Determinants of Adoption and Levels of Demand for Fertiliser for Cereal Growing Farmers in Ethiopia

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ABSTRACT: The current government of Ethiopia has put agriculture at the heart of its policies. There is particular emphasis on promoting adoption of fertiliser, improved seeds and the efficiency of input marketing and distribution. In this paper we use a nationally representative data set for 1994 to analyse what factors influence adoption of as well as intensity of fertiliser use of small-scale farmers. Results show that farmer literacy, access to all-weather roads, access to banking, extension services, and the labour availability play a role in fertiliser adoption. Addressing the first four points would substantially increase the rate of adoption. With regard to the amount of fertiliser used we find that smaller sized farms use this input more intensively. Further we find that previous experience with fertiliser, supply, liquidity, oxen owned by the household, and the ratio of the price of the main crop to the cost of fertiliser are important. Availability of credit and supply constraints are important factors in constraining fertiliser use. Our results suggest that the effect of the subsidy on fertiliser consumption is small and that providing credit would be much more effective in terms of raising adoption of and level of use of fertiliser and thus contributing to increasing agricultural output.

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1. Introduction

Improving the agricultural sector's performance in Ethiopia is of crucial importance for a variety of reasons. For one, there is the relative importance of this sector. Agriculture accounts for 60% of GNP[1] and about 87% of the population live in rural areas and depend, directly or indirectly, on this sector for their livelihoods. Agricultural goods — mainly coffee, hides and skins, and oilseeds — account for 90% of exports and are therefore the main source of foreign exchange and an important source of government revenue.

Past performance of the economy has been dismal. GNP per capita shrunk by about -1.9% over the period 1980-92. Agriculture only grew at the rate of 0.7 and 0.4% over the period 1970-80 and 1980-92 respectively[2]. Moreover, Ethiopia, a country of 51.9 million is categorised as the third poorest; 60% of the population is below the poverty line and 60% of children suffer from chronic malnutrition. Ethiopia has also suffered two large-scale famines (1973-74 and 1983-85) claiming hundreds of thousands of lives. Cereal imports and food aid came to 1045 and 963 thousand metric tons respectively, in 1992.

These figures paint a dire picture and one which indicates that the agricultural sector will play a vital role in achieving food security, combating poverty and promoting overall economic development. It is therefore not hard to see why the present government has put agriculture at the heart of its policies. These policies were developed by the Transitional Government of Ethiopia[3] and focus on promoting the adoption of new technology, hybrid seeds and fertilisers as well as improving the marketing and distribution of agricultural inputs[4]. Cereal growing peasant farmers will inevitably play a leading role if any agricultural policy is to have the desired impact. Individual peasant farming is the dominant sub-sector, accounting for 97% of output. Moreover, cereals account for about 83% of the area used to cultivate major crops. This is distributed as follows: Teff = 26.5% of coverage; Maize = 15.9%; Barley = 12.6%; Sorghum = 12.7%; Wheat= 11%; and Millet = 3.3%; other crops include Neug, Linseed, Fenugreek and Rapeseed (CSA (1995)). Production of cereals came to 6.15 million tons in 94/95. This was down from 6.5 million tons in 80/81. This 5% decline compares with a 40% increase of the population.

In this paper we use a representative data set to assess factors which influence the adoption of fertiliser as well as the level of fertiliser consumption of cereal producing peasant farmers in

[1]Figures taken from the World Development Report (1995, 1994 and 1993) the Fertiliser Marketing Survey prepared by Kuawab (1995) and the Agricultural Sample Survey prepared by the Central Statistical Authority (CSA) (1995).

[2]This compares to a population growth rate of 2.7% and 2.5% over the periods 1970-80 and 1980-91.

[3]The TGE took power in 1991 by overthrowing the Soviet style "Derg" regime. Elections were held in 1995, but policies regarding agriculture have not changed.

[4] The benefits of using improved seed varieties and the increased use of fertiliser (as promoted for example by Global 2000) and the need to reverse the serious food-deficit situation in Ethiopia was highlighted in a recent article in "The Economist" (November 25th, 1995, p. 49).

Ethiopia. The emphasis on fertiliser is appropriate because: a) much of the land in the high potential cereal zone is already under cultivation so increasing output calls for intensification of production; b) financial limitations make it unlikely that an entire package of improved seeds, improved soil and water conservation and more irrigation can be adopted. It would therefore appear more promising to focus on increasing fertiliser use.

