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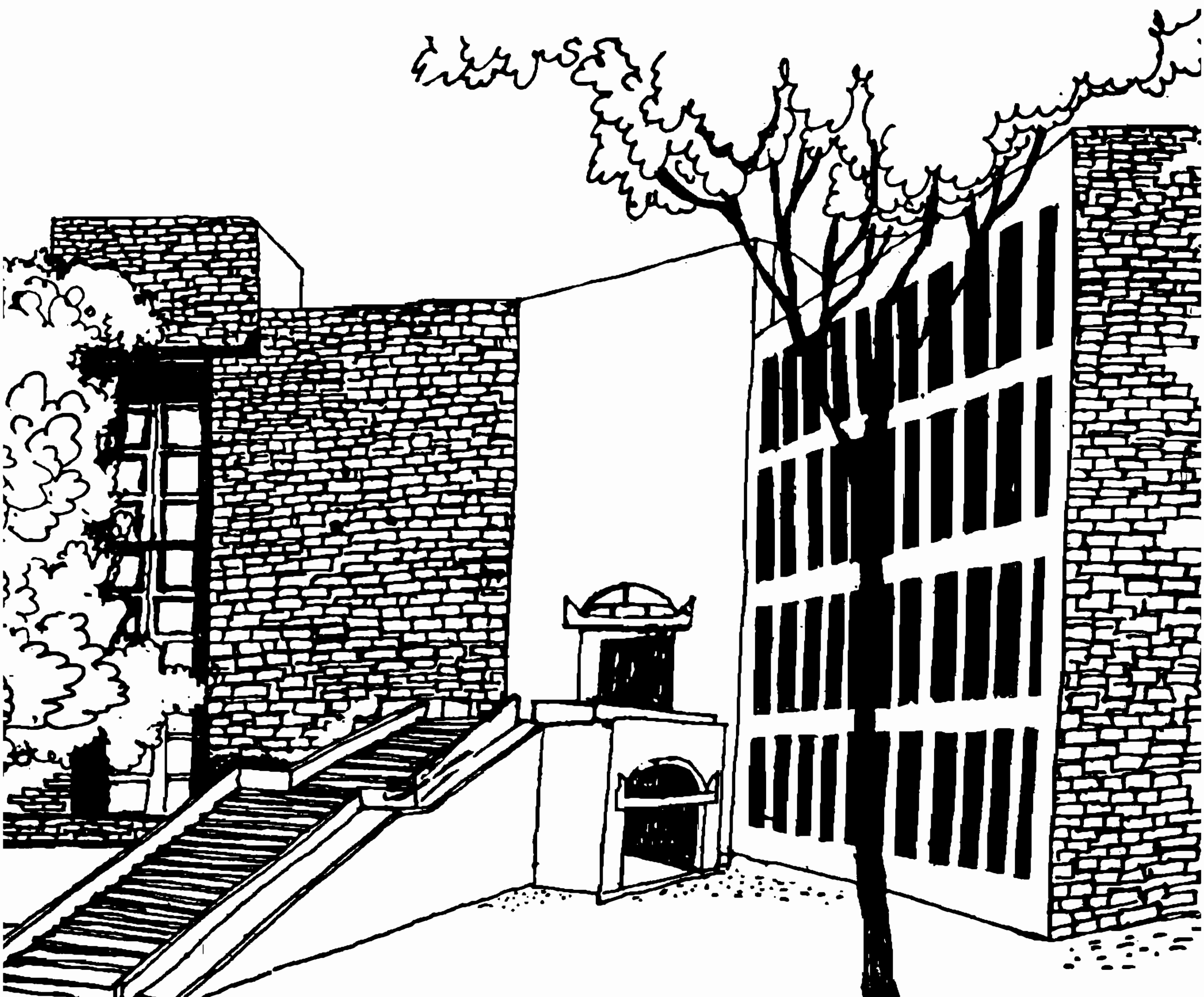

ESTIMATION OF PRICE ELASTICITY OF FERTILIZER DEMAND IN INDIA

By

Ravindra H. Dholakia
Jagdip Majmudar

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INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
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Estimation of Price Elasticity of Fertilizer Demand in India

- Ravindra H.Dholakia[*]
and
Jagdip Majmudar[**]

Abstract

The empirical evidence on the price elasticity of fertilizer demand in India is not conclusive. In order to properly estimate the likely impact of the policy changes affecting fertilizer prices on the fertilizer use and hence on the agricultural growth in the country, magnitude of the short-run and long-run price elasticity of fertilizer demand is essential. The present study attempts to estimate the elasticity coefficients by appropriately specifying the fertilizer demand function. Both static as well as dynamic models are considered. The fertilizer demand in India is found to be price inelastic in the short-run and even in the long-run. Our estimates based on a time series macro level data from 1966-67 to 1991-92 are corroborated by the findings of a recent survey carried out in U.P.

