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Some Non-price Explanatory Variables in Fertiliser Demand: The Case of Irrigated Pakistan

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1. INTRODUCTION

It follows from the experience of World economies that rising and balanced use of fertilisers is the key factor in agricultural productivity [FAO (1995); SFS and STI (1996); Habib-ur-Rehman (1982) and Pinstrup-Anderson (1976)]. In the case of Pakistan the stepped up fertiliser use has been argued to be incritable to realise existing untapped yield potential of major crops [Johnston and Kilby (1975)] and to induce yield increasing technological change in future [John Mellor Associates and Asianics Agro-Dev. International (1993)].

Although proper malnutrition involves the use of primary, secondary and micro-nutrients, Nitrogen (N), Phosphorus and Potassium (K) or NPK is generally considered to be sufficient to harvest normal crop yields [FAO and IFA (1999)]. Given this situation, this paper looks at various factors that determine fertiliser use in Pakistan. Although price of fertiliser is a critical factor in this respect [Schultz (1965) and Johnston and Cownie (1969)], only non-price factors are considered in this paper due to limitations of data. Apart from this introductory section, the paper comprises of three more sections. The following Section 2 explains the data and the empirical model. Section 3 presents the results. Section 4 summarises the main findings along with their policy implications.

2. THE DATA AND EMPIRICAL MODEL

The Data

The data used in this study comes from a Fertiliser Use Survey 1997-1998 conducted by the Pakistan Institute of Development Economics for the National Fertiliser Development Centre, Planning and Development Division, Government of Pakistan. The details about the survey and the procedures are given in Ahmad and

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Chaudhry (2000). However, a brief discussion about the survey follows.

This survey covers NWFP, Punjab and Sindh out of four provinces of Pakistan, which consume more than 98 percent of the total fertiliser use in the country. A total of 18 *tehsils* (sub-districts) were selected—10 from Punjab, 5 from Sindh and 3 from NWFP.[1] The considered bases for the selection of these *tehsils* were the cropping pattern, water availability and the intensity of fertiliser use. On that account, the selected *tehsils* represent the average condition of the respective provinces. Six villages from each *tehsil,* and about 22 farmers from each village were selected for interview. The overall sample thus comprised 2368 respondents from all the provinces. While screening the whole data set, about 62 cases were found deficient in displaying reliable farm level information. The remaining sample includes 2306 farmers. Out of this sample 1923 farmers belong to irrigated areas in Punjab, Sindh and NWFP, which serves the basis of this investigation. It may be interesting to note that non of these farmers is non user of fertiliser.

Empirical Model

Given the nature of the data, the following general model is specified:

Ln(FERT) = f(PRIM, MID, MATR, INT, Ln(AGE), EXTEN, NOLOAN, COMERC Ln(FMDIST), DDIST, OTEN, TENE, CAN,TUB, Ln(FYMA), DFYMA, Ln(CA), PWHEAT, PRICE, PCOTTON, PSUGAR, PVEFRUT, PMAIZ)

Where,

Ln	=	Stands for natural log;
FERT	=	Fertiliser nutrients (NPK) measured in kilograms per cultivated acre;
PRIM	=	1, for primary education; 0 otherwise;
MID	=	1, if the farmer has middle level education; 0 otherwise;
MATR	=	1, if the farmer has matric level education; 0 otherwise;
INT	=	1, for intermediate or a higher level education; 0 otherwise;
AGE	=	Age of the farmer;
EXTEN	=	1, if the farmer was contacted by the extension workers or he himself visited the officials for guidance;
NOLOAN	=	1, if used own savings for purchase of fertiliser; 0 otherwise;
COMERC	=	1, if the farmer gets loan from commercial bank; 0 otherwise;
FMDIST	=	Farm to market distance in kilometres;
DDIST	=	1, If the market is near the village (zero distance); 0 otherwise;

[1]The selected Tehsils in Punjab province include Arifwala, Chishtian, Hifizabad, Kabirwala, Lodhran and Sammundari from perennial irrigated region, Mianwali and Rajanpur from partially irrigated zone, and Attock and Chakwal from the rainfed region. Tehsils selected from Sindh include Khairpur, Nawabshah and Shahdadpur as having perennial irrigation, and Mirpurkhas and Thatta from partially irrigated zone. In case of NWFP, Charsada, Swat and Kulachi were selected from perennially irrigated, partially irrigated and rainfed regions, respectively.

