Demand for Nitrogenous Fertilizers and Fertilizer Price Policy in Pakistan

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Introduction

One of the major constraints to an increase in Pakistan's agricultural production is low fertilizer input. Despite spectacular growth of fertilizer consumption during the '60s the rate of fertilizer application in Pakistan remains below the optimal rate [8, pp. 77-90] and far below the rates in advanced countries [15, p. 24]. An upward movement of the rate of fertilizer application, essential to avoid recurring loss of agricultural production, entails appropriate policy measures over a long time-horizon.

Appropriate policy guidance may well be derived from the experience of the '60s. It is believed that low fertilizer prices, among other factors, contributed enormously to the growth in fertilizer consumption [9, pp. 419-25]. Towards the end of the '60s, however, the fertilizer prices increased causing a decline of per acre and total fertilizer consumption [15, p. 24]. As fertilizer is a critical input, reduced consumption is translated into reduced agricultural output, higher prices of agricultural commodities or both.

The purpose of the present study is to review agricultural price policy and the demand for fertilizer. The demand for fertilizer in Pakistan has been studied previously by Leonard [9, pp. 419-25] and Ayub [1, pp. 135-41]. The present paper supplements those studies in two respects. First, the paper redefines key

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demand variables. Second, the paper considers broad implications of the fertilizer price policies and not just the earlier issue of the continuation or removal of fertilizer price subsidy.

Among other things, the time period of the dependent variable in the fertilizer demand function is changed from the fiscal year (July to June) to the agricultural year (March to February). This change more closely approximates to the time cycle of the fertilizer use. A more important redefinition is the use of the nominal price of fertilizer in the demand function. The earlier studies in Pakistan used real prices of fertilizer and approximated it by deflating nominal price by an index of agricultural income. (The latter also served as the income variable in their demand function.) This approach is not adopted here. Instead, the income variable is redefined as gross money revenue per crop-acre which is compatible with the use of nominal price of fertilizer. This redefinition is desirable because nominal prices are relevant policy instruments under the direct control of the government.

Variables of Demand and Their Choice

Demand for fertilizer is a complex dependent variable determined by a set of independent variables. It may be considered a function of its own price [4, p. 37], the prices of substitutes (such as organic manure) and the prices of complementary inputs (such as land and water) [9, pp. 320-21]. As an intermediate input, fertilizer demand is a derived demand, which will be determined by the physical yields of agricultural commodities and their prices [6, pp. 475-525]. Yield, in turn, is a function of technology and the weather. Other factors which could affect demand for fertilizer include changes in farm size [9, p. 429], cropping intensity [10, p. IV], the tenure system, credit availability, fertilizer distribution system, and farmer's awareness of returns from fertilizer [12, p. 23].

The estimation of a demand function which includes all of the above factors poses problems. Time series data on many of these variables are not available. Also, most of the above factors are interrelated and their use may involve multi-collinearity problem.

These statistical problems are avoided by the use of a limited number of explanatory variables: (1) price of fertilizer, (2) revenue per cropped acre, and (3) a trend variable representing technology and institutional changes. The fertilizer price variable is the average annual price of fertilizer from March to February of each financial year. The lack of data on prices of manure precluded its use as an independent variable but this is not considered a serious analytical drawback as the prices of manure may be expected to fluctuate with the price of fertilizer. The second variable—revenue per crop-acre at current prices—reflects changes in the physical yields of agricultural commodities and their prices. The variable was derived from the national income estimates. The income from principal agricultural crops at current prices was divided by their total area to get income per crop-acre.

A composite trend variable (T) will reflect fertilizer demand changes as a result of technological developments. Among the technological changes of the '60s were the development of tubewells and the introduction of high yielding varieties (HYVs); both factors necessitated higher fertilizer use.

Tubewell installation was associated with a doubling of fertilizer input per crop-acre and greater cropped acreage [7, p. 75]. The HYVs require more fertilizer input per corp-acre [15, pp. 9-11]. In addition, the trend variable also reflects changes in fertilizer demand associated with the spread of knowledge about its usefulness and changes in institutional arrangements such as farm size, tenurial system, credit policy, canal water supplies, and the like.