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[*] Professor of Economics, Indian Institute of Management, Ahmedabad.

[**] Lecturer in Economics, Bhavnagar University, Bhavnagar.

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I. Introduction

Several studies have attempted to estimate the price elasticity of demand for fertilizer in India. However, the available empirical evidence on this crucial parameter is not conclusive. Some recent studies have found it to be price elastic (Kundu and Vashist, 1991; Subramaniyan and Nirmala, 1991); whereas some earlier studies have found it to be price inelastic (Parikh, 1965). It is also argued that there would be considerable differences in the estimates of the elasticity in the short-run and long-run (Timmer, 1974; Mudahar, 1978). These arguments are corroborated when Sharma (1993) finds that fertilizer demand in India is price inelastic in the short-run but is price elastic in the long-run. In order to estimate the likely impact of any policy affecting the price of fertilizers on their consumption, a clearer idea about the magnitude of the price elasticity of fertilizer demand is necessary. This is all the more important because most of the existing studies on the fertilizer demand in India suffer from serious limitations affecting the estimate of the price elasticity directly.

Kundu and Vashist (1991) have combined chemical fertilizers with insecticides and pesticides. Subramaniyan and Nirmala's reported estimates (1991) contain serious errors since they cannot be derived from the basic data provided by them in their study. If we re-run their regressions, the findings suggest that fertilizer demand is highly price inelastic (-0.28) in the short run but is highly price elastic (-2.8) in the long run. Even their estimate in the static model works out to -0.55. These estimates are, however, not statistically reliable since they contain serious problems of specification errors and measurement of variables. As for example, the authors have taken a qualitative variable for weather conditions (rainfall) with values ranging from 1 to 5! Apart from the difficulty in interpreting the coefficient of such a variable, it affects the estimates of other coefficients in the model. Most of the other studies hardly spell out the theoretical basis for their fertilizer demand equation. (e.g. Parikh, 1965; Raju, 1989; Sharma, 1993.) As a result, it appears as if the variables are chosen by data mining which is a very questionable methodology making the usual statistical tests of significance strictly inapplicable. (See Maddala, 1977, p.122) Moreover, if the input demand function is not properly derived, some important variables are likely to be missed or some irrelevant variables are likely to enter. Thus, hardly any study on fertilizer demand in India considers the price of other inputs in the function. Such a specification error is likely to lead to the biased estimates of other parameters.

The present study makes a modest attempt to overcome some of these shortcomings in estimating fertilizer demand function in

India. It is a time-series study using the annual data from 1966-67 to 1991-92. The demand function for fertilizer is estimated using both the static as well as dynamic models. The static model is considered in the next section where the input demand function is derived from the production function in the farm sector. In the process, some new variables like price of non-agricultural commodities, cost of capital, population, etc. are identified as the possible variables affecting fertilizer demand. The third section is, then, devoted to the dynamic model based on partial adjustment with and without adaptive expectations. Measurement of variables and sources of data used in the study are briefly outlined in the fourth section. In the section five, we discuss the results of both the static and the dynamic models. The final section of the study summarizes the main findings of the study and briefly examines the implications of these findings.

II. The Static Model

A producer's input demand is derived from the underlying demand for the commodity which he produces within given production conditions. Thus, the demand for fertilizer can be derived from a given aggregate production function for the agricultural commodities. Instead of specifying the form of the production function, we prefer to use a general function which may be assumed to satisfy all requirements of production equilibrium. This is because the use of any specific production function imposes certain unintended constraints on parameters of the input demand function which are not usually recognised. For instance, Subramaniyan & Nirmala (1991) use Cobb-Douglas production function to derive the fertilizer demand function which has a property that the price elasticity of fertilizer demand in absolute terms cannot be less than one so long as the marginal productivity of fertilizer is positive. The authors do not recognize this constraint and as such report an estimate of the price elasticity which is much less than unity in their static model results!