OTEN	=	1, if the farmers is owner-cum-tenant; 0 otherwise;
TENE	=	1, if the farmers is tenant; 0 otherwise;
CAN	=	1, if irrigation source is canal only; 0 otherwise ;
TUB	=	1, if the source of irrigation is tube well; 0 otherwise;
FYMA	=	Farm Yard Manure per acre in maunds;
DFYMA	=	1, if there was no use of FYM; 0 otherwise;
CA	=	Cultivated area in acres—Farm Size;
PWHEAT	=	Area under wheat in acres at the *i*th farm divided by the total cropped area of the same farm;
PRICE	=	Area under rice in acres at the *i*th farm divided by the total cropped area of the same farm;
PCOTTON	=	Area under cotton in acres at the *i*th farm divided by the total cropped area of the same farm;
PSUGAR	=	Area under sugarcane in acres at the *i*th farm divided by the total cropped area of the same farm;
PVEFRUT	=	Area under vegetables and fruits in acres at the *i*th farm divided by the total cropped area of the same farm; and
PMAIZ	=	Area under maize in acres at the *i*th farm divided by the total cropped area of the same farm.

In the above-specified model two of the independent variables that are FMDIST and FYMA have significant number of cases assuming zero values. For these variables to be transformed into natural log the usual practice has been to add a small value to the whole variable in order to take the log of such an independent variable. Recently, Battese (1997) has shown that such a procedure results into biased parameter estimates while using Cobb-Douglas or translog functional forms. In order to get unbiased parameter estimates, the following procedure as suggested by Battese (1997) is employed. The variables FMDIST and FYMA are transformed into logs in such a way that the zero cases are taken as zero and the cases assuming positive values are transformed into log form: For example, Ln(FYMA) is natural log of the farm yard manure variable when its use is positive, i.e., FYMA>0. Additional dummy variables such as DFYMA and DDIST are introduced having 0 or 1 values. For example, DFYMA assumes a value of 1 when the use of FYMA at the *i*th farm is zero and DFYMA takes value of 0 when FYMA is positive. The coefficients of these dummy variables estimate the difference between two regimes—the one, when an independent variable assumes zero values and the other when it has positive values. For example, if the coefficient of dummy variable, DFYMA, is positive, it implies that the intercept in case of no use of farm yard manure is higher than that with positive use. The equality of these intercepts can be tested using *t*-tests on the parameter estimates of the dummy variables.

3. EMPIRICAL RESULTS

The analysis is performed separately for the provinces of Punjab, Sindh and NWFP. Out of total sample of 1923 farmers, 1043 belong to Punjab, 845 lie in Sindh and 235 pertain to NWFP. Before the model results are discussed, it is considered more appropriate to briefly draft the sample statistics.

Descriptive Statistics

The descriptive statistics are given in Table 1. The averages relating to per acre use of fertiliser show that the farmers in Sindh use the highest quantity, i.e.,