We used time-series data from 1961-62 to 1973-74. Because the price of fertilizer was extremely low before the Green Revolution of the mid-'60, we estimated two separate equations, based on data for the periods 1961-62 to 1967-68 and 1965-66 to 1973-74. The overlapping of the two time periods was inevitable to have reasonable degree of freedom and because of uncertainty about the exact date of the beginning of the Green Revolution (sometime between 1965 and 1967) in Pakistan.

Ayub, in his econometric study of demand for fertilizer in Pakistan, experimented with several alternative forms of equations and concluded that the use of complicated forms did not improve the analysis [1, pp. 135-141]; the simple linear equation provided the best fit. Following Ayub, we used a linear equation of the following form:

$$D_f = a_o + a_1 P_f + a_2 R_c + a_3 T + u$$

where:

D_f = effective demand or consumption of fertilizer in million nutrient pounds of nitrogen from March to February;

P_f = average annual prices per nutrient pound of nitrogen from March to February of each year;

R_c = revenue or value per crop-acre of principal crops at current prices;

T = a trend variable depicting technological development in agriculture;

a = the intercept;

u = error terms; and

a_1, a_2 and a_3 are the regression coefficients corresponding to the explanatory variables, P_f, R_c and T respectively.

Presentation of Results

The time-series data from 1961-62 to 1967-68 yielded unsatisfactory results. R^2 was high but the F ratio and coefficients of variables were non-significant. Hence the equation was not reported. Similar results were obtained and reported by Ayub [1, pp. 135-141] and Leonard [9, pp. 419-25]. The follwoing linear equation was derived from the data relating to the period 1965-66 to 1973-74:

$$D_f = 242.0 - 1059.8\ P_f + 1.4\ R_c + 113.9\ T$$
$$(-5.54) \quad (2.76) \quad (12.81)$$

Figures in parentheses represent "t" statistics.

$R^2 = 0.99$ D.W. Statistic = 1.24

Degrees of freedom = 5

F. Value = 227.39

As one would expect, the price of fertilizer was negatively related to fertilizer consumption whereas both revenue per crop-acre and level of technology had a positive relationship. The three variables together explained 99 percent of the variation in demand and the individual explanatory variables were found to be highly significant (at the 1 percent level) except revenue per crop-acre, which was significant at the 5 percent level of significance. The Durbin-Watson statistic does not indicate the presence of serial correlation.

Demand Elasticities

The elasticity of demand measures the percentage change in the quantity demanded of a good associated with a one percent change in the individual explanatory variables. Demand elasticities for fertilizer are especially important because fertilizer is a critical input for modernizing agriculture; a decline in its consumption may seriously hinder and disrupt an economy's agricultural development. The elasticities of fertilizer demand with respect to individual explanatory variables are presented in Table 1.

Table 1

Elasticities of Demand for Fertilizer

Variable	Elasticities based on average for 1965-66 to 1973-74	Elasticities based on 1973-74 fertilizer price and consumption
Price	−1.21	−1.48
Value per crop-acre	0.74	0.87

Source: Calculations based on regression equation and data in Appendix Table A.

The price elasticity of demand for fertilizer was −1.21 for the period 1965-66 to 1973-74, and −1.48 based on 1973-74 data. The demand elasticity with respect to the value per crop-acre was 0.74 for the whole of the period and 0.87 for 1973-74. Using 1973-74 elasticities, a one percent increase in the price of fertilizer would lead to a 1.48 percent decline in the consumption of fertilizer; an increase of one percent in value per crop-acre increases the demand for fertilizer by 0.87 percent.

Economic Implications and Recommendations

The elasticity of demand with respect to price is negative with a value of 1.21. The revenue and time trend variables are both significant and positive. Significant policy implications follow from the empirical findings of the present study.