We consider the following profit function of an agriculturist with two inputs:

1) $\pi = Pf(X_1, X_2, T) - P_1 X_1 - P_2 X_2$

Where π is profits; P is the price of output; X_1 and X_2 are inputs; T is technology shift variable; P_1 and P_2 are respective input prices; and f(--) denotes function.

Employing profit maximizing conditions and simplifying, we have

2) $P_1 = P\ f_1(X_1, X_2, T)$; and $P_2 = P\ f_2(X_1, X_2, T)$

From equations (2), it is possible to get two explicit functions of the following form:

3) $X_1 = (P/P_1) \cdot g_1(X_2, T)$; and $X_2 = (P/P_2)\ g_2(X_1, T)$

Where g(--) denotes function.

When we solve these two equations in (3) simultaneously, we get the following input demand function for X_1:

4) $X_1 = g(P, P_1, P_2, T)$

Since we are interested in the price elasticity of fertilizer demand, logarithmic form of the function is preferable. Thus, we may write the demand function for fertilizer expressing all variables in natural logarithms as:

5) $F = a_0 + a_1 P_F + a_2 P_C + a_3 P_A + a_4 H$

Where F represents fertilizer use; P_F the price index of fertilizer; P_C the index of cost of capital; P_A the price index of agricultural output; H the technology shift variable like HYV; and a_i's the parameters.

Equation (5) represents the basic demand function for fertilizer. It is a function homogenous of zeroeth degree in prices to ensure that consumers do not suffer from money illusion. This condition implies the following linear restriction on the parameters of the equation (5):

$$a_1 + a_2 + a_3 = 0$$

Using this linear restriction, it is possible to write the equation (5) in alternative forms as:

6) $F = a_0 + a_1 (P_F - P_A) + a_2 (P_C - P_A) + a_4 H$ or

7) $F = a_0 + a_1 (P_F - P_C) + a_3 (P_A - P_C) + a_4 H$

It can be observed from the last three equations which are essentially alternative ways of expressing the same function that price of fertilizer, price of capital input and price of agricultural commodities enter the fertilizer demand function as explanatory variables either directly or in the ratio form. Moreover, these equations assume that all the three price variables are exogenously determined. If, however, we consider the price of agricultural commodities as endogenous, we should consider the demand and supply functions of agricultural commodities.

Let demand (DA) and supply (SA) of agricultural commodities be:

$DA = D\ (Y, Pop, P_A, P_{NA});$

$SA = S\ (Du, P_A, P_{NA})$

and DA = SA (equilibrium condition).

Where Y represents personal disposable income; Pop the population; P_A the price of the agricultural commodities; P_{NA} the price of the non-agricultural commodities; and Du the dummy variable for the weather condition.

Solving these three equations simultaneously, we obtain the following equation for P_A in terms of the other variables in the system:

$$P_A = h\ (Y, P_{NA}, Pop, Du)$$

Considering a linear form in the natural logarithms of the variables except Du, the equation becomes:

8) $P_A = b_0 + b_1 Y + b_2 Pop + b_3 Du + b_4 P_{NA}$

Substituting the value of P_A from equation (8) in equation (5), we get,

9) $F = a_9 + a_1 P_F + a_2 P_C + a_4 H + a_5 Y + a_6 Pop + a_7 P_{NA} + a_8 Du$

Equation (9) states that the fertilizer demand is a function of price of fertilizer, price of other inputs, technological shifts, real income, population, price of non-agricultural commodities and weather condition. In this equation, however, price of agricultural commodities does not appear as an independent variable because it has been replaced by the four other variables as given in equation (8). It is important to note that P_A and any of the other four variables given in equation (8) cannot be used simultaneously in the fertilizer demand function. Otherwise, the specification error is likely to distort the results.

Moreover, we should also recognise that for estimation of the price elasticity of fertilizer demand, supply function of fertilizer is not likely to be very relevant because the supply price of fertilizer during the period under consideration was largely exogenously determined by the government policy. This feature would ensure that sumultaneity bias in the estimate of the price elasticity would not be present in the single equation estimates. (cf.Sharma, 1993). Equally important, however, is to appreciate that other non-price factors affecting the availability or the supply of fertilizers also do not enter into the estimation of the price elasticity of fertilizer demand. If those factors, e.g. number of retail outlets or transport network, etc. are also considered while estimating the price elasticity of fertilizer demand, the specification error and biased estimates are most likely to result. This is because the exogenously determined price of fertilizer implies either of the two: (i) supply is not a constraint so that only factors determining demand are important; or (ii) supply is a constraint so that the effective point of consumption lies inside the demand curve. In the latter case, although the supply factors are relevant in determining the actual fertilizer use, the coefficient of the price variable would not show demand elasticity.

