Cultivator Market Responsiveness in Pakistan—Cereal and Cash Crops

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Introduction

In an attempt to identify the effect of various economic, social and political factors on the degree of market responsiveness displayed by cultivators of both food and cash crops, estimates of the supply elasticities of several crops were made. The analysis employed a Nerlove-type supply model [5], which has been widely applied in recent years to the production of a considerable number of crops. Most of the earlier studies have been aggregate in nature, but, given the motivation of the present effort, such an approach was not appropriate. Pakistan displays a profile made up of a wide variety of climatological, topographical, and even sociological circumstances ranging from the littoral districts near Karachi to the mountains above Peshawar, and our basic intention was to highlight any inter-regional rural differences. Thus the supply model was applied not only to national output, but also to that of the divisions and districts and the results are reported herein.

The Nerlove Supply Model

During the late 1950s, Marc Nerlove postulated a mathematical supply model embodying both price expectation and output adaptation concepts for the consideration of researchers interested in assessing the links between market impulses and cultivator output decisions. Since then, literally dozens of authors have adopted and adapted this model, fitting it to the particular needs of their given situations or accounting for the several statistical estimating difficulties that arise from its use.

The specific version of the Nerlove supply model used in this study is quite similar to that employed by others who have investigated crop production elsewhere in the sub-continent [6]. The area that cultivators wish to plant in a particular crop is represented as a function of the price expected to prevail *after* the harvest, the anticipated availability of water during critical periods between sowing and reaping, and a trend variable. Nerlove price expectation and area adjustment formulations complete the model.

(1) $A_t^* = a_o + a_1 P_t^* + a_2 R_t^* + a_3 T + U_t$

(2) $P_t^* - P_{t-1}^* = b \ (P_{t-1} - P_{t-1}^*)$

(3) $A_t - A_{t-1} = c \ (A_t^* - A_{t-1})$

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where A_t^* is the desired acreage in the crop;

P_t^* is the expected realized price;

R_t^* is the expected availability of water;

T is the trend variable;

A_t is actual planted acreage ; and

P_t is actual realized crop price.

Thus, this year's price expectations [equation (2)] are modified relative to those of last year by some fraction of the *difference* between last year's actuality and expectation, while the actual area adjustment from last year to this is equal to a proportion of the *desired* adjustment.

However, equation (1) cannot be directly estimated because it includes unobservable variables. If (2) and (3) are substituted in (1) and the latter is then algebraically manipulated, we obtain :

$$(4)\ A_{t-1}\ (1\text{-}b)\ A_{t-1} = a_0bc + a_1bc\ P_{t-1} + (1\text{-}c)\ (A_{t-1}\text{-}(1\text{-}b)A_{t-2}) + a_2c\ (R_t^*\text{-}(1\text{-}b)\ R^*_{t-1}) + a_3c\ (T\text{-}(1\text{-}b)\ (T\text{-}1) + c(U_t\text{-}(1\text{-}b)\ U_{t-1})$$

A parameter identification problem which occurs in the Nerlove model is avoided by estimating equation (4) for various specified values of b, the price expectation coefficient, which can be reasonably assumed to fall between zero and two. What is basically a maximum likelihood approach is then used—that value of b for which the error sum of squares is minimized is chosen as the ***best*** estimate.

Because of the presence on the right-hand side of equation (4) of lagged values of the dependent variable, auto-correlative problems are introduced into the estimating procedure. Thus, an ordinary least squares regression analysis which incorporated the Cochrane-Orcutt technique [1] was used to estimate the parameters. The procedure was thus doubly iterative—first, a range of price expectation coefficient values and then the Cochrane-Orcutt procedure for minimizing the disruptive effect of correlated disturbance terms was employed in the regression analysis.

