Vol XLVI
No. 1

ISSN 0019-5014

JANUARY-
MARCH
1991

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

Ind. Jn. of Agri. Econ.
Vol. 46, No. 1, Jan.-March 1991

A Macro Analysis of Fertiliser Demand in India (1966-67 to 1985-86)

G. Subramaniyan and V. Nirmala*

I

Agricultural output can be increased through the expansion of cultivable area or through improving the productivity of available land. With the gradual closing of the land frontier, however, future increase in agricultural output has to depend on increasing the productivity of land only. One of the crucial inputs to increase the productivity of land is fertiliser. In fact, widespread use of chemical fertiliser in most of Asia is largely a post-World War II phenomenon. Total fertiliser consumption in Asia by the early eighties was of the order of 31.7 million metric tons of nutrients, almost five times the level in the mid-sixties and nearly 25 times that of the early fifties. Asia's share of world fertiliser consumption increased from 8 per cent in 1950-52 to 28 per cent in 1980-82. The compound growth rate in fertiliser use from 1964-65 to 1974-75 was the lowest at 6.3 per cent for Sri Lanka and the highest at 24.8 per cent for Nepal, while the Asian average was 10 per cent. Though India ranks fourth in fertiliser consumption after U.S.A., U.S.S.R. and China, the average fertiliser use is about 60 kg./ha against the global average of 87.3 kg./ha (Desai 1986).

The level of use of fertiliser in India was less than one-half of the Asian average. This distressing trend compels us to find out answers to the following two questions: *(i)* Despite high growth rate in fertiliser consumption, why does fertiliser use in India at farm level remain low? *(ii)* How do changes in real fertiliser price affect fertiliser demand? Of course, these two questions are directly related to micro and macro aspects of fertiliser demand respectively. Although micro economic analysis at farm level provides the feedback to design macro policies, it cannot provide all the information required by policy makers (Mudahar, 1978). As self-sufficiency in foodgrains production, and employment and income growth remain the basic issues in developing countries like India, it is necessary to view the fertiliser subsidy and pricing policies from macro perspectives. Moreover, there is a large body of studies at micro level to identify the factors affecting fertiliser use. But studies relating to fertiliser demand at macro level hardly exist in India. Hence this study makes an attempt in that direction.

The primary aim of this study is to understand the factors affecting fertiliser demand at macro level, using static and dynamic models. By deriving the demand for fertiliser, one can understand the implications of fertiliser price and agricultural product price on fertiliser use and their interrelationship. The analysis is based on time-series data from 1966-67 to 1985-86. The main source of data for this study is Fertiliser Statistics, 1986-87, published by Fertiliser Association of India (FAI), New Delhi. Time-series data on variables are given

* Reader in Econometrics, Madurai Kamaraj University, Madurai and Lecturer in Economics, Pondicherry Central University, Pondicherry, respectively.

The authors wish to express their gratitude to J.C. Flinn, International Rice Research Institute, Manila, C. Ramasamy and S. Varadarajan, Tamil Nadu Agricultural University, Coimbatore and an anonymous reference of this Journal for their comments on an earlier draft of this paper. We are thankful to the Indian Council of Social Science Research, New Delhi for financial support of part of the work reported. The technical help by N. Murugesan is gratefully acknowledged.

in the Appendix.

The paper is organised as follows. Section II deals with model specification (Static and Dynamic) and estimation. Section III discusses empirical results and, finally Section IV offers policy suggestions.

II

MODEL SPECIFICATION

Static Model

The demand for fertiliser is usually a derived demand. It is derived from a given production function. In economic theory, the utilisation of any input, say fertiliser, depends upon the conditions of profit maximisation and the nature of the production function, *i.e.*, technology adopted. Assuming Cobb-Douglas production function with two inputs, and using profit definitional identify, we have

Production function: $Y = A \cdot F^{b_1} \; L^{b_2} \; U_1$ .... (1)

Profit identity : $\pi = PY - P_1F - P_2L$ .... (2)

where Y = output,
F = fertiliser,
L = labour,
π = profit,
P = output price,
P_1 = fertiliser price, and
P_2 = price of labour or price of any other input.