Table 1

Descriptive Statistics

Name	Punjab		Sindh		NWFP	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
FERT	91.99	47.32	103.29	52.57	82.97	52.87
PRIM	0.17	0.37	0.28	0.45	0.08	0.27
MID	0.15	0.36	0.04	0.20	0.08	0.27
MATR	0.21	0.41	0.06	0.24	0.14	0.34
INT	0.09	0.29	0.10	0.30	0.12	0.33
AGE	41.28	14.65	38.42	13.04	43.67	15.47
EXTEN	0.43	0.49	0.13	0.34	0.09	0.28
NOLOAN	0.73	0.44	0.62	0.49	0.89	0.31
COMERC	0.06	0.24	0.04	0.20	–	–
OTEN	0.15	0.36	0.09	0.29	0.11	0.31
TENE	0.15	0.36	0.40	0.49	0.37	0.49
CAN	0.30	0.46	0.89	0.32	0.94	0.24
TUB	0.10	0.29	0.06	0.24	–	–
FMDIST	7.87	5.86	7.90	4.98	6.19	8.43
DDIST	0.10	0.30	0.02	0.15	0.29	0.45
FYMA	42.17	85.6	25.22	47.33	68.51	79.47
DFY	0.32	0.47	0.46	0.50	0.09	0.28
CA	13.07	15.62	10.11	10.08	5.95	11.07
PWHEAT	0.43	0.14	0.37	0.18	0.30	0.22
PRICE	0.06	0.13	0.10	0.21	0.11	0.20
PCOTTON	0.25	0.22	0.24	0.21	–	–
PSUGAR	0.05	0.11	0.07	0.15	0.19	0.29
PVEFRUT	0.05	0.07	0.11	0.17	0.14	0.25
PMAIZ	–	–	–	–	0.16	0.21
No. of Observations	1043	645	235			

Note: Independent variables in Punjab and Sindh are the same, while these variables differ in number in NWFP model: There were only a few observations in case of the sources of loans—commercial loan and others were combined and compared with NOLOAN. For the same reason canal plus tube-well cases were combined and compared with canal only. No farmer was found growing cotton in NWFP. About 47 percent of the NWFP farmers were found growing maize on their farms and thus maize variable is added in NWFP regression.

103.3 kg, and the lowest is observed in NWFP with 83 kg. The literacy rate is higher in Punjab, which is about 62 percent (= sum of averages of educational dummy variables), as compared to Sindh (48 percent) and NWFP (42 percent). The average age of the farmer is higher in NWFP than the mean age in other two provinces.

About 43 percent of the sample farmers in Punjab either meet the agricultural extension agents in their village or they themselves contact the office of the agriculture extension department for technical advice. This figure is three to five times higher than that in other provinces. The variables relating to the sources of rural finance suggest that about 73 percent of the farmers in Punjab, 62 percent in Sindh and 89 percent in NWFP used their own resources to buy fertiliser from the market. The rest of the respondents get support either from the Agricultural Development Bank of Pakistan (ADBP)—6 percent in Punjab, 4 percent in Sindh and 8 percent in NWFP, or from some other private sources such as commission agents in the town markets, fertiliser dealers, other traders, etc.—21percent in Punjab, 34 percent in Sindh and 2 percent in NWFP.

With regard to the tenancy status, Table 1 shows that each of the tenants and the owner-cum-tenants comprise 15 percent of the sample in Punjab and the remaining 70 percent are owner cultivators. In Sindh, 40 percent of the sample farmers are the tenants and only 9 percent are owner-cum-tenants, while the remaining 51 percent are self-cultivators. The tenancy status of sample farmers in NWFP is approximately the same as that of in Sindh.

The distribution of survey farmers according to the sources of irrigation suggests that about 94 percent of them have been using the canal water alone in NWFP, and this figure in Sindh is 89 percent indicating very small proportion of the farmers having tubewell irrigation. While in Punjab only 30 percent of the total sample farmers depend on canal water as a sole source of irrigation. A large proportion of the farmers makes use of tubewell water along with the canal water.

The average distance of the farm from the main input-output market is approximately the same in all the provinces. However, the distance dummy variables shows that 29 percent of the sample farmers in NWFP are located near the market, whereas in Sindh only 2 percent are in proximity of the market. Looking at the use of farm yard manure, the average figures in Table 1 reveal that its application rate is highest in NWFP—about 68 maunds per acre with 91 percent users, and is lowest in Sindh amounting to 25 maunds per acre with 50 percent users.

