreage responded negatively to yield (Table II). Maize and rapeseed/mustard seed gave insignificant negative coefficients for yield variable. The yield variable was not significantly related to the areas under gram, rice, and *jowar*. The only significant negative elasticity of *bajra* acreage to yield changes may be explained due to the subsistence nature of the crop. As mentioned earlier, the farmers have fixed demand for *bajra* depending upon the requirements of their own consumption and the fodder for their livestock. If yield is higher, the fixed demand for output can be met with less area and the area thus released from *bajra* may be transferred to other remunerative crops such as *guara* or maize.

We observe from the responses of various crops to the above two variables that acreage under wheat, barley, sugarcane, groundnut, and cotton (American) are positively related to both price and yield changes. And mostly (except sugarcane) these are the crops which significantly gained in their areas. This implies the importance of relative revenue productivity (per unit area) in acreage allocation decisions of the farmer. This is well explained in the case of areas under gram and rapeseed/mustard seed. Despite the significant positive response of areas under gram and rapeseed/mustard seed to their price movements, the areas under them have declined; though in the absence of favorable price impact, the decline might have been sharper.

H. *Irrigation and Rainfall*

Regarding these two supply shifters related to water availability, total irrigation of areas in the region has favorably influenced the areas planted under wheat, rice, maize, and Desi cotton and it perversely affected areas under gram, *jowar* and groundnut. For the remaining crops, this variable did not turn out to be significant. The positive short-run elasticities (column six of Table III) range from the medium magnitudes 0.24 to 0.29 in the cases of rice and maize to as high as 0.94 to 1.44 for wheat and Desi cotton. The magnitudes of negative elasticities are 0.56, 0.96, and 1.33 for groundnut, gram, and *jowar* respectively.

The second variable for water availability, i.e., sowing-season rainfall, shows significant positive impact on areas under gram, rapeseed/mustard seed, barley, and rice. In the case of remaining crops it does not turn out to be significant. The positive short-run elasticities (column eight, Table III) vary from as low as 0.06 for rice in *kharif* season to medium magnitudes of 0.16 to 0.58 in the cases of barley, gram, and rapeseed/mustard seed (all are *rabi* season). Acreage response to these variables points out that in the growing of crops, such as gram, rapeseed/mustard seed, and barley, the occasional low availability of water is sufficient (which is provided by rainfall) and the continuous availability of water (through assured irrigation) might make possible and induce the farmers to sow another alternative crop (wheat) which is more remunerative.

The long-run response of acreage to the above variables is almost similar to short-run in terms of both direction and magnitude, except in the case of sugarcane which shows unusually high long-run impact as compared to short-run.

I. *Risk Variables*

Of the two risk variables, i.e., variability due to price and yield (in terms of coefficient of variation of preceding three years price and yield); the variability due to price gives expected negative coefficient in the cases of gram, *jowar,* and wheat (Table II, row six). Price variability was positively associated with the acreage under groundnut and it did not turn up significant for other crops. On the other hand, the variability due to yield does not uphold our a priori expectation for wheat and rice but it was bearing correct sign (negative) in the cases of groundnut, rapeseed/mustard seed, and *jowar.* Thus the area under the latter three crops have been prone to risk due to yield variations. *Jowar* is the only crop whose area is prone to risk due to both yield and price variability. The sign opposite to expectation in the model for yield and price risk variables may be due to continuous trend in the yield and price levels of the crop concerned. In fact the total variability considered by us consists of expected and unexpected variability and it is the latter which actually accounts for risk. If some crops have continuous expected trend in yield or price, the expected variability may predominate the total variability and hence the sign opposite to expected one may occur for the risk variable. For example, the variability in yield of wheat may increase, but if the increase is always caused by upward increase in yield, the resulting effect of this variability will not be negative as the variability was expected.

The technology (dummy) variable was also introduced to take account of increasing use of HYV seed, mechanization, fertilizers, and pesticides for the post-1966 period. Although the dummy variable subsumes in itself the time effect of factors just enumerated; in practice, it is a catch-all variable as much it is associated[6] with other explanatory variables. This variable turned out significant for wheat, *bajra,* cotton (American), rice, and barley. For the rest of the crops it did not enter significantly.