Using profit maximising conditions $\left(\frac{\partial \pi}{\partial F} \text{ and } \frac{\partial \pi}{\partial L}\right)$, one could arrive at

$$\frac{Y}{F} = \frac{P_1}{b_1 P} \cdot U_2 \quad \text{.... (3)}$$

$$\frac{Y}{L} = \frac{P_2}{b_2 P} \cdot U_3 \quad \text{.... (4)}$$

In the above relations, U_2 and U_3 are random terms. Expressing (1), (3) and (4) in logarithmic form and solving for F, we get

$$\log \; F = \frac{\log A + \log\left(\frac{P_1}{b_1 P}\right)(b_2 - 1) + b_2 \log(U_2 - U_3) - \log\frac{P_2}{P} + \log U_1 - \log U_2}{1 - b_1 - b_2} \quad \text{.... (5)}$$

Relation (5) indicates that any demand function for fertiliser must incorporate product price, prices of fertiliser and other inputs, technological shifts and random disturbance term.

Based on this, the demand function for fertiliser in the present study has been specified using double-log form as:

$$\log (F/ha) = b_0 + b_1 \log(P_f/P_A) + b_2 \log MV + b_3 \log IRR + b_4 \log W + b_5 \log S + b_6 \log T_i + U. \qquad .... (6)$$

where F/ha = consumption of fertiliser in kg./ha,
P_f/P_A = ratio of price of fertiliser to agricultural commodity price,
MV = per cent of area planted to high-yielding varieties (HYVs),
IRR = per cent of area irrigated,
S = measure of land intensity (gross area sown per capita),
T_i = trend variable, and
W = weather condition, which was ranked by giving 1 for very poor, 2 for poor, 3 for average, 4 for good and 5 for very good. These qualifications were based on the amount of rainfall.

In the above model, MV and IRR are regarded as proxy variables for technological shifts.

Dynamic Model

To perceive the dynamic aspect of demand for fertiliser, the Nerlovian adjustment model used by Griliches (1958) and many subsequent researchers is made use of in the present study to estimate both short-run and long-run elasticities of fertiliser demand. This model captures some of the dynamic elements in fertiliser demand better than simple static models, without merely resorting to time trends. Simple static models have frequently failed to discern significant price impact on demand. Parikh (1965) in his work on Indian demand for nitrogenous fertilisers, for instance, found that the impact of fertiliser price on fertiliser use was insignificant. To quote Timmer (1974), "the dynamic adjustment model was much superior to the static model, even when the latter introduced time or income proxy variable." Hence, fertiliser demand is analysed in the study using the Nerlovian version of dynamic model too. The model is specified below:

$$F_t^* = a_0 + a_1 P_{ft} + U_t \qquad .... (1)$$

$$(F_t - F_{t-1}) = c(F_t^* - F_{t-1}) \qquad .... (2)$$

Substituting (1) in (2) and rearranging, we get

$$F_t = a_0 c + a_1 c\, P_{ft} + (1\text{-}c)\, F_{t-1} + c\, U_t \qquad .... (3)$$

where F_t = actual fertiliser consumption,
F_t^* = desired fertiliser consumption in long-run equilibrium,
P_{ft} = price of fertiliser relative to price of agricultural commodities,
c = adjustment coefficient ($0 \leq c \leq 1$), and
U_t = a random disturbance term.

The two models were estimated using the principle of least squares.

III

RESULTS AND DISCUSSION

The results of the static model are presented in Table I. All the explanatory variables used in the model emerged statistically significant along with theoretically expected signs. Relative price and land intensity were negatively related with fertiliser demand, while per cent area under HYVs, per cent area irrigated and weather had a positive relationship with fertiliser demand.

TABLE I. FERTILISER DEMAND IN INDIA: RESULTS OF STATIC MODEL

Variable (1)	Parameter estimate (2)
Intercept	-1.738
Relative price	-0.4263* (-3.0357)
Per cent area under HYV	0.09374* (7.367)
Per cent area under irrigation	1.438* (2.63)
Weather	0.0814* (2.262)
Trend	-0.0665** (-1.7572)
Land intensity	-2.6283* (-2.289)
R^2	0.9943
F-value	217.79
D-W statistic	1.6128

Figures in parentheses represent 't' values.
* Indicates significance at 5 per cent level.
** Indicates significance at 10 per cent level.

