## *Notes & Comments*

# A Note on the Demand for Fertilizer in West Pakistan

*by*

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### INTRODUCTION

West Pakistan has experienced a remarkable revolution in agriculture during its Third Five Year Plan. Very large increases in agricultural output have resulted from the rapidly growing use of improved seeds, fertilizer, and from improved water supplies. Agricultural pricing-policy has also played a part in this achievement. In this paper only one aspect of this revolution will be examined in isolation—the rapidly growing demand for chemical fertilizers. It is to be hoped that similar studies on other agricultural inputs will follow and that as a result it will be possible to consider the interactions and aggregate significance of various inputs.

Increasing quantities of fertilizers are being sold in West Pakistan, and considerable public resources have been devoted to their purchase and distribution. The growth of fertilizer industry and of sales has largely been the result of efforts in the public sector, whereas in the case of tubewells it was the private sector which led the way. The private sector has recently been brought into the distribution of fertilizers, and will be taking over the responsibility for retail distribution. The sale of fertilizer has been subsidised in West Pakistan and for this reason it is of primary importance to identify and quantify the factors determining demand.

Fertilizers have been used in West Pakistan for many years, and the government recognised the need for their introduction as early as 1952. The first real efforts at introducing fertilizers date from 1953/54 when 72,000 tons[1]

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[1]Quantities are in tons of sulphate of ammonia equivalent throughout the paper.

of fertilizer were sold. Since then the expansion of fertilizer use has been rapid; it took seven years to double the 1953/54 sales, three more years to double them again, and a further four years to triple these again. In 1968/69 the demand for fertilizer is expected to be eighteen to twenty times that of 1953/54. This is a remarkable record, and it is of considerable interest to policy-makers to examine this record to see what factors underly the growth of fertilizer demand and what implications this has for future policy.

## II. METHODOLOGY

The construction of an adequate model of farmers responsiveness to prices within the context of a developing country and a rapidly changing technology under conditions of uncertainty will have to await a considerable improvement in the techniques of agricultural economics and social anthropology and it is to be hoped that combined fieldwork in the social sciences will help to throw some light on the behavioural responses of the farmer. We may, however, expect that in the consideration of a problem such as the demand for fertilizer in West Pakistan certain constraints would be operative and that the study of these constraints may in itself be a useful guide to policy formulation even in the absence of a closely reasoned model of the farmers' economic behaviour.

Data for fertilizer sales in West Pakistan are available for the period 1952 to 1968. Only two nutrients are at present being sold on a commercial scale in West Pakistan: nitrogen and phosphorus. The sales of phosphatic fertilizers have only recently commenced and it has, therefore, been convenient to treat fertilizer sales in terms of ammonium sulphate equivalent without reference to nutrient.

A series of functions were fitted to the data, where the dependent variable was the total consumption of fertilizer in thousand tons of ammonium sulphate equivalent in a given financial year[2]. The independent variables were:

$X_1$ = time, a variable measuring levels of technology and information in the farm sector and other relevant but unspecified variables, (Base year-1952[3])

$X_2$ = the real price of fertilizer at farm level, *i.e.*, the actual price deflated by an agricultural income index ($X_5$),

$X_3$ = the acreage of land cultivated in the previous twelve months,

$X_4$ = the average size of holding cultivated,

[2]July 1st to June 30th.

[3]*See* [2, p. 378].

$X_5$ = index of agricultural income, based on average net income for four major crops in West Pakistan — wheat, rice, sugarcane, and cotton,

$X_6$ = sales of fertilizer in the previous year,

$X_7$ = irrigation index — the percentage of the cultivated land which is irrigated.

## III. RESULTS

The first approach to the problem of demand determination was to fit a suitable function to the time series for sales of fertilizer in West Pakistan. A linear function was fitted to the sales data using time and real price as the independent variables, the resultant function is shown in the first row of Table I. The coefficient of determination is 0.70 which is low, and only the time variable is significant. The price variable is negative and nonsignificant with a price elasticity of — 0.11 at the mean level. The function is not a satisfactory one for explaining the relationship between fertilizer sales, time and prices. A logarithmic function with the same independent variables was then fitted. The resultant function as shown as second row of Table I and has high coefficient of determination, however only the time variable is significant. The coefficient of price is negative and indicates a price elasticity of demand of — 0.13.

The results thus far only indicate the form of the growth function and the fact that price is not a significant long-run determinant of demand. A simple adjustment model was fitted to the data with the results shown in the third row of Table I. This serves to confirm that price was not a significant determinant of demand and we may, by implication, suggest that one of two constraints is, therefore, likely to be significant: either current demand is correlated with some desired level of demand and the time variable is measuring the rate at which farmers are becoming aware of the returns from fertilizer, or the desired level of demand exceeds current demand and adjustment is being constrained due to lack of resources. A first difference model in logarithms was then fitted to the data, with the result shown in the fourth row of Table I when the first year's data were omitted. The inclusion of the first year's observation led to a large increase in the error of the estimate. The short-run price elasticity indicated by this function is — 1.08 which suggests that the availability of resources to purchase fertilizers in the short run is the relevant constraint.

In order to verify the importance of resource constraints it was necessary to examine cross-sectional data[4]. The first of the two possible constraints cannot be specified until data become available on farmers' behaviour patterns.

[4]Time-series data for such an exercise, even in the simple form specified, were not available.