III. The Dynamic Model

Dynamic models consider the process of adjustment in the variables over time. Adjustment process in the independent variables is generally based on the relationship between the expected and the actual values of the variables, but in the dependent variables it is generally the relationship between the desired versus the realized quantities that provides basis for the adjustment process. The existence of such adjustment processes leads to the continuously lagged response in the variables giving rise to the difference in the initial or short run response and long run response. Whether the demand for fertilizer in India is also subject to a sharp difference in its short run and long run response to the price change is an empirical question. In order to investigate this question, we consider a very general dynamic model of fertilizer demand in which desired fertilizer use (F^*) depends on expected prices of the inputs and output. Moreover, we consider the adaptive expectation model in which expectations are formed on the basis of past experience. Thus, we use the partial adjustment with adaptive expectations model for deriving the short run and long run estimates of the price elasticity.

We begin by considering the basic demand function for fertilizer as derived in equation (5) which is equivalent to equation (7) with the dependent variable defined as the desired quantity and independent variables of prices as the expected prices. For the sake of frugality, we use only one variable (H_t)

to denote technological shifts in the function. Let us also denote the relative prices as P_t and R_t respectively for the actual values of input price ratio (P_F/P_C) and output to input price ratio (P_A/P_C); and P^*_t and R^*_t for the respective expected price ratios. Thus, the modified demand function for fertilizer is given as:

10) $F^*_t = A_0 + A_1 P^*_t + A_2 R^*_t + A_3 H_t + U_t$

The partial adjustment model hypothesises that the actual change in the fertilizer use over time is some fraction (k) of the desired change; *i.e.*

11) $F_t - F_{t-1} = k\,(F^*_t - F_{t-1})$;

Where t-1 denotes the quantities in the time period t-1. Substituting for F^*_t in equation (11) using equation (10) and simplifying, we get

12) $F_t = A_0 + (1-k)\,F_{t-1} + A_1 P^*_t + A_2 R^*_t + A_3 H_t + U_t$

Similarly, using the adaptive expectation model (See Dernburg, 1985; p.301-2), we postulate:

13) $P^*_t - P^*_{t-1} = m\,(P_t - P^*_{t-1})$ and

$R^*_t - R^*_{t-1} = m\,(R_t - R^*_{t-1})$

Where m is the coefficient of adaptation which always lies between 0 and 1. The advantage of defining the process of expectation formation as in equation (13) is that the special case of m = 1 would represent rational expectation view (See, Dernburg, 1985; p.302). It may also be noted that we take the same coefficient of adaptation (m) for both the relative prices, P_t and R_t. The value of the coefficient of adaptation (m) is indicative of the weights assigned to the past values of the variable in arriving at its expected value today. Since the producer or agent remains the same who forms expectations about the relative prices in order to decide his desired use of fertilizer, there is some justification for taking the same value of m in equation (13) for both relative prices, P_t and R_t.

In order to derive the estimable equation for the fertilizer demand function, we lag the equation (12) by one period, multiply it by (1-m) and then subtract it from equation (12). Using the relationships stated in equation (13), we then obtain:

14) $$F_t = A_0 mK + (1-k+1-m) F_{t-1} - (1-k)(1-m) F_{t-2} + A_1 kmP_t + A_2 kmR_t + A_3 kH_t - A_3 k(1-m) H_{t-1} + [U_t - (1-m)U_{t-1}]$$

In order to avoid serious econometric problems in estimating equation (14), we follow the search method (See, Maddala, 1989; p.354) by simplifying the equation and defining the following variables:

15) $$\bar{F}_t = F_t - (1-m) F_{t-1}$$

$$\bar{H}_t = T_t - (1-m) H_{t-1}$$

$$\bar{F}_{t-1} = F_{t-1} - (1-m) F_{t-2}$$

Using the variables defined by equation (15), the estimable equation (14) becomes

16) $$\bar{F}_t = \alpha_0 + \alpha_1 \bar{F}_{t-1} + \alpha_2 P_t + \alpha_3 R_t + \alpha_4 \bar{H}_t + V_t$$

Where V_t is the error term. The search procedure is applied over m by choosing different values from the interval (0,1) and estimating equation (16) for each chosen value of m. It can be seen from equation (15) that all the three variables change as m varies. The value of m for which the residual sum of squares is minimum provides the best estimate of m and the corresponding estimates of all parameters (including k) of the equation (16) are the desired ones. Thus, the estimate of α_2 ($= A_1 k m$) is the short-run price elasticity and A_1 is the long-run price elasticity of fertilizer demand.