The benefits of increased fertiliser use in Ethiopia have been documented by the ADD/NFIU (1992). Four year trials (1988-91) showed that the yield response to fertiliser was substantial, but varied regionally. For example, increments of 3kg of teff (using local seed types) perkg of fertiliser (at optimal rates of 100kg per hectare (Kuawab, 1995)) were obtained for Shewa, Gojam and Arssi. However, yield increases of 1.8kg were obtained in other regions. For wheat, the national average was 4.3kg of additional wheat per kg of fertiliser (using improved seeds), while for maize this figure was 6.5kg per kg of fertiliser[5]. It would appear that substantially increasing fertiliser consumption in Ethiopia would go a long way to addressing some of the pressing issues, such as the food deficit, faced by the country.

2. The Model

Econometric studies of fertiliser adoption in Africa are rare. Falusi (1974) used a probit model to analyse fertiliser adoption of farmers in Western Nigeria. Green and Ng'ong'ola (1993) applied a logit model to data from Malawi. While the former identified extension services and access to credit to be important, the latter found that the crop grown; the farming system; access to credit; off-farm employment opportunities; and regular labour were the main determinants of fertiliser adoption. In this paper we model fertiliser adoption and fertiliser demand for a representative sample of cereal farmers in Ethiopia. We use a self-selection model which corrects for the selectivity bias (which would occur if one dropped the observations for those farmers not using any fertiliser). More sophisticated techniques have been employed by Coady (1995) who used a double-hurdle approach to model fertiliser adoption[6]. Our possibilities are limited by the fact that some of the data has only been collected for the sub-sample of farmers that use fertiliser (see the discussion in the data section below).

The choice of fertiliser adoption is modelled by the following selection function:

$$(1) \qquad I_i^* = \alpha' x_i + \epsilon_i \ , \quad I_i = 1 \text{ if } I_i^* > 0 \quad \text{and} \quad I_i = 0 \text{ if } I_i^* \leq 0 \ .$$

[5]A majority of the trials were conducted in the high potential areas. The numbers reported are therefore on the optimistic side. Sasakawa Global 2000 reported yield increases of 52.7 and 1.8 tons/ha for maize, wheat and teff for locally available seeds and prevailing agronomic practices.

[6]In an interesting parallel, the supply and use of fertiliser was seen as an important means of adressing the food supply problem (in conjunction with the introduction of high yielding varieties of wheat and rice) in Pakistan. 48% of the total increase in agricultural output in the Sixth Five Year Plan (mid-80s) was expected to come from increased use of fertiliser (Coady (1995)).

Here I_i is the selection variable of which we only observe the sign; x is a vector of factors that affect adoption; ϵ is a random disturbance term distributed with mean 0 and variance 1; the subscripts denote the ith farmer. The regression equation for the demand for fertiliser is given by:

$$y_i = \beta' z_i + \xi_i \quad , \tag{2}$$

where y is the amount of fertiliser purchased per hectare (in natural logarithms); z is a vector of factors affecting the level of purchases made (not necessarily the same factors that affect adoption); ξ is a random disturbance with mean 0 and variance σ^2; the subscripts are as above. We observe y_i and z_i only if $I_i = 1$ and hence we have a problem of truncation[7]. If we apply least squares to equation (2) for the full sample we generate inconsistent estimates. The same is true if we use only the sub-sample of farmers that use fertiliser. The most popular estimation technique, that generates consistent estimates, is to use Heckman's (1976) two-step procedure: 1) to estimate the probit stage (equation (1)) and then, using the estimated α, to compute:

$$\lambda_i = \frac{\phi\,(\hat{\alpha}' z_i)}{\Phi\,(\hat{\alpha}' z_i)} \tag{3}$$

where ϕ and Φ are the density and the cumulative distribution functions of a standard normal variable, respectively. Equation (3) is the Mills-ratio, without which equation (2) will suffer from omitted variable bias.

3. The Data

The data are obtained from a fertiliser marketing survey undertaken as part of the Development of Competitive Markets Programme, funded by the United States Agency for International Development (USAID)[8]. The survey, conducted in 1994, covered four regions and seventeen zones. These are:

Region	Zone
Amhara	East Gojam, West Gojam, North Shewa, South Gonder.
Oromia	Arssi, East Shewa, East Wolega, Jimma, West Shewa, North West Shewa.
Southern	Guraghe, Hadiya, Kembata, North Omo, Sidama.
Tigray	South Tigray, West Tigray.

[7]Some of the variables contained in z are observed over the whole sample, but most are not.

[8]The survey was conducted by Kuawab for USAID. We are grateful to Kuawab and USAID for making this data set available to us.

The number of households interviewed were 6240. After some cleaning of the data we were left with 4942 households[9]. These were distributed among the regions as follows: Amhara = 1337; Oromia = 2167; Southern = 1139; Tigray = 299. We aggregated the zonal groups into 7 geographical groups (the name by which we will refer to them) that we used for dummies in the analysis. The explanatory variables used in this study are described below.