The Results

Seven crops were considered—among them, both major cereal (wheat, rice and barley) and cash crops (cotton, rape and mustard seed, sesamum, and tobacco). The former claim nearly half the country's acreage and the latter another fifteen percent. These crops are *not* found uniformly throughout the country ; rather, their cultivation reflects the Pakistani diversities mentioned earlier. For example, rice is the major subsistence cereal in the southernmost districts along the coast, but wheat quickly becomes dominant as one proceeds northward through the Indus plain. Similarly, barley is grown mostly in the more temperate northern climes, under much the same conditions as wheat.

Unfortunately, data on the actual prices paid to farmers in local markets were not available; in their place, wholesale prices prevailing in those urban markets closest to the region in question were used.[1] Prices were deflated by a measure of the change in the cost of living for the urban working class. In the absence of any measure of change in rural purchasing power, this seemed the best available substitute, especially in light of the increasingly urban consumption patterns of rural residents during the post-independence period.

Rainfall expectations, like those regarding price, are of course impossible to measure directly. The approximation employed herein was an index computed from the actual rainfall during the period immediately preceding and accompanying the sowing of each crop relative to average precipitation during similar past periods.[2]

Parameter estimates obtained from regressions run on equation (4) are shown in Table 1 for Pakistan as a whole, while the supply elasticities derived from the price parameters are listed in Table 2. Elasticities for the divisions and selected districts[3] are shown in Tables 3 and 4 respectively.

As can be seen from Table 1, positive price responsiveness is indicated on the national level for all crops except the two claiming the least area, sesamum and tobacco. While not much statistical significance is attached to the estimated price coefficients for wheat and barley, those for rice and the other three cash crops (American cotton, *desi* cotton, and rape and mustard seed) are significantly different from zero at the 30 percent level or better. Supply elasticities for both cotton varieties and for rape and mustard seed are notably higher (Table 2) than those for the less market-oriented cereal crops. Our estimates are compatible with those estimated by Walter Falcon [4] for wheat and cotton; for slightly different time periods, he calculated a short-run elasticity for wheat of about zero on unirrigated land and between +0.10 and +0.20 on irrigated acreage (1933 to 1959) and for cotton of about +0.50 (1949 to 1963).

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1 For nation-wide regressions, weighted average wholesale prices were used.

2 This paper reports part of the results which focused on the entire subcontinent. In hopes of obtaining comparable results, the same model was used to estimate supply in all crop districts, and consistency in the variables used was stressed, although this required making certain simplifying assumptions.

For example, it would probably be preferable to use the quantity of each crop actually brought to market (the so-called marketed surplus) rather than planted acreage as the dependent variable. However, data on such surpluses were not available on anything approaching the scale across districts and over time that would be needed to carry out the regression analysis. Obviously, the use of planted acreage as the dependent variable is a more serious shortcoming for the food crops than for cotton, oilseeds and tobacco.

Similar considerations of consistency dictated the use of a single formulation of prices. Theoretically, an index incorporating the prices of competing crops would have been more satisfactory. However, again the data needed for the construction of a suitable index were not available for a majority of the districts studied.

As indicated in the text, the rainfall indices were calculated specifically for each crop and, as far as was practicable, for each geographic region. The trend variable incorporated herein is a useful though imperfect device for accounting for the effects of input(s) whose use varies monotonically (more or less) over time. In this case, the trend variable serves principally as a means of including what can be called either technology or capital, whose beneficial effects are assumed to grow over time with their use and for whose disaggregated components there are insufficient data to include them separately in the estimating equation.

All data were taken from official sources, principally from Pakistani government documents, with some supplementary rainfall data coming from the United States Department of Commerce. Other parts of this study have been reported by the author in [2 and 3].