Finally, if we take m = 1, the model reduces to the partial adjustment model because the expected prices are the actual prices. The estimable equation of such a model is:

17) $F_t = A_0 + (1-k) F_{t-1} + A_1 k P_t + A_2 k R_t + A_3 k H_t + U_t$

In this model, the short-run price elasticity is given by $A_1 k$ and long-run elasticity is A_1.

IV. Measurement of Variables and Sources of Data

1. Fertilizer consumption of N,P & K is measured in Kilograms per hectare of total cropped area in the country. Annual data are obtained from *Fertiliser Statistics, 1991-92*, FAI, New Delhi and *Fertilizer Marketing News*, Vol.24, No.9, September 1993.

2. The time series data for fertilizer price index (1970-71 = 100) are taken from H.L.Chandhok and the Policy Group: *Indian Database*, Vol.1, 1990 and for later years, from the *Report on Currency and Finance*.

3. The index of cost of capital (COC) is constructed with 1970-71 = 100. The COC is defined as the maximum deposit rate of commercial banks plus real depreciation rate in agricultural

capital less the expected rate of inflation. The maximum deposit rate of commercial banks is considered to be the opportunity cost of the investible funds with the agriculturists. The relevant figures are obtained from various volumes of the *Report on Currency and Finance*. Net capital stock in agricultural sector is taken at constant price (1980-81 = 100) and the data are obtained from Dholakia and Dholakia (1993). The estimates of real depreciation are obtained from various volumes of the National Accounts Statistics, published by the CSO, New Delhi. Time series data for expected inflation rate are obtained from R.H.Dholakia (1993).

4. The variable on irrigation which is taken as an alternative to denote technological shifts is measured as proportion of gross area under irrigation to total cropped area. Similarly, the variable on HYV which is also considered as an alternative to represent technological shifts is measured as percentage area under high yielding varieties to total cropped area. The data for both these variables are obtained from *Fertilizer News*, August 1993 and *Fertilizer Statistics, 1991-92*.

5. The income variable is measured as personal disposable income at constant prices per hectare of total cropped area. The current price estimates of the personal disposable income are converted into constant prices by deflating it with the NNP deflator. The relevant figures are obtained from various volumes of *National Accounts Statistics* published by the CSO.

6. For measuring weather effect, a dummy variable is consi-

dered. The value 0 is assigned to the normal year and 1 to the drought year. The source of information used is the CMIE: *Basic Statistics Relating to Indian Economy*, Volume I, August 1993.

7. Price indexes of agricultural and non-agricultural commodities with 1970-71 = 100 are derived from the wholesale price index statistics obtained from Chandhok (1990) and from the *Report on Currency and Finance* for later years by considering their weights.

8. The variable on population is measured as population per unit of total cropped area. Data for population is taken as the mid-year estimates provided in the *National Accounts Statistics*, CSO. Basic data on all these variables are presented in *Appendix Table-1*.

V. Results

Our main objective in this paper is to estimate the price elasticity of demand for fertilizer in India over time. As we have discussed in the preceding sections, the fertilizer demand function under static framework can be estimated using equation (9) or (7); and with dynamic considerations through equation (16) or (17). It is important to note that in all these equations, we have not precisely defined the variable/s denoting technological shifts in the agricultural production function. Irrigation and HYV seeds are the two very commonly used indicators of such technological shifts. Though they are distinct variables, in practice, a high degree of complementarity between them usually leads to the problem of multi-collinearity. Since we need to depict technological shifts, inclusion of only one of them may also not be considered as introducing specification bias. *Table-1* presents our estimates of equation (9) above.