1. Any rise in the price of fertilizer would lead to a reduction in the use of fertilizer provided other relevant variables determining the quantity of fertilizers used are not affected by government policy. Reduced fertilizer use would imply reduced agricultural production and higher prices of agricultural goods. It is, thus, in line with the government policy of containing the inflationary pressures

that the subsidy on fertilizer should be allowed to continue. An added justification for the continuation of subsidy on fertilizer is the low procurement price of wheat in Pakistan compared to international market prices. While the procurement price of wheat in Pakistan is fixed at Rs. 37.00 per maund, the PL 480 wheat, imported between March and June, cost Rs. 60.38 per maund.[1]

2. The conclusion reached in the previous sub-section that subsidy on fertilizer should be continued depends on the assumption that (i) fertilizer consumption augmenting technology is not evolved and (ii) revenue per acre does not change to affect the demand for fertilizer. Both these assumptions do not hold in the agricultural sector of any country. In Pakistan, during the period 1965-66 to 1973-74, the annual rate of growth of fertilizer consumption-augmenting technology was 21.24 percent and that of revenue per crop-acre was 2.67 percent. The two factors together allowed for a 20.26 percent (=21.24÷1.14 plus 2.67÷1.64) annual increase in the price of fertilizer without a decline in fertilizer consumption. Any increase in fertilizer price greater than the above permissible rate is bound to have adverse effects on fertilizer consumption, agricultural production and inflation. The experience of 1973-74 in Pakistan in this regard seems to confirm the above finding. During 1973-74, the price of fertilizer was raised by 50 percent, which, among other things, caused a decline in agricultural production and an accelerating trend in inflation. It is, therefore, recommended that the fertilizer price increase in excess of the above permissible rate in any year be avoided.

3. Whether the permissible rate of fertilizer price increase is applicable in the future is a pertinent question which deserves our attention. As the changes in technology and revenue per crop-acre are the major determinants of the rate, its magnitude in the future will depend on the rate of changes in fertilizer-augmenting technology and revenue per crop-acre. The rate of growth of both these factors in future, however, is expected to slow down due to: (i) full awareness of the farming community of the usefulness of fertilizer; (ii) almost complete introduction of HYVs; (iii) decline in private tubewell development due to increases in the cost of installation and the energy crisis; (iv) declining physical yields of agricultural commodities; and (v) little scope to allow further price increases for agricultural commodities.

The expected slow-down of the rates of growth of fertilizer-augmenting agricultural technology and revenue per crop-acre suggests that the future permissible rate of fertilizer price increses would be lower than the estimated rate of 20.26 percent. It, however, is difficult, with the present set of data, to ascertain the exact magnitude of the permissible rate for future policy.

Conclusions

The analysis of the present study indicates that the demand for fertilizer is quite sensitive to changes in the price of fertilizer. Changes in revenue per

[1] Average c.i.f. price of wheat at Karachi port weighted by the quantities imported against each price, from March to June 1975. The dollar value of imports was converted into Rupee value at the official exchange rate of 9.90 per dollar. The information on wheat imports and their prices was collected from the files of the PL 480 Branch, Ministry of Food and Agriculture, Islamabad.

crop-acre and technical change have been important factors in determining the total use of fertilizer in Pakistan.

Changes in the revenue per acre and fertilizer consumption-augmenting technology are essential factors to be taken into account in assessing the effect of the changes in the price of fertilizer on agricultural output and the general price level. The study reaches an important policy conclusion that, based on the experience in Pakistan over 1965-66 to 1973-74 period, the fertilizer prices can be increased by 20.26 percent per year without adversely affecting the level of agricultural output. This result is an important one to justify the gradual withdrawal of subsidy on fertilizer in Pakistan.

Appendix Table A

Fertilizer Consumption, Fertilizer Price and Revenue per Crop-Acre: 1961-62 *to* 1973-74

Year	Consumption of nitrogenous fertilizer	Price of fertilizer	Revenue per crop-acre
	(Million lbs.)	(Rs. per lb.)	(Rs.)
1961-62 ..	82.9	0.33	144.04
1962-63 ..	91.4	0.46	148.23
1963-64 ..	152.3	0.42	171.44
1964-65 ..	190.4	0.38	183.83
1965-66 ..	155.1	0.39	184.50
1966-67 ..	241.4	0.47	210.22
1967-68 ..	397.5	0.47	215.22
1968-69 ..	455.9	0.50	224.21
1969-70 ..	610.5	0.55	269.93
1970-71 ..	563.4	0.65	263.28
1971-72 ..	770.5	0.65	303.17
1972-73 ..	865.5	0.72	369.03
1973-74 ..	765.9	1.08	464.83

Source: For Cols. 2 & 3, [13]

Col. 4: Calculations based on GDP of principal crops at current prices and their acreage given in [11, pp. 10 & 17, appendix section].

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