3 For each crop, the districts shown are the more important producers.

Table 1

Supply Model Estimated Parameters

Crop	Time Period	Constant	Price	Lagged Area	Rainfall	Trend	R^2
Rice	1949—1968	+963.7[a] (1.39)	+15.03[b] (2.11)	+0.310 (0.78)	+0.107 (0.32)	+55.59[c] (2.21)	0.94
Wheat	1949—1968	+1636.0 (0.03)	+90.83 (1.03)	+0.310 (0.65)	+4.391[a] (1.37)	+120.7 (0.63)	0.89
Barley	1951—1968	+514.8[d] (4.40)	+1.434 (0.38)	-0.308 (1.02)	+0.312[d] (3.02)	-6.218[c] (2.17)	0.54
Cotton (American)	1950—1962	+1448.0[d] (3.46)	+16.46[d] (4.96)	+0.139 (0.99)	+1.057[b] (1.89)	+122.96[c] (2.60)	0.82
Cotton (*Desi*)	1950—1962	+690.7[c] (2.94)	+2.839[c] (2.34)	-0.490[b] (1.85)	+0.046 (0.24)	-10.53 (0.78)	0.41
Rape and Mustard	1951—1967	+363.2 (0.94)	+20.60[a] (1.65)	+0.208 (0.55)	+0.366 (0.51)	-19.42[a] (1.30)	—
Sesamum	1951—1967	+59.78[b] (2.01)	-0.160 (0.46)	+0.021 (0.04)	+0.040[a] (1.32)	+1.256[a] (1.44)	0.31
Tobacco	1951—1967	+36.98[a] (1.71)	-0.106 (0.72)	+0.100 (0.30)	+0.031 (0.50)	+7.005[d] (3.87)	.074

Notes **:** Figures in parentheses are t-values.
a. 30 percent significance level
b. 10 percent significance level
c. 5 percent significance level
d. 1 percent significance level

Table 2

Expectation and Adjustment Coefficients and Supply Elasticities

Crop	Price Expectation Coefficient	Area Adjustment Coefficient	Short-Run Elasticity	Long-Run Elasticity
Rice	+0.9	+0.69	+0.12	+0.17
Wheat	+0.7	+0.45	+0.10	+0.22
Barley	+0.85	+1.31	+0.03	+0.02
Cotton (American)	+1.1	+0.86	+0.40	+0.47
Cotton (*Desi*)	+1.1	+1.49	+0.41	+0.28
Rape and Mustard	+0.8	+0.79	+0.38	+0.48
Sesamum	+0.9	+0.98	-0.09	-0.09
Tobacco	+0.7	+0.94	-0.13	-0.14

Considering each crop in turn, the small supply elasticity indicated nationally for rice is repeated in most divisions and districts. Though negative estimates were found in a few cases, most of those which show any degree of statistical significance are positive. This situation is more or less reversed for wheat. Though many of the geographically disaggregated estimates, like that for the nation as a whole, are not significantly different from zero, those for which any notable significance is indicated are mostly negative. This is particularly true in the major wheat regions of the Punjab.

For barley, a crop which is grown in most wheat districts, generally the more localized the analysis, the more statistically significant are the positive price parameter estimates. Only in Sind (where barley cultivation is slight) were negative coefficients indicated. On the whole, elasticity amplitudes were somewhat greater than those of either of the other two more important cereals.

For the major cash crop, cotton, positive price responsiveness is clearly indicated for both varieties, though the relative degree is somewhat greater for the hybrid American cotton which commands the higher market price. On the district level, only in Hyderabad, one of the most important districts producing American cotton, was the estimated price parameter negative, and in this case, statistical significance was lacking at even the 30 percent level. Since the model employed did not regress acreage in each variety on the price of the other, no direct evidence for (or against) the substitution of one for the other can be obtained. However, prices for both American and *desi* cotton do tend to move together. Despite this, on the division level, in only two cases do the estimated price coefficients have opposite signs (which would be at least indirect evidence of substitution of the inferior *desi* for American cotton), and in neither