Table-1: Estimates of the Static Model with All Variables

Variables	OLS		Autocorrected	
	Coefficients	t-Values	Coefficients	t-Values
1	2	3	4	5
Fertilizer Price (FPI)	-0.338 *	-2.33	-0.277 *	-2.35
Cost of Capital (COC)	-0.046	-0.62	-0.037	-0.86
Irrigation	0.102	0.19	0.510	1.16
HYV	0.234 *	4.51	0.270 *	4.31
Income	0.767	1.15	0.618	1.46
Population	0.226	0.116	0.435	0.35
Weather Dummy	0.028	0.43	0.002	0.05
Non-agri.Prices	0.630 *	2.66	0.357	1.99
Constant	-6.175	1.69	-5.490 *	2.21
R-Square	0.9864		0.9915	

* Significant at 5 per cent level.

Note: (1) The variables except the weather dummy are in natural logarithms.
(2) R-Square is between observed and predicted values of the dependent variable.
(3) DW Statistic for the OLS regression is 0.945 which may be taken to indicate presence of autocorrelation.
(4) Autocorrected regression is based on Cochrane-Orcutt iterative procedure.

From *Table-1*, it may be observed that the OLS estimates of the equation suffers from the problems of autocorrelation and multicollinearity. Although the overall goodness of the fit is very good, most of the variables turn out to be statistically insignificant. This feature does not change even after correcting for autocorrelation. Irrigation, HYV, personal disposal income and population are very highly correlated variables. The zero order correlation coefficient between any two of them is found to be between 0.91 and 0.98. Out of all these variables, however, only HYV turns out to be statistically significant in our equation. The price elasticity of fertilizer demand is estimated to be (-)0.28 which is also statistically significant. No other variable in the equation turns out to be significant at 5 per cent level of significance. This includes all those variables which have been included in equation (9) to substitute the price of agricultural commodities. If, instead, we use agricultural output prices as an exogenous variable, our fertilizer demand function is given by equation (5) in the unrestricted form and equation (7) with the linear restriction imposed. *Table-2* presents the results of the static model with and without the restriction of zero degree homogeneity.

Table-2: Results of The Restricted and Unrestricted Static Demand Model for Fertilizer in India

Variables	Unrestricted		Restricted	
	Coefficient	t-Value	Coefficient	t-Value
1	2	3	4	5
HYV	0.653*	2.78	0.055*	5.47
FPI	-0.328*	-2.78	-	-
COC	-0.004	-0.02	-	-
P_A (Agri.Prices)	0.316	1.57	-	-
FPI/COC (P_t)	-	-	-0.338*	-2.97
P_A /COC (R_t)	-	-	0.349*	3.00
Constant	1.523	1.86	1.775*	4.27
R-Square	0.990*	-	0.989*	-
RSS	0.106		0.110	

* Significant at 5 per cent level.

Note: (1) All Variables are in natural logarithms.
(2) The estimates are obtained after correcting for autocorrelation through Cochrane-Orcutt method.
(3) R-Square is between the observed and predicted values of the dependent variable.

The results of the restricted model are accepted because the calculated F Statistic works out to only 0.766 as against the table value of 4.32 with (1,21) degrees of freedom. The *Table-2* suggests that both the relative prices of inputs and output are significant influences on the fertlizer demand in India. The estimate of the price elasticity of fertilizer demand is found to be (-)0.34. The static models, thus, suggest that fertilizer demand in India is highly price inelastic.

In order to distinguish between the short run and long run price elasticities by considering processes of adjustment and expectation formation, we may now examine the estimates of the dynamic models, *i.e.*, equation (16) and (17). As discussed earlier, equation (16) represents a more general dynamic model of the fertilizer demand in which the fertilizer use adjusts with a lag to its desired level and the relative prices of inputs and outputs are based on adaptive expectations of the agriculturists. The search procedures yield the minimum residual sum of squares (RSS) when the coefficient of adaptation (m) is 0.4. The corresponding OLS estimates of the parameters are presented in *Table-3*.

Table-3: The OLS Estimates of the Partial Adjustment Model with Adaptive Expectation for the Fertilizer Demand Function in India

Variables	Coefficient	t-Values
1	2	3
$\bar{F}_{t-1}$	0.708*	4.08
P_t	0.059	0.68
R_t	-0.007	0.08
$\overline{HYV}$	0.014	1.41
Constant	0.268	1.77
R-Square	0.952*	F-Stat.(4,19) = 94.8
		D-W Stat. = 1.782*

* Significant at 5 per cent level.
Note: (1) Variable definitions are as per equation (16)
(2) The test for autocorrelation in this equation may be carried out by D-W Statistic since $\bar{F}_{t-1}$ is not the lagged dependent variable. (See equations 15 for details.)