The coefficient of relative price indicates that when relative price of fertiliser (real price of fertiliser) increases by 10 per cent, there is a 4.26 per cent decrease in the use of fertiliser. The coefficient for area under irrigation indicates that a 10 per cent increase in irrigated area leads to a 14.38 per cent increase in fertiliser use. For a 10 per cent increase in area under HYVs, the increase in fertiliser demand is less than one per cent.

As land becomes more scarce, fertiliser demand per hectare increases as indicated by the negative coefficient of the measure of land constraint (gross area sown per capita). Though weather has emerged statistically significant in influencing fertiliser use, it is a factor that is beyond human control.

The R^2 value of 0.9943 indicates that the explanatory variables in the model have accounted for over 99 per cent variation in fertiliser use. The model was significant at 1 per cent level.

The results of the dynamic model studied are presented in Table II.

TABLE II. RESULTS OF DYNAMIC MODEL

Variable (1)	Parameter estimate (2)
Intercept	4.823
Relative price (P_{ft})	-1.296** (1.53)
Consumption in previous period (F_{t-1})	0.1641* (3.09)
R_2	0.65
F-value	7.121
D-W statistic	1.4041

Figures in parentheses represent 't' values.
* Indicates significance at 5 per cent level.
** Indicates significance at 10 per cent level.

Since the variables are in logarithms, the short-run elasticity of demand for fertiliser with respect to its relative price is given by the estimate of a_1c, while the long-run elasticity is given by $a_1c/1-(1-c)$. For this period between 1966-67 and 1985-86, the short-run price elasticity for fertiliser demand was -1.30 and the adjustment coefficient was 0.84. The long-run price elasticity for fertiliser demand worked out to be -1.54, indicating that the demand for fertiliser is price elastic. In the short-run, fertiliser demand decreases by 13 per cent and in the long run by about 15 per cent, in response to a 10 per cent increase in its real price.

A comparison between the price elasticities of fertiliser demand based on static and dynamic models reveals that a 10 per cent increase in the relative price of fertiliser results in a reduction in its demand by less than 10 per cent in the static model and more than 10 per cent in the dynamic model. This contrast is observed due to a relatively more number of explanatory variables and also due to a high degree of inter-correlation among them in the static model. To investigate the superiority of dynamic model over static model, the latter was re-estimated with relative price of fertiliser as the only independent variable. Its parameter estimate was found to be -1.71, which was significant at 10 per cent level. This result confirms that fertiliser demand is price elastic and projects the merit of the dynamic model which certainly has an edge over the static model.

The absence of a wide difference between short and long-run elasticities in the dynamic model may be due to the long time-series data used for the analysis. The high value of the adjustment coefficient (c = 0.84) is indicative of the actual fertiliser consumption moving towards the desired level of fertiliser use.

In this context, it is worth observing the demand for fertiliser in response to changes in its price in various countries. Table III presents the price elasticities estimated for different countries.

TABLE III. FERTILISER DEMAND ESTIMATES FOR DIFFERENT COUNTRIES

Country	Time-period	Elasticity of demand		Adjustment coefficient
		Short run	Long run	
(1)	(2)	(3)	(4)	(5)
Brazil	1949-71	-1.12	-	-
India	1953-54 - 1967-68	-0.30*a*	-0.34	0.92
		-0.53*b*	-6.36	0.08
	1958-59 - 1963-64	-1.20	-2.50	0.50
Japan	1983-1987	-	-0.74	-
Korea	1960-72	-0.17	-0.88	0.20
	1971	-0.70	-	-
Philippines	1958-72	-0.59	-	-
Taiwan	1950-66	-0.55	-	-
U.S.A.	1911-56	-0.53	-2.99	0.23

Source: Timmer (1974); Mudahar (1978).
a. Demand function contains area irrigated.
b. Area irrigated excluded.

