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Demand for Nitrogenous Fertilizer in Nepal

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INTRODUCTION

The impact of chemical fertilizer in the development of an economy primarily based on agriculture is encouraging. Fertilizer, a most influential input to boost production, has to play a significant role in the economy of Nepal. A least developed country, land-locked by location and with an economy, dominated by agriculture Nepal has to rely on agriculture and agro-industries to feed it's ever increasing population. Fertilizer, with proper use of water and other support services can keep pace production with population explosion in least developed countries where the economy is based on agriculture.

Despite the ever increasing trend for fertilizer demand druing the past two decades, per-unit consumption is to low at 14 kg/hectare in arable land, and lowest in Asia.

This paper tries to explain the increased demand for nitrogenous fertilizer over the last two decades (1965-66 to 1983-84) almost from the non existent level to nearly a hundred thousands metric tons (gross) per annum and to analyze the factors affecting this demand by estimating demand function based on time-series data for Nepal. The discussion is confined to nitrogenous fertilizer for a number of reason, the most important being the more than 70 percent share of nitrogenous fertilizer application in the country while remaining the "limiting" group of fertilizer to influencing the application of P_2O_5 and K_2O.

METHODOLOGY

The methodology so far used to estimate the demand function can be categorized into direct and indirect approaches. Heady and Tweenten (1963) formulated the indirect approach using production function under the condition of profit maximization. But as cautioned by Timmer (1974), it is difficult to make an assumption on the maximizing behaviour of farmers and their knowledge of relevant agronomic functions. Research findings indicate that the former varies abruptly across the region and vast difference has been observed on the agronomic response function in the case of the latter.

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The direct approach involves the estimation of fertilizer demand function directly from the time-series data, including among others, fertilizer price, output price, farm income, cropped area, irrigation services, seeds, insecticides and time as explanatory variables. Two models, Traditional and Adjustment have been formulated to deal with fertilizer demand adequately. The Traditional model is simply a static demand function which assumes that change in fertilizer demand is usually associated with the change in variables which affect fertilizer demand. The Adjustment model assumes that adjustment to the quantity does not take place instantaneously, partly because of imperfect knowledge which leads to the disequilibrium differentiating short-run and long-run demand. Griliches (1958) used this model for estimating demand for fertilizer in the United States and depicted short-run and long-run elasticities for the variables incorporated in the model.

MODEL

Both static and dynamic models under the direct approach are incorporated to estimate the significant and consistent demand function for the nitrogenous fertilizer for the Kingdom of Nepal.

TRADITIONAL DEMAND MODEL

The demand for nitrogenous fertilizer is expressed in long-linear form. The upper case letter in the equation are expressed in the logarithms of the variables.

$$1)\quad N_t = a + b_1\ NCPR_t + b_2\ Y_{t-1} + b_3\ A_t + b_4\ I_4 + b_5\ HYV_t + b_6\ T + U_t$$

Where: N_t = Total nitrogen consumption in year t.

$NCPR_t$ = Crop-price ratio in year t.

A_t = Acreage planted in year t.

Y_{t-1} = Crop yield lagged one year.

HYV_t = Consumption of high yielding variety of seeds in year t.

T = Time in years.

U_t = Disturbance term.

Instead of a single price for the given fertilizer and crop, the ratio is used because of certain advantages related to the reduction of the occurrence of multicollinearity in the model itself. The fertilizer - crop price ratio is calculated by dividing the given fertilizer price by the weighted average price of main crops: paddy, wheat and maize which constitute about 90 percent of the total cereal crops. The yield of the three major crops for previous year explicitly affects the fertilizer demand. The cultivated area used in the model comprises the area covered by all crops, while high yielding variety seeds (HYV_s) includes paddy, wheat and maize.

Time has been considered as one of the relevant economic variables in the static demand function. It reflects the greater technological knowledge of farmers through education, extension services etc. over time. This variable represents 1 for the year 1965/66.

ADJUSTMENT DEMAND MODEL

The adjustment demand model for nitrogenous fertilizer, as in the traditional model, follows the same log-linear form as follows:

2) $N_t^* = a + b_1\ NCPR_t + b_2 Y_{t-1} + b_3 A_t + b_4 I_t + b_5\ HYV_t + U_t$

Where N_t^* = is the "desired" or long-run equilibrium of Nitrogen consumption. The other variables are represented with the same notation as before.