From *Table-3*, it can be inferred that the model does not seem to fit the data satisfactorily. The t-values of all variables except one are too low and statistically insignificant to reject the null hypothesis of the zero coefficients. Though statistically insignificant, even the sign of the estimated price elasticities turn out to be different! It appears that the assumption of the adaptive expectations of inputs and output prices does not describe the reality well. If we replace the assumption by the instantaneous adaptation in line with the rational expectation view (*i.e.* m = 1), the relevant model becomes the one of partial adjustment (*i.e.* equation 17). The OLS and auto-corrected estimates of this model are presented in *Table-4*.

From *Table-4*, it can be seen that the model fits the data very well. All coefficients are significant and with expected signs. The short run price elasticity of fertilizer demand in India seems to be around (-)0.2 while the long run elasticity is estimated to be around (-)0.35. The small difference between the two elasticities in absolute terms is due to a very high value of the coefficient of adjustment (0.53) implied by our estimates. This implies that more than half the disequilibrium is eliminated within a year. Moreover, it is worth noting that the fertilizer demand in India is also inelastic with respect to the relative output price, the short-run elasticity again being 0.2 and the long-run elasticity being around 0.35. These estimates are, however, at the macrolevel and should be interpreted with

Table-4: Estimates of The Partial Adjustment Model for Fertilizer Demand Function in India

Variable	OLS		Auto-corrected	
	Coefficient	t-Value	Coefficient	t-Value
1	2	3	4	5
F_{t-1}	0.652*	4.32	0.466*	2.89
P_t	-0.132	1.31	-0.185**	1.79
R_t	0.175**	1.87	0.199**	1.99
HYV	0.016**	1.75	0.027*	2.66
Constant	0.829*	2.91	1.198*	3.90
R-Square	0.991		0.993	

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

Note: (1) All variables except HYV are in natural logarithms.
(2) R-Squares are between observed and predicted values of the dependent variable.
(3) For the OLS estimates, the Derbin's h Static works out to 3.61 which implies presence of autocorrelation. The collection for autocorrelation is made through Cochrane-Orcutt method.

caution. They represent the percentage increase/decrease per hectare of the cropped land. If as a response to changes in the output and input prices, gross cropped area changes, it may lead to a much greater response in total fertilizer demand. Similarly, the positive and significant coefficient of HYV also indicates that 10 per cent increase in area under HYV would lead to around 3 per cent increase in the short-run and about 5 per cent increase in the long-run in the fertilizer use per hectare of total cropped area. This estimate is likely to change over time as more and more area is covered under HYV. Currently the estimate of its coefficient turns out to be low because the area under HYV forms less than 40 per cent of the total cropped area in the country.

VI. Summary and Conclusion

In the present paper, an attempt is made to derive the fertilizer demand function in India and estimate its price elasticity in the short run as well as the long run. We have also considered some alternative specifications of the model by taking the output price first as an endogenous variable and then as an exogenous variable. Similarly, for the input and output prices, first an adaptive expectation model was tried and then instantaneous adaptation of expectation was considered. Our results clearly show that fertilizer demand in India is price inelastic. A 10 per cent increase in relative price of fertilizer may lead to less 2 per cent decrease in the short-run and 3.5 per cent decrease in the long-run in the fertilizer use per hectare of cropped area. Thus, according to our findings, the fertilizer demand in India is price inelastic both in the short-run and in the long-run. Since our estimates are based on inclusion of relevant variables in a theoretically derived demand function, they are likely to be more dependable. A recent study based on a sample survey in Uttar Pradesh finds that in response to a sharp and sudden increase in fertilizer prices by more than 30 per cent due to the cut in fertilizer subsidy in August 1991 and the subsequent dual pricing of fertilizer, the fertilizer consumption during Rabi 1991-92 declined by 5.65 per cent from Rabi 1990-91 level. (Agrawal et al., 1993). This short-term response is perfectly in line with our estimate of the short-run price elasticity of fertilizer demand. The study also finds that the fertilizer consumption in majority of the crops has declined and that the fertilized area during Kharif 1992-93 also declined by 1.37 per cent as compared to Kharif 1991-92. This implies that the fertilizer demand response to the price change in the longer-run is likely to be higher but not substantially more than the one in the short-run. This again corroborates our findings.