Variables available over the entire sample (numbers in parentheses are cases in this category — out of a total of 4942 observations):

AGE:	The age of the head of the household. We expected age to be a proxy for experience and thus be positively correlated with adoption and level of demand for fertiliser.
SEX:	1 if household is male, 0 otherwise. Because female headed households often tend to be poorer and more subsistence oriented we expect a male headed households to be more likely to use and apply more fertiliser. An additional argument is that female headed households are likely to have a lower endowment of labour (4570 farmers are male).
EDUCA:	1 if head of household is literate, 0 otherwise. The ability to read and write would imply greater access to information and thus we anticipated a positive coefficient in the two equations (1695 farmers are literate).
TOTVAL:	We use the natural logarithm of the total value (in Ethiopian Birr) of sale of crops in 1993[10] (adding 1 for the zero values) as a measure of the households liquidity. Liquidity is expected to be an important constraint for farmers wishing to use fertiliser, as well as to the amount they wish to use.
ADULT:	The number of adults, in natural logarithms, is a proxy for labour availability, and should positively influence adoption and the level of fertiliser.
DEPD:	The number of dependents in the household.
DUOX:	1 if household has 2 or more oxen, 0 otherwise. 2 oxen are required to plough a field. Households with less than 2 oxen face the uncertainty of being able to hire in at the right time (or at all). We expect a significant difference between these two groups for the choice of adopting fertiliser (2517 farmers have 2 or more oxen).
OXEN:	The number of oxen (in natural logarithms) are expected to play a role in determining the amount of fertiliser used. In particular having two or more oxen is expected to be positively correlated with fertiliser adoption. Farmers with none or only one oxen face the additional risk of obtaining oxen at the right time and may therefore be discouraged from buying fertiliser.
CULTLAND:	Land area cultivated by the household, in hectares.
EXTEN:	1 if extension services are strong, 0 otherwise. Good extension services are expected to be positively correlated with fertiliser adoption (1579 farmers had good extension services).
ACCESS:	1 if farmer has access to all-weather road, 0 otherwise. Farmers with access to all-weather roads are expected to be more likely to adopt fertiliser as well as using more of it (4051 farmers had access to all-weather roads). We note that of the surveyed farmers, 88% used pack animals to transport fertiliser.
BANK:	1 if farmer has access to bank (within 30km), 0 otherwise. This variable captures the farmers access to credit in 1994 (although of course not all farmers with access to banking received credit) as well as in the past. The argument is that credit to purchase fertiliser in the past will still have a positive impact on fertiliser adoption in the present. This is borne out by our finding that experience with fertiliser is an important variable in the decision of how much fertiliser to use (2788 farmers had access to a bank).
PCRA:	The price of output to cost of fertiliser ratio. We note here that fertiliser prices in Ethiopia have always been under state control and have remained pan-territorial to date. The Price of output

[9]Details available from the authors. Essentially the cleaning entailed dropping missing values and eliminating some extreme observations.

[10]It is therefore a predetermined variable and hence we treat it as exogenous.

is the price obtained for 100kg of the main crop (in that area) in several market towns for each particular zone. We had output price information for 65 market towns (between 2 and 5 for each zone) for the main crop[11]. The output price is divided by 178, the subsidised price of fertiliser (per 100kg.).

DU0: Dummy for western and southern Tigray (299 farmers). This group serves as the reference group in the econometric analysis.

DU1: Dummy for Arssi and Guraghe, Hadiya and Kembata (1035 farmers).
Dummies for the geographical areas are introduced to capture some of the geographic variations, such as altitude, rainfall and erosion (particularly bad in Tigray and South Gonder). We note that grain production is largely rain-fed so these dummies are expected to be very important.

DU2: Dummy for East and West Shoa, East Welega and Jimma (1424 farmers).

DU3: Dummy for Gojam (811 farmers).

DU4: Dummy for North Shewa (124 farmers).

DU5: Dummy for Sidama and North Omo (511 farmers).

DU6: Dummy for South Gonder (402 farmers).

DU7: Dummy for North West Shewa (336 farmers).

Variables available only for households who purchased some fertiliser (3060 cases in this category):

SPKNOW: 1 if the farmer reported to know the specific use of fertiliser, 0 otherwise (2693 farmers know about the specific use of fertiliser - out of 3060).

SUPPLY: 1 if the farmer perceived supply of fertiliser to be a problem (i.e. a shortage), 0 otherwise (1255 farmers have a supply problem).