J. *Conclusions and Suggestions*

The results of the supply response of the different crops estimated in our study result in the following main conclusions. The responsiveness of acreage to prices

[6] Exclusion of significant dummy variable in estimating equation of the crops increased the magnitudes of coefficient of total irrigated area. If the association was significant, then equation without dummy was considered.

is not only positive with most crops but also higher than those of earlier studies. This implies the increase in a market-oriented nature of production and it may be true in this food-surplus state Haryana. Furthermore, the study confirms the earlier hypothesis that cash crops are more elastic to price movements than food crops. But the impact of yield estimated in the study indicates that only those crops which positively responded to both price and yield have generally gained in their proportionate acreage at the cost of competing crops. It was found that the acreage under gram and rapeseed/mustard seed is positively and significantly associated with price but insignificantly related with yield and perhaps this explains the paradox of increasing prices but declining proportionate areas under pulses and oilseeds in the cropping pattern.

The analysis further reveals that areas under groundnut, rapeseed/mustard seed, and *jowar* are adversely affected by the variability in their yields. This hints to need for stabilizing their yield by introducing some varieties which are more resistant to environmental factors and hence diseases. In the cases of gram and wheat, our results emphasize the need to minimize the risk due to price.

Irrigation, the potential variable for adoption of modern inputs, has been favorable to wheat, barley, and cotton while it has negatively influenced the acreage under gram, groundnut, and *jowar*. This establishes that changes in cropping pattern have resulted from increase in irrigation to a large extent which even determine the adoption of new farm technology. The impact of a technology variable further strengthens the view widely held that irrigation and other constituents of new technology have acted in a package form for a few crops. This has led to the diversion of land from gram and rapeseed/mustard seed to wheat in *rabi* season. Cultivation of both of these crops is significantly determined by the sowing-season rainfall perhaps on un-irrigated land. Hence, the imperative need is to secure varietal improvement for gram and rapeseed/mustard seed to compete with irrigated wheat in terms of stable revenue so that nutritionally desirable and profitable crop mix may be achieved.

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APPENDIX TABLE I

SHORT- AND LONG-RUN PRICE-ELASTICITY ESTIMATES OF SOME EARLIER STUDIES

Crop	Our Estimates for Haryana, 1960–76			Raj Krishna's for Combined Punjab, 1914–45[a]			Kaul and Sidhu's for Punjab, 1960–69			Acharya and Bhatia's for Rajasthan, 1952–70		
	SR	B[b]	LR	SR	B[b]	LR	SR	B[b]	LR	SR	B[b]	LR
Wheat	0.25	1.00	0.25	0.08	0.59	0.14	0.08	0.14	0.58	0.12	0.50	0.25
Rice	—	0.42	—	0.31	0.52	0.59	0.05 to 0.25	0.36 to 0.39	0.05 to 0.64	—	—	—
Maize	—	1.00	—	0.24	0.40	0.56	0.11 to 0.13	0.79 to 0.85	0.14 to 0.16	0.17	0.32	0.39
Groundnut	0.40	0.88	0.46	—	—	—	0.51 to 0.77	0.16 to 0.24	3.00 to 3.20	1.27	0.35	3.61
Sugarcane[c]	0.44	−0.07	−6.29	0.34	0.56	0.60	—	—	—	1.00	0.32	3.11
Bajra[d]	−0.26	1.00	0.26	—	1.00	−0.33	—	—	—	0.03	0.42	0.07
Barley	0.58	0.69	0.83	0.39	0.77	0.50	—	—	—	0.67[e]	0.46	1.46
Cotton, American	0.79	0.61	1.30	0.72	0.44	1.62	0.45 to 0.68[f]	0.53 to 0.58	0.79 to 1.17	0.67[f]	0.68	0.08

Sources: [10] [9] [1].

[a] The period may slightly differ for individual crops from the end years (rice estimates for price are not statistically significant).

[b] Coefficient of (area) adjustment.

[c] The elasticities obtained by Jha [7] for Bihar are 0.66 (SR) and 0.79 (LR) for the period 1950–65 and for Tamil Nadu 0.63 (SR) and 0.76 (LR) for the period 1947–64 estimated by Madhavan [11].

[d] Batra [3] obtained negative coefficient of price variable for the period 1966–71 in Gujarat.

[e] These results are taken from Cumming's study [5] for the period 1950–68.

[f] These results relate to Desi variety of cotton.