The adjustment model is a Nerlovian adjustment model used by Griliches and subsequently by several other economists. The adjustment equation, obtained by assuming the percentage change in the actual consumption is a power function of the percentage difference between desired and actual consumption. So we have

3) $N_t - N_{t-1} = r\ (N_t^* - N_{t-1})$

Where N_t is the actual fertilizer consumption and r is the coefficient of adjustment. Short-run demand equation is obtained by substituting equation (2) in equation (3). In effect the adjusted demand model for nitrogen becomes as follows:

4) $N_t = ra + rb_1\ NCPR_t + rb_2 Y_{t-1} + rb_3 A_t + rb_4 I_t + rb_5 HYV_t + (1-r) N_{t-1} + rU_t.$

The adjustment equation enables us to estimate short-run and long-run elasticities. The size of the coefficient of adjustment determines the range of the run. The larger the size of the coefficient the smaller the range of run. There is perfect adjustment if the coefficient of adjustment is equal to the unity. This means that the actual and desired levels will be the same, a situation which leads to the uselessness of the model itself.

THE RESULTS

The regression results obtained from the ordinary least square analysis are listed below:

Table 1
Regression coefficient for N-nutrient

Traditional	Const. term Model	$NCPR_t$	y_{t-1}	A_t	I_t	HYV_t	T/N_{t-1}	R^2	SE
1	1.721	-0.350* (0.234)	-0.728@ (0.399)	0.372 (1.464	0.119 (0.298	0.143@ (0.073)	1.075¢ (0.194	0.994	0.0193
2	6.572	-0.345* (0.224)	-0.735@ (0.382)	-	0.163 (0.233)	0.145& (0.070)	1.090¢ (0.177)	0.994	0.0809
3.	8.732	-0.394@ (0.208)	-0.806& (0.361)	-	-	0.144& (0.067)	1.195¢ (0.091)	0.992	0.0182
Adjustment	Model								
4	-12.775	-0.183 (0.267)	-0.242 (0.493)	0.714 (1.730)	0.684& (0.315)	0.238* (0.088)	0.406¢ (0.094)	0.992	0.0230
5	- 3.749	-0.214 (0.232)	-	-	0.810& (0.180)	0.121* (0.073)	0.430¢ (0.081)	0.992	0.0215
6	- 5.758	-	-	-	0.847¢ (0.175)	0.131@ (0.072)	0.405¢ (0.076)	0.991	0.0214

NB: *Significant at 20 percent level

@Significant at 10 percent level

&Significant at 5 percent level

¢Significant at 1 percent level

All unmarked coefficients are statistically insignificant at 20 percent or less level.

Figures in parenthesis are the standard error of the associated coefficient.

The equation shown in the table are all in log-linear form, the advantage of such log-liner equations is to detect elasticity estimates directly but possibly unrealistic as it assumes constant elasticity throughout the time period. The time variable (T) is replaced by consumption of lagged nitrogenous fertilizer (dependent lagged variable) to estimate short-run and long-run elasticities in the adjustment equation.

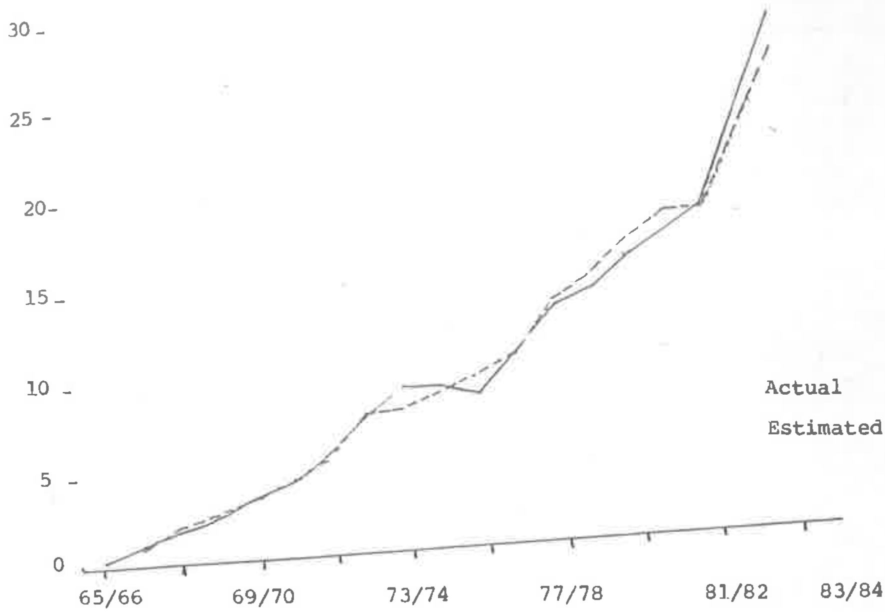
As seen in the above table, equation 1 (first row) some coefficients are found statistically not significant even at 20 percent level. This is primarily due to the serial dependence of error term (auto correlation) and linear dependence of explanatory variables (multicollinearity). Consequently the explanatory variable A, was dropped in row - 2 and both A and I were dropped in row - 3. The equation 3 is found to be more significant in terms of significance level which at 10 percent or lower level, R^2 and standard error of estimate. In this equation the DW statistic of serial correlation is found in indeterminant level.