## TABLE I

**REGRESSION EQUATIONS EXPLAINING FERTILIZER CONSUMPTION IN WEST PAKISTAN: 1952-68**

| Form of equation | Initial constant | Time $X_1$ | Real price $X_2$ | Sales of fertilizer lagged one year $X_6$ | $\bar{R}^2$ |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1. Linear | —38.41 | 49.9465* (3.7180) | —32.9233 (28.1104) | | 0.70 |
| 2. Log linear | 1.2077 (0.0207) | 0.1117** | —0.1279 (0.1075) | | 0.98 |
| 3. Adjustment model | 0.6421 | | —0.0416 (0.2111) | 0.7449* (0.1030) | 0.81 |
| 4. First differences in logs | 2.1941 | | —1.0775*** (0.4991) | | 0.33 |

*Significant at the 0.1% level.
**Significant at the 1.0% level.
***Significant at the 5.0% level.

The second constraint can, however, be examined indirectly; data on expendable farm incomes are not available, but may be approximated with an index of agricultural income from the four major cash crops, on the assumption that expendable income would be closely tied to gross income. The data on which this model was tested refer to thirty-two districts for a period of three years. Separate functions were fitted to the data for each of the three years so that the time and price variables could be omitted. The acreage of land cultivated was used as a measure of district size, the average size of holding was included to determine whether there was any measurable substitution of fertilizer for land, and the irrigation index was included to determine any interrelationship between water usage and fertilizer usage. The previous year's sales of fertilizer were included as an independent variable to measure the attained level of usage. Three linear functions were fitted to the data for the years 1964/65, 1965/66 and 1966/67. The three resultant functions were very similar, and that for 1965/66 is shown in the first row of Table II. The only significant variables are the acreage of land cultivated and the sales of fertilizer in the previous year. The three other variables are not significant.

Evidence concerning saving patterns and consumption in rural areas would suggest that expendable income may be more closely related to changes in income than to their absolute level. A further function was, therefore, fitted to district sales over the three-year period, the time and price variables now

## TABLE II

### REGRESSION EQUATIONS EXPLAINING DISTRICT DEMAND FOR FERTILIZER IN WEST PAKISTAN

| Form of equation | Initial constant | Time $X_1$ | Real price $X_2$ | Acreage of land cultivated $X_3$ | Average size of holding $X_4$ | Index of agriculture income $X_5$ | Sales of fertilizer in previous year $X_6$ | Irrigation index $X_7$ | $\bar{R}^2$ |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1. Linear (1965/66) | —8305 | | | 6.1489* (1.6599) | 183.1891 (294.7518) | 50.4506 (46.5022) | 0.3796* (0.0019) | 24.9435 (31.5107) | 0.58 |
| | | | | | | | Area irrigated $\left\{\frac{X_3 X_7}{100}\right\}$ | | |
| 2. Log linear (1964-67) | —7.29 | +0.4061* (0.0751) | +0.0877 (0.1021) | | | 2.6551* (0.3922) | —0.2375** (0.1308) | | 0.44 |

*Significant at the 0.1% level
**Significant at the 1.0% level

had to be included. The size of holding variable was discarded and variables referring to cultivated area and the irrigation index were combined. The resultant function for the years 1964-67 is shown in the second row of Table II. The value of the coefficient of multiple determination has declined, nevertheless the income and time variables are now highly significant. The combined acreage and the irrigation index variable are now significant at the 1-per-cent level. This result serves to confirm the previous findings for demand on an aggregate provincial basis, they also suggest that changes in income are a highly significant determinant of fertilizer demand. The low coefficient of determination and the highly significant time variable suggest that credit availability and the level of information may also be relevant. The specification of further relevant variables will, however, have to await further fieldwork [1].

## IV. CONCLUSIONS AND POLICY CONSIDERATIONS

A simple hypothesis concerning the growth of demand for fertilizer in West Pakistan has been formulated and tested. The available data suggest that the growth of fertilizer demand is a function of a complex variable which has been called time: this variable includes such unmeasurables as the level of technology and the level of information in the agricultural sector. Price is not a significant determinant of the level of long-run demand but income is, when it is measured over time. A more realistic model should be formulated on the basis of seasonal incomes and seasonal demand patterns, unfortunately data for this purpose are not yet available. The position has been further complicated by occasional shortages of fertilizer supplies and the operation of the black-market for which no data are available[5].

The very low estimated long-run price elasticities suggest that the removal of the fertilizer subsidy would have virtually no long-term effect. To the extent that the supply of resources for investment is very inelastic in the short run, the apparent short-term effect of the removal of the subsidy might be reflected in a short-term price elasticity of upto one. The reduction of the fertilizer subsidy in 1965/66 from 50 per cent to 35 per cent resulted in such a response. This study indicates, therefore, that the fertilizer subsidy is in fact an economic rent and that a more effective method of stimulating fertilizer sales might be through the credit system. This will depend on the extent to which credit acts as a substitute for the subsidy and the extent to which new users are stimulated by the credit facilities.

The construction of a more sophisticated model of farmer's behaviour will require a research effort in which economists, sociologists and social anthro-

[5]The present analysis has assumed that supply has been on a fixed price-inventory adjustment basis. Fertilizer rationing and the development of a black-market would complicate the model, particularly on a regional basis since shortages have occurred in certain regions.

pologists must cooperate. The necessity for such work in order to formulate realistic agricultural development policy cannot be overemphasized.

## REFERENCES

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