A recent study finds that increased total factor productivity growth (TFPG) in the Indian agriculture has led to the release of resources to other sectors and has basically contributed to the acceleration in the overall growth rate in the economy. (Dholakia and Dholakia, 1993). It also finds that the TFPG in Indian agriculture is determined by the use of modern inputs like fertilizer, irrigation and HYV seeds. If these input demands are highly price elastic, any policy changes which affect the input prices would significantly influence the rate of TFPG and hence the sectoral growth. Our findings in the present study, on the contrary, show that fertilizer demand in India is price inelastic and that policies affecting fertilizer prices are not likely to have serious impact on the growth of the agricultural sector and of the economy if the prices are not allowed to change drastically.

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Appendix Table-1

Time Series Data of Variables

Sr.No	Year	FC/H	FPI	IRR	HYV	COCI	PDI/H	Du	PNA	POP/H	PA
1	1966-67	7.00	76.1	20.80	1.20	165.30	4086.63	1	83.31	3.15	82.04
2	1967-68	9.40	91.4	20.30	3.69	39.64	4272.63	0	91.99	3.10	92.99
3	1968-69	11.05	92.7	22.20	5.83	146.02	4491.16	1	92.18	3.24	90.00
4	1969-70	12.21	98.0	22.80	7.03	66.87	4678.53	1	93.79	3.26	96.29
5	1970-71	13.61	100.0	23.00	9.28	100.00	4808.56	0	100.00	3.26	100.00
6	1971-72	16.14	100.6	23.30	11.00	170.68	4859.26	1	113.46	3.35	100.44
7	1972-73	17.06	105.7	24.10	13.77	196.51	4944.82	1	128.10	3.50	111.77
8	1973-74	16.71	113.9	23.70	15.33	110.81	4943.90	0	170.93	3.41	139.23
9	1974-75	15.67	203.0	25.40	16.65	222.91	5146.41	1	176.62	3.61	169.89
10	1975-76	16.93	214.7	25.40	18.61	84.68	5493.62	0	166.16	3.55	157.35
11	1976-77	20.39	186.5	26.00	20.05	221.79	5578.30	0	198.12	3.70	158.48
12	1977-78	24.83	177.4	26.70	22.59	93.79	5904.06	0	185.67	3.68	178.32
13	1978-79	29.28	175.2	27.60	22.96	130.72	6144.05	0	204.14	3.70	171.87
14	1979-80	30.97	167.2	29.00	22.62	345.84	5975.01	1	261.37	3.91	188.70
15	1980-81	31.82	242.7	28.90	24.94	122.65	6534.08	0	311.55	3.92	210.48
16	1981-82	34.27	273.6	29.10	26.26	141.69	6682.20	0	304.77	3.91	236.51
17	1982-83	36.83	277.7	30.10	27.39	213.72	6916.09	1	327.19	4.08	248.29
18	1983-84	42.79	267.5	29.90	29.83	125.32	6468.10	0	348.15	4.01	282.70
19	1984-85	46.54	262.5	30.70	30.69	201.46	7662.70	0	375.51	4.18	303.23
20	1985-86	47.39	266.9	30.60	30.99	200.31	7836.91	1	392.99	4.22	309.63
21	1986-87	48.94	288.8	31.40	31.80	201.38	8318.28	1	408.58	4.36	329.95
22	1987-88	51.12	288.5	32.50	31.29	171.92	8976.60	1	427.99	4.59	372.10
23	1988-89	61.30	288.4	32.90	33.38	73.68	9467.41	0	458.80	4.47	400.66
24	1989-90	64.23	271.1	39.70	34.00	163.79	9715.60	0	486.55	4.52	418.75
25	1990-91	69.30	271.1	41.20	35.50	157.64	10508.40	0	530.54	4.60	470.46
26	1991-92	70.30	349.1	42.60	38.70	299.19	10420.20	0	583.10	4.70	563.00

Source: See the text, Section IV

FC = Fertilizer Consumption per hectare (of Cropped Area)
IRR = Percentage of Irrigated Area
COC = Cost of Capital Index
Du = Weather Dummy
POP = Population per hectare
FPI = Fertiliser Price Index
HYV = Percentage of Area under High Yielding Varieties of Seeds
PDI/H = Personal Disposable Income per hectare
PNA = Price Index of Non-agricultural Commodities
PA = Price Index of Agricultural Commodities