Table III shows that in response to a one per cent increase in fertiliser price, the decrease in demand ranges between 0.17 and 1.2 per cent in the short run and between 0.34 and 6.36 per cent in the long run, across the countries at different points of time. The short-run and long-run responses of Brazil, Korea, Taiwan and India to fertiliser price are reasonably consistent with each other, and also with the Griliches values for U.S.A. The price elasticities in the present study also fall in line with these results.

IV

POLICY SUGGESTIONS

The findings of the study point out that a reduction in the relative price of fertiliser is needed to boost its demand. This may be achieved either through an increase in agricultural commodity price or a decrease in fertiliser price. Of these two policy instruments, the latter is solely ruled out in India because of ever increasing cost of indigenous feedstock and inputs. Against this background, fertiliser subsidy is a common feature in most developing countries. It is justified on the ground that it makes fertiliser available to farmers at prices they can afford and thus seeks to ensure self-sufficiency in foodgrains production. "The fertiliser subsidy is thus an unavoidable outcome of pursuing the basic goal of self-sufficiency in foodgrains production based on increase in fertiliser use supported in turn, by low price of fertilisers to the farmer and increased availability from domestic production" (Gupta, 1989, p. 14). Therefore, the Government of India has given due importance to fertiliser subsidy in the budget. In fact, for the year 1989-90, the fertiliser subsidy amounted to Rs. 3,100 crores. But the fertiliser industry even then is of the opinion that the quantum of the subsidy will not be sufficient to meet the steep increase in the cost of indigenous inputs. It has been pointed out that of the net increase in fertiliser subsidy received by the fertiliser industry between 1980-81 and 1987-88, 99 per cent was accounted for by the steep increase in the cost of indigenous feedstock and inputs (87 per cent) and increased railway freight (12 per cent) (Gupta, 1989). More precisely, the bulk of the fertiliser subsidy is in the nature of intra-economy transfer and therefore there is no drain on the exchequer. In this context, it may be appropriate to mention the recommendation of G.V.K. Rao Committee Report on Consumer Price of Fertiliser, which has suggested that fertiliser prices could be increased by five to seven per cent if the demand has grown over 30 per cent in the immediate past three years. The adoption of this recommendation aims at preventing an increase in the quantum of subsidy without adversely affecting the healthy growth of the industry. However, while implementing this recommendation, adequate care has to be taken to avoid steep increase in fertiliser prices and cost of food. Otherwise, this would lead to serious socio-political repercussions (Gupta, 1989).

In developing countries, the crop price policy is regarded as an instrument for influencing the real fertiliser price. But the constraint on the policy of supporting prices of crops at higher and higher levels is the relatively slow growth in effective demand for foodgrains and the inability of surplus production to compete in the world markets without export subsidies. This has resulted in growing burden of food subsidies (Desai, 1986).

Thus the conflict between the choice of either of the two policies continues to exist. Barker and Hayami (1976) examined the impacts of fertiliser subsidy and rice price support programmes, as the two competing policy alternatives, to achieve self-sufficiency in rice production. The result projected fertiliser subsidy to be a more preferable means to achieve the stated goal. However, it is worth noting that "simple judgements such as 'good' or 'bad' cannot be made with respect to fertiliser subsidies, nor a single policy be adopted across countries, areas, or income groups. Merits of fertiliser subsidies must be considered in the broader context of development objectives, the risk of returns, the adoption of new technology, and macro economic feasibility of subsidy. In particular, the relative importance of fertiliser subsidies must be compared to other investments that increase fertiliser use" (Lele *et al.*, 1989, p. 49). In order to overcome such difficulties relating to fertiliser subsidy and price policy, Desai (1986) stressed that non-price factors (like cropping pattern, crop varieties and irrigation, agricultural research and extension, credit, fertiliser supply and distribution system, etc.) need to be given due importance which could certainly help to increase fertiliser use. As self-sufficiency in foodgrains production remains the basic issue in developing countries, it becomes necessary to view fertiliser subsidy and pricing policy from macro economic perspectives. This study also suggests that HYVs be sown on a larger scale and more and more area be brought under irrigation to boost fertiliser consumption. For this, massive investment on extension services and infrastructure facilities are indispensable in the context of a developing country like India.