Table 3

Supply Elasticities By Division

Division		Rice	Wheat	Barley	Cotton (American)	Cotton (*Desi*)	Mustard	Sesamum	Tobacco
Bahawalpur	SR	-0.15	+0.08	+0.48[a]	+0.40[a]	+0.60[c]	+1.09[c]	+0.30[c]	—
	LR	-0.17	+0.10	+0.51	+0.29	+0.44	+0.61	+0.42	—
Dera Ismail Khan	SR	—	+0.01	+0.55[d]	—	—	-1.94[c]	—	—
	LR	—	+0.01	+0.45	—	—	-1.15	—	—
Hyderabad	SR	+0.35[c]	+0.02	-0.50[a]	0	—	-0.33	-0.74[d]	—
	LR	+0.36	+0.02	-0.28	0	—	-0.11	-0.51	—
Khairpur	SR	-0.11	+0.57[b]	-0.34[b]	+1.84[d]	+0.45	+0.74[a]	-0.20	—
	LR	-0.13	+0.63	-0.30	+3.54	+0.51	+0.77	-0.07	—
Lahore	SR	+0.09	-0.09	+0.20[a]	+0.42[b]	-0.05	+0.63	-0.99[d]	-0.03
	LR	+0.14	-0.09	+0.34	+0.67	-0.03	+0.73	-1.05	-0.03
Multan	SR	+0.08	-0.03	+0.09	+0.52[c]	-0.57	+0.81[d]	-0.33[a]	-0.37[c]
	LR	+0.42	-0.04	+0.06	+0.46	-3.35	+0.47	-0.58	-0.46
Peshawar	SR	+0.08	0	+0.21	—	+0.15	-0.45	—	+0.83[a]
	LR	+0.07	0	+0.22	—	+0.21	-0.38	—	+0.94
Quetta	SR	+0.11	-0.26[a]	+0.46[b]	—	—	—	—	—
	LR	+0.16	-0.27	+0.47	—	—	—	—	—

—*Continued*

Table 3—*Continued*

Division		Rice	Wheat	Barley	Cotton (American)	Cotton (*Desi*)	Mustard	Sesamum	Tobacco
Rawalpindi	SR	+0.76[d]	-0.26[c]	+0.19	+0.26[a]	+0.57[c]	+0.11	—	+0.31[a]
	LR	+38.0	-0.42	+0.17	+0.72	+0.32	+0.20	—	+0.34
Sargodha	SR	-0.34[a]	-0.39[a]	+0.14	+0.23[c]	+0.33[a]	+0.94[c]	+1.01[d]	+1.10[c]
	LR	-0.34	-0.40	+0.22	+0.16	+0.20	+0.94	+0.68	+0.65

***Notes*:** (1) Lack of a figure indicates no supply analysis was performed.

(2) Significance level of price parameter from which elasticity was derived:

a. 30 percent c. 5 percent
b. 10 percent d. 1 percent

Table 4

Supply Elasticities—Selected Districts

District	Short-run Elasticity	Long-run Elasticity	District	Short-run Elasticity	Long-run Elasticity
1	2	3	4	5	6
Rice					
Dadu	+0.28[c]	+0.72	Larkana	-0.06	-0.09
D. G. Khan	+0.02	+0.03	Sahiwal	+0.08	-0.24
Gujranwala	-0.36	-0.32	Muzaffargarh	+0.56[a]	+1.33
Gujrat	+0.91[d]	-10.1	Sanghar	+0.47	+0.37
Hazara	+0.47[b]	+0.26	Sheikhupura	-0.24	-0.22
Hyderabad	+0.42[a]	+0.23	Sialkot	+0.82[c]	+1.00
Jacobabad	-0.06	-0.15	Sibi	+0.13	+0.25
Khairpur	+0.80	+0.86	Sukkur	+0.05	+0.06
Kurram	+0.20[b]	+0.33	Tharparkar	+0.81[a]	+0.65
Lahore	+0.18[e]	+0.69	Thatta	+0.49[d]	+4.90
Wheat					
Attock	-0.33[d]	-0.67	Loralai	-0.16	-0.19
Bannu	-0.05	-0.06	Lyallpur	-1.22[c]	-1.03
Chagai	+0.94[b]	+1.52	Mianwali	+0.49[a]	+0.35
Dadu	+0.52[e]	+0.52	Sahiwal	-0.18[d]	-0.15
D. G. Khan	-0.05	-0.04	Multan	+0.01	+0.02
D. I. Khan	-0.19	-0.12	Muzaffargarh	0	0
Gujranwala	-0.13	-0.17	Nawabshah	-0.46[a]	-0.43
Gujrat	-0.13[a]	-0.20	N. Waziristan	+0.01	+0.01
Hazara	-0.15[d]	-0.09	Peshawar	-0.06	-0.24