The statistics regarding the cultivated area indicate that Sindh has a larger average farm size with about 16 acres of land as compared to Punjab and NWFP where the average size is 13 acres and 6 acres, respectively. As far as the cropping pattern is concerned, wheat is the dominant crop in all the provinces ranging from 30 percent of the total cropped area in NWFP to about 43 percent in Punjab. Nonetheless, about 2 percent of the farmers in Punjab, 8 percent in Sindh and 18 percent in NWFP have not allocated any area to wheat. Cotton stands second both in Punjab and Sindh with 25 percent and 24 percent of the total cropped area, respectively. In the NWFP none of the farmers was growing any cotton. The rice crop stands at third place in terms of area allocation in Punjab, against vegetables plus fruits as the third important crop in Sindh. In NWFP sample, sugarcane and maize take the second and third position respectively in terms of area allocation.[2]

The Model Results

The results of the three separately estimated models—one each for Punjab, Sindh and NWFP, are reported in Table 2. The adjusted R^2 values of 0.34, 0.32 and

Table 2

Parameter Estimates of Fertiliser Use Equations in Various Provinces[#]

Variable	Punjab		Sindh		NWFP	
	Coefficient	S.Error	Coefficient	S.Error	Coefficient	S.Error
PRIM	0.1511***	0.0427	0.0654	0.0446	0.1201	0.1363
MID	0.1050**	0.0467	–0.0175	0.1007	0.3142**	0.1360
MATR	0.1650***	0.0409	0.0951	0.0818	0.1483	0.1170
INT	0.1878***	0.0584	0.1565**	0.0702	0.2968**	0.1486
Ln(AGE)	0.0138	0.0427	0.0094	0.0560	–0.2494**	0.1166
EXTEN	0.0842***	0.0306	0.1754***	0.0484	0.3209**	0.1556
NOLOAN	0.0858**	0.0432	–0.0078	0.0455	–0.1167	0.0936
COMERC	0.1359*	0.0721	–0.0847	0.0990		
OTEN	0.0364	0.0422	–0.1191*	0.0695	0.0272	0.1021
TENE	0.0782*	0.0437	0.0592	0.0485	0.1917**	0.0990
CAN	–0.0981***	0.0366	–0.1784**	0.0897	0.0411	0.1698
TUB	–0.1380**	0.0580	0.0222	0.1085		
Ln(FYMA)	0.0594***	0.0101	0.0681***	0.0165	0.0535**	0.0267
DFYMA	0.1452***	0.0547	0.2067***	0.0763	0.2810**	0.1445
Ln(FDIST)	–0.0113	0.0225	0.0271	0.0258	0.0461	0.0432
DFDIST	–0.0512	0.0642	0.2246**	0.1011	–0.0757	0.1068
Ln(CA)	–0.0526***	0.0176	–0.0466**	0.0240	–0.2170***	0.0506
WHEATP	0.5071***	0.1339	0.3012	0.2180	0.5140*	0.2923
RICEP	0.9919***	0.1704	1.7579***	0.2028	0.8542***	0.3252
COTTONP	1.9209***	0.1168	0.4036	0.2500		
SUGARP	1.4033***	0.1568	1.2508***	0.2194	0.9128***	0.2971
VEFRUTP	–0.0793	0.2309	0.4765**	0.2314	0.7091***	0.2866
MAIZP					0.3668	0.3090
CONSTANT	3.2519***	0.2063	3.6498***	0.3153	4.4986***	0.5174
Adj. R^2	0.34		0.32		0.19	

[#] Various tests were performed to detect the presence of heteroscedaticity problem in the data. The dependent variable heteroscedasticity problem was detected in case of both Punjab and Sindh and the results presented in this table are obtained using the transformed data [see Ramanathan (1992) for detailed procedure]. However, no heteroscedasticity problem was detected in case of NWFP. Moreover, the linear versions of all of these three models were also tried and in most of the cases the standard errors of the estimates were very large and in some cases unexpected signs were also observed.

*, **, *** represent 10, 5 and 1 percent level of significance respectively.