All regression coefficients are consistent as hypothesised except that of crop yield lagged one year which is contrary to the theoretical justification and is more difficult to rationalize as the coefficient should have positive sign on an 'a prior' consideration. The elasticity of demand with respect to crop-price ratio (real price of fertilizer) is (-) 0.394. This indicates that one percent increase in the real price of fertilizer consumption is predicted to decrease by about 4 percent, all other factors remaining the same. This price inelastic nature of demand function may be attributed to the low rate of fertilizer application. The mean elasticity of nitrogen demand with respect to HYV seeds is 0.144. This reveals that with a one percent increase in HYV seed the nitrogenous fertilizer is predicted to increase by about one percent. David (1974) in her studies for nine Asian countries revealed a slightly higher elasticity for this variable. The dominant variable is time, which represents the greater technological knowledge of farmers over time acquired through experience, sales program, extension services etc. The time trend variable was included as a "catch all" variable to represent variety of relevant factors not included in the model itself. This variable was found to be the most dominant explanation for demand for nitrogenous fertilizer.

Dependent variable lagged one year is included as an explanatory variable instead of time trend variable in the adjustment model. In the adjustment model (equation 4,5, and 6) crop price ration (NCPR) yield lagged one year (Y_{t-1}) and acreage planted (A) was not found statistically significant even at 20 percent level. When these three variables were omitted, as in traditional model, all the remaining variables were found statistically significant at a level of 10 percent or less. Considering R^2, SE and DW statistics, equation 6 is found to be the significant equation for interpretation.

The significant variables are irrigation services, HYV seeds and lagged dependent variable. The cofffficient of lagged dependent variable is found to be 0.405 and thus the coefficient of adjustment being 0.595. This adjustment coefficient relates to the fraction of disequilibrium eliminated within one year towards equilibrium. This indicates that only about 60 percent of the adjustment is completed within one year. The elasticity coefficient attached to irrigation services and HYV seeds reveals that, with one percent change in water supply and HYV seed, the demand for nitrogenous fertilizer is predicted to change by about 0.85 percent and 0.131 percent in the short-run and 1.423 percent and 0.220 percent in the long-run respectively in the same direction.

The actual and predicted quantities of nitrogenous fertilizer equation 4, the traditional model is shown below.



Actual and Estimated Quantity of Nitrogen.

CONCLUSIONS

The traditional model is found to be more significant affecting fertilizer demand as hypothesized by comparison with the adjustment dynamic model. The real price of fertilizer did not come out as statistically significant in the adjustment model, a result which inhibited a reliable estimation of the short-run and long-run price elasticities.

With regard to the relative price of fertilizer, HYV seeds and time variable are found highly significant in their affect upon fertilizer demand, a closer look into such factors should be given to realise greater application of fertilizer. The policy options seem to be that affecting price e.g. changing the relative price of fertilizer through subsidy and institutional support e.g. developing suitable modern varieties of seeds and other support services such as education, sales programmes, extension services etc. Price policy is likely to have a short-run impact on demand but estimated price elasticities should be appropriately considered before making any choice. The question is not only the short-run increased demand through subsidies but the upward movement of fertilizer response function at all times.

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