Received August 1990. *Revision accepted January 1991.*

APPENDIX

TIME-SERIES DATA ON VARIABLES

Year	Consumption of (N+P+K) (kg./ha)	Relative price	Percentage area under modern varieties	Percentage area irri-gated	Weather con-ditions*	Land intensity	Consumption of (N+P+K) ('000 tons)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1966-67	7.00	20.08	1.14	20.80	1	.31	1,100.6
1967-68	9.40	21.19	3.66	20.28	4	.31	1,539.0
1968-69	11.05	19.52	5.77	22.19	3	.30	1,760.7
1969-70	12.21	21.48	7.03	22.75	4	.30	1,982.4
1970-71	13.61	20.18	9.23	22.99	5	.30	2,256.6
1971-72	16.14	20.69	10.96	23.26	3	.29	2,656.9
1972-73	17.06	20.99	13.76	24.06	1	.28	2,767.9
1973-74	16.71	20.13	15.31	23.67	2	.28	2,838.6
1974-75	15.67	30.36	16.64	25.41	1	.27	2,573.3
1975-76	16.93	24.73	18.61	26.30	4	.27	2,893.7
1976-77	20.39	23.25	20.03	26.02	2	.26	3,410.9
1977-78	24.88	19.63	22.57	26.69	4	.26	4,285.8
1978-79	29.28	17.57	22.95	28.96	4	.26	5,116.9
1979-80	30.97	17.81	22.58	31.01	1	.25	5,255.6
1980-81	31.82	22.65	24.85	31.27	2	.25	5,515.4
1981-82	34.27	22.53	26.21	31.63	2	.25	6,067.2
1982-83	37.08	20.98	27.46	33.66	2	.24	6,386.6
1983-84	44.70	18.31	29.77	32.48	4	.24	7,710.1
1984-85	47.60	16.10	30.32	33.91	3	.24	8,211.0
1985-86	47.00	15.04	30.71	34.48	3	.24	8,474.0

Source: Government of India. Directorate of Economics and Statistics, Ministry of Agriculture, New Delhi. Fertiliser Association of India (1986). Fertiliser Statistics, 1985-86, New Delhi; *Fertiliser News*, Vol. 32, No. 10, October 1987.
* 1 = Very poor, 2 = Poor, 3 = Average, 4 = Good and 5 = Very good.

REFERENCES

Barker, Randolph and Yujiro Hayami (1976). "Price Support versus Input Subsidy for Food Self-Sufficiency in Developing Countries", *American Journal of Agricultural Economics*, Vol. 58, No. 4, November.

Desai, Gunvant M. (1986). "Fertiliser Use in India: The Next Stage in Policy", *Indian Journal of Agricultural Economics*, Vol. 41, No. 3, July-September.

Griliches, Z. (1958). "The Demand for Fertiliser: An Economic Interpretation of a Technical Change", *Journal of Farm Economics*, Vol. 40, No. 3, August.

Gupta, Uttam (1989). "Fertiliser Pricing Policy and Subsidy: Need for Pragmatic Approach", *Fertiliser News*, Vol. 34, No. 8, August.

Lele, Uma; R.E. Christiansen and K. Kadiresan (1989). Fertiliser Policy in Africa: Lessons from Development Programs and Adjustment Lending, 1970-87, MADIA (Managing Agricultural Development in Africa), Discussion Paper 5, The World Bank, Washington, D.C., U.S.A.

Mudahar, Mohinder S. (1978). "Needed Information and Economic Analysis for Fertiliser Policy Formulation", *Indian Journal of Agricultural Economics*, Vol. 33, No. 3, July-September.

Parikh, A.K. (1965). "Demand for Nitrogenous Fertilisers: An Econometric Study", *Indian Journal of Agricultural Economics*, Vol. 20, No. 3, July-September.

Timmer, Peter C. (1974). "The Demand for Fertiliser in Developing Countries", *Food Research Institute Studies*, Vol. 13, No. 3.