[2]The crops which were grown by less than 6 percent of the farmers in various provinces were excluded from the right hand side of the models to avoid too many variables. For the same reason area under vegetables and fruits were combined to gather—in total vegetables plus fruits is grown from 32 percent to 50 percent of the sample farmers.

0.19 for the models in Punjab, Sindh and NWFP, respectively, imply that from 19 percent to 34 percent of the original variances of the dependent variables are explained by the included independent variables. Given the cross-section nature of the data and the specification of variables on per acre basis, the magnitudes of the adjusted R^2s statistics are reasonable.

The results of the three separately estimated models—each for Punjab, Sindh and NWFP, are reported in Table 2. The results show that 19 of the total 23 parameter estimates are statistically significant in Punjab—14 at the 1 percent level, 3 at the 5 percent level and 2 at the 10 percent level. In Sindh, a total of 11 parameter estimates (out of 23) is found statistically significant—5 at the 1 percent level, 3 at the 5 percent level and 3 at the 10 percent level. While in NWFP, 8 out of total 21 estimated coefficients turns out to be statistically significant—3 at the 1 percent level, 2 at the 5 percent level and 3 at the 10 percent level.

Table 2 reveals that the parameter estimates of all the four educational dummy variables are statistically significant at the 5 percent level or better in Punjab. Only one coefficient of educational dummies, i.e., INT is found statistically significant at the 5 percent level in the model for Sindh. Two of the four coefficients of educational variables in NWFP are statistically significant at the 5 percent level of significance. These results very clearly demonstrate that farmers' education emerges as an important factor in enhancing the use of chemical fertilisers in general and in Punjabi particular.

This conclusion is in line with Jha and Hojjati (1993) in case of Zambian agriculture. But, this result is in contrast to the findings of Shakya and Flinn (1985) in case of Nepal, where the education variable proved to be an unimportant fertiliser use-enhancing factor.

The extension affects per acre use of fertiliser positively in all the provinces. The relationship is statistically significant in Punjab and Sindh. But, the impact is not significant in NWFP, which could be due to a relatively weaker link between farmers and extension department in NWFP. Only 9 percent of the farmers contacted with the extension staff in NWFP—where the respective figures in Punjab and Sindh are 43 and 13 percent (Table 1). The magnitudes of the parameter estimate show that the farmers who are in touch with the agricultural extension department apply about 9 percent more fertiliser nutrients per cultivated acre in Punjab and 21 percent higher in Sindh. Shakya and Flinn (1985) using Nepal's agricultural data also found positive association of extension advice with that of fertiliser use.

The coefficients of age in all the regressions have negative signs as expected indicating that the old age discourages the higher use of chemical fertiliser per acre. However, the impact is not generally statistically significant. This result is in line with the finding of Jha and Hojjati (1993).

The variables regarding the sources of finance provide conflicting results in different regions. In Punjab, the farm operators who purchase fertiliser from their own savings (NOLOAN) or farm loans from commercial banks (ADBP) apply significantly higher rates per acre than those obtaining loan from private sources. In Sindh and NWFP fertiliser use does not vary with sources of funding.

The variables relating to tenurial status show that the tenants apply significantly higher rates of fertiliser per acre than do the owner operators—it is true for all the provinces. The use of fertiliser per acre on owner-cum-tenant farms appears to be no different than the use on owner operated farms in all the provinces. These results confirm the findings of NFDC (1994 and 1996) and Ahmad and Chaudhry (2000) that the tenants use higher rates of fertiliser.

Farm yard manure emerges as an important fertiliser use enhancing factor. The parameter estimates of FYMA are statistically significant carrying positive signs in all the provinces. The coefficients imply that the use of fertiliser per acre increases 6-8 percent with 10 percent increase in per acre use of farm yard manure in various provinces. The coefficients of dummy variables (DFYMA) are not only positive but also statistically significant implying that the intercept for the no FYMA cases is larger than for those with positive FYMA. This result support our hypothesis stated earlier that the farmers would use higher quantities of chemical fertiliser per acre along with higher use of FYM since the later increases the crop production response for the former.