—*Continued*

Table 4—*Continued*

1	2	3	4	5	6
Wheat—*contd.*					
Hyderabad	-0.90	-1.03	Quetta	-0.09	-0.11
Jacobabad	+2.60[d]	+3.38	Rawalpindi	-0.05	-0.06
Jhang	-0.51[d]	-0.46	Sanghar	+0.04	+0.05
Jhelum	+0.05	+0.09	Sargodha	-0.17[b]	-0.20
Khairpur	+0.62[a]	+1.17	Sheikhupura	-0.07	-0.06
Kohat	-0.19	-0.19	Sialkot	-0.08	-0.07
Kurram	-0.02	-0.02	Sibi	+0.13[a]	+0.25
Larkana	+0.17	+0.15	Zhob	+0.05	+0.04
Lahore	-0.07	-0.08			
Barley					
Attock	-0.06	-0.08	Mardan	-0.40[b]	-1.74
Bannu	+0.90[a]	+0.85	Mianwali	+0.26	+0.27
D. I. Khan	+0.47[a]	+0.28	**Sahiwal**	+0.02	+0.02
Gujranwala	+0.32[e]	+1.10	Muzaffargarh	+0.01	+0.01
Gujrat	+0.55[d]	+2.75	Peshawar	+0.09	+0.21
Hazara	+0.16[b]	+0.17	Quetta	-0.04	-0.05
Khairpur	+0.04	+0.11	Sheikhupura	+0.43[d]	+0.43
Kohat	+0.81[c]	+0.63	Sialkot	+0.08	+0.06
Lahore	+0.40[a]	+0.54	Sukkur	-0.37	-0.36
Loralai	+0.48	+0.50	Thatta	-0.31[a]	-0.36
Cotton (American)					
Gujrat	+0.26[a]	+0.72	Multan	+0.43[a]	+0.35

—*Continued*

Table 4—*Continued*

1	2	3	4	5	6
Cotton (American)—*contd.*					
Hyderabad	-0.18	-1.13	Nawabshah	+0.94[c]	+0.82
Jhang	+0.18	+0.18	Sanghar	+0.09[a]	+0.07
Khairpur	+1.44[c]	+4.50	Sargodha	+0.40[b]	+0.34
Lyallpur	+0.74[d]	+1.72	Sheikhupura	+0.34[a]	+0.81
Sahiwal	+0.65[d]	+0.81	Tharparkar	+0.02	+0.02
Cotton (*Desi*)					
Gujranwala	+0.64[d]	+0.94	Lahore	-0.41[b]	-0.95
Khairpur	+2.16[d]	+2.14	Nawabshah	-0.22	-0.28
Sahiwal	-0.66	-3.67	Sialkot	+0.56[a]	+0.61
Rape and Mustard					
Attock	-0.27	-0.64	Lyallpur	+0.44[b]	+0.27
Dadu	+0.28[c]	+0.31	Mianwali	+0.61[c]	+0.80
D. I. Khan	-0.60[a]	-0.36	Nawabshah	+0.71[a]	+0.74
Hyderabad	-0.57[c]	-2.48	Sanghar	-0.84[b]	-4.94
Jacobabad	-0.52[b]	-2.17	Sibi	+2.74[d]	+5.71
Khairpur	-0.06	-0.06	Sukkur	+0.75[b]	+1.29
Larkana	+1.39[c]	+2.44	Thatta	-0.87[a]	-0.88
Tobacco					
Attock	+0.16	+0.21	Mardan	+0.46	+0.46
Gujranwala	-0.19[a]	-0.17	**Sahiwal**	-0.19[a]	-0.12
Gujrat	+0.39[c]	+0.36	Peshawar	+1.29[a]	+2.30
Lahore	-0.26	-0.27	Sheikhupura	+0.27[a]	+0.22
Lyallpur	+0.11[c]	+0.08	Sialkot	-0.19	-0.15