The farm to market distance, FDIST, shows a negative and statistically significant relationship with the fertiliser use in Punjab. The parameter estimate of the DIST variable in case of Sindh and NWFP is positive but is not statistically significant. The Punjab's result is consistent with our *a priori* expectation which holds that farther the input market from the farm lower is the use of fertiliser per cultivated acre and vice versa. This in other words means that widespread location of fertiliser sale points would be instrumental in enhancing farm level fertiliser use. The distance to fertiliser sale depot seems to matter little in the case of Sindh and NWFP.

A statistically significant inverse relationship exists between farm size and fertiliser use per acre in all the provinces. The fertiliser use elasticities with respect to farm size are –0.0709, –0.0516 and –0.2579 in Punjab, Sindh and NWFP, respectively. The magnitudes of these elasticity coefficients imply that a 10 percent increase in farm size reduces the use of fertiliser per cultivated acre by nearly 0.5 to 2.6 percent in various provinces of Pakistan. Although small farmers may in general be assumed to use less fertiliser because of their financial constraints, the inverse relationship points to small farmer's keen interest in fertiliser use as a critical technological factor in raising crop yields. Facing land constraints, the small farmers are hard pressed to make their livings and thus put in their maximum, including financial resources, to reap maximum possible output.

The coefficients of the crop variables—area under a crop divided by total cropped area, have generally shown positive and statistically significant association with the fertiliser use per cultivated acre. The variables, which have positive and significant impact on the use of fertiliser per acre, include WHEAT, RICE, COTTON and SUGAR in Punjab. While the one that carries a negative sign is VEFRUT, but the impact is not statistically significant. All of the five crop area variables carry positive signs in Sindh, but only two, i.e., COTTON and SUGAR, have shown statistically significant association with fertiliser use per acre. In case of NWFP, only the sugarcane has a positive and statistically significant impact on per acre use of fertiliser, while all the other crops—wheat, rice, vegetable and fruits, and maize, show no statistically significant association with per acre use of fertiliser.

4. CONCLUSION AND POLICY IMPLICATIONS

This paper was aimed at empirical verification of factors determining farm level fertiliser demand in Pakistan. In spite of the importance of the prices, it was difficult to quantify their effect on fertiliser demand due to cross section nature of the data. But following the conclusions of a large body of literature, fertiliser price must have a negative effect on fertiliser demand. The other main findings of the paper can be summarised as follows. Firstly, education in general has a positive impact on fertiliser use and so does the access to extension. Secondly, fertiliser demand is inversely related to farm size, distance to fertiliser depot and the age of the farmer. However, the coefficient of age is statistically non-significant. Thirdly, the dummy variables for canal and tubewell water availability have negative signs, which means that the contribution of individual variables to fertiliser use is less relative to water available from both these resources. Fourthly, the effect of tenurial status is less marked but farm yard manure use promotes fertiliser use. Fifthly, all major crops add positively to farm level fertiliser use but increase in proportionate area under cotton makes the maximum contribution followed by sugarcane and rice. Finally, institutional credit, at least in Punjab was important in determining fertiliser use, despite the insignificance of source of funding for fertiliser.

Many policy implications follow from the conclusions of this paper. For example, disproportionate increases in the price of fertilisers relative to those of agricultural commodities have deleterious effects on fertiliser use and should be discouraged. If fertiliser price increase becomes an absolute necessity, then this must carefully be matched with corresponding increase in commodity prices. As better education and access to extension are positive factors, investment in human capital in rural sector should be given somewhat greater importance. In spite of poor financial resources, tenants and small farmers are making greater use of fertiliser. It might be worthwhile as under micro-finance banking to redirect credit emphasis towards these classes. It might be advisable to promote tubewell irrigation to supplement canal water to raise fertiliser use. Finally, the objective of greater use and higher productivity in agriculture can be best achieved by concentrating efforts at growing of more valuable cash crops like cotton and by encouraging greater use of farmyard manure.

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