***Notes*:** **Significance level of price parameter from which elasticity was derived :**
(a) 30 percent ; (b) 10 percent ; (c) 5 percent ; (d) 1 percent.
Sahiwal was formerly known as Montgomery.

case are both the estimates statistically significant. In Lahore division, where each variety claimed about the same acreage during the period of this study, the non-significant negative price parameter (for *desi*) yields an elasticity very close to zero, while in Multan division the two elasticities are about equal in magnitude, though the negative price relationship (for *desi*) is again not very significant. However, *desi* planting in Multan is very slight, accounting for only about six or seven percent of cotton acreage, ruling out any major degree of substitution. On the district level, only in Lahore was significance attached to a pair of parameter estimates with opposing signs; that for American cotton was significant at the 10 percent level and yielded short- and long-run elasticities (not shown in Table 4 because of the crop's minor status in this district) of +0.96 and +0.80 respectively.

Of the two oilseeds (sesamum on the one hand and rape and mustard seed on the other) considered herein, rape and mustard seed is considerably more important. The fairly large and statistically significant positive elasticity indicated on the national level is generally borne out in the division and district calculations. While several negative significant estimates are seen in Table 4, about three-fourths of those made (including the ones for the minor producing districts not shown in this table) were positive. These elasticities (like the positive values shown) tend to be greater than one-half, indicating overall a rather strong market orientation among cultivators of this crop.

On the other hand, for sesamum, which claims only about 10 percent of the acreage in rape and mustard seed, the negative market relationship nationally is emphasized by the division-level results.[4] Of the six divisions analyzed, only in two (which together produce less than a seventh of the crop) are positive price coefficients indicated.

The negative (but not statistically significant) link between prices and acreage for tobacco is overridden by the results of the more disaggregated analyses. Though tobacco is grown in small quantities in many areas, the bulk of the crop originates in a few districts (for example, in Peshawar division), and in these major production centres, positive elasticities are indicated. Tobacco is a very specialized crop as regards land and other inputs. It also rewards its cultivators with a fairly steady per acre return which is generally higher than for 'next-best' alternative uses. Other results of this study for tobacco regions in India and Bengal indicate a tendency for major tobacco districts to be relatively isolated from the market. Good tobacco land seems to be *already* in the crop because of the crop's generally strong rewards to its cultivators. At least relatively minor short-run variations in price don't seem to affect greatly tobacco acreage elsewhere in the sub-continent.

Summary and Conclusion

The market responsiveness of cereal cultivators is dichotomous, with distinctions that seem to be related to both the relative importance of the crop and the region being analyzed. For wheat, by far the leading grain crop, little positive reaction to prices is indicated. Particularly in the major wheat districts in the

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be made to identify the effects of various market and non-market factors on the direction and intensity of cultivator responsiveness to prices. General comments about geographic patterns, however, are not enough. Such analysis must have a rigorous statistical base if recommendations of meaningful policies designed to influence cultivator responsiveness are to emerge. For any society which intends to use the market mechanism to induce greater crop output, the policy implications of identifying what factors influence responsiveness (and how much) are clear—the means could be indicated not only for expanding output but also for increasing the degree of responsiveness. But, for the present at least, we have fairly consistent evidence that Pakistani cultivators are indeed positively affected by prices.

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