CREDIT: 1 if fertiliser is bought on credit, 0 if fertiliser is bought on a cash basis (1928 farmers bought fertiliser on credit).

EXYIELD: 1 if the farmer reported to have obtained the expected yield in the previous season, 0 otherwise. We expect this variable to act as a proxy for an uncertain environment and hence we anticipate a positive coefficient (1867 farmers got the yield they expected).

EXPER: The number of years (in natural logarithms) that the farmer has been using fertiliser.

DISTANCE: Distance (in natural logarithms) that the farmer travels to buy fertiliser, in minutes.

We added a one to the variables which had some zero observations and which we wanted to use in natural logarithms. Some preliminary work (not reported here) suggested that this yielded better results than using the variables without the transformations. It also makes for an easier interpretation of the coefficients. Some descriptive statistics of the variables are given in tables 1 and 2.

Before turning to the econometric results we present some of the national findings of the survey which are interesting in themselves. The four regions dominate fertiliser consumption. 99% of the 165,000 metric tons of fertiliser distributed to small-scale farmers by The Agricultural Inputs Supply Corporation (AISCO, the principal fertiliser distribution agency) in 1994 went to these four regions.

[11] As some prices were missing we only had 53 observations available. We used average prices (per zone) for missing observations.

In table 3 we give the rate of application of DAP[12] (Di-ammonium phosphate) for the four regions. While the recommended rate of application is 100kg/hectare it is only in Tigray and in the Southern Peoples Regions that a substantial number of farmers operate at this level. Over the whole sample, about 28% use 100kg/ha or more and 47% of farmers apply 50kg/ha or less. What is noteworthy is that there is a high degree of variation between regions and that there is quite a range of fertiliser application rates within regions. The average DAP application rates for all regions were: 51kg/ha in 1994, 38kg/ha in 1993 and 35kg/ha in 92.

Table 4 shows the distribution of DAP application by crop. While Teff has the lowest yield, it also commands the highest prices, which is generally held to explain why relatively more fertiliser is apportioned to this crop. Table 5 relates market participation to fertiliser application. It is interesting to note that a large proportion of farmers using fertiliser produces only for themselves. 51.1% produce in part for the market as well as for additional income. Table 6 gives a ranking of why farmers prefer one supplier over another and brings out the importance of credit and fertiliser cost.

4. The Results

4.1 Factors Affecting the Adoption of Fertiliser

The results of the probit estimates are given in table 7. As heteroscedasticity is a serious problem which generates inconsistent estimates in probit models (Yatchew and Grilliches, 1985) we chose to test for a violation of this assumption. We found that the hypothesis of homoscedasticity could be rejected using an LM test[13] and therefore used a model correcting for multiplicative heteroscedasticity[14]. After correcting for heteroscedasticity we find that all the parameters increase quite markedly in magnitude (DUOX increases from 0.3021 to 0.3788 as a typical example). What these results show is that it is important to check for heteroscedasticity and correct for it if necessary. The conclusions we draw below will obviously be different (stronger) from the model with heteroscedasticity.

The variables SEX and AGE are not found to be significant. With regard to AGE, we note that the absence of a well developed labour market (as in Ethiopia) implies that the attributes of the household's own labour are of increased significance. If this variable captures the age

[12]DAP has 88.6 of the market share.

[13]This test was based on assuming that CULTLAND, AGE, TOTVAL, ADULT, and OXEN might be related to the variance. The Chi-square statistic was 38.27 and since the critical value is given by 11.07 at the 0.95 level we can reject the null hypothesis of homoscedasticity at the 5% level.

[14]We included CULTLAND, AGE, ADULT, and OXEN as possible sources of heteroscedasticity. We found that ADULT and CULTLAND (both 5%) and AGE (10%) were statistically significant. OXEN did not come out significant and neither did DUOX (although we kept the latter in the specification as the t-ratio was greater than 1). TOTVAL was not used as it was found to be insignificant in a trial run.

structure of the household then age may capture not only experience but also strength of the household labour, and these two effects will work in opposite directions[15].

In table 11 we present the marginal effects for the different variables for each geographical dummy in the probit function (excluding AGE and SEX). For the dummy variables these marginal effects give us the percentage increase in the probability of adopting fertiliser due to a change in status (of say EDUCA) of the farmer (i.e. from a 0 to a 1). For example, for Tigray (DU0) a literate farmer is 18% more likely to be using fertiliser than an illiterate one. There is clearly a lot of variation in the marginal effects over the different regions.

The strongest effects are for ACCESS and EDUCA. Except for DU1 we find that in all cases a literate farmer having access to all-weather roads is much more likely to be adopting fertiliser. The fact that all effects are much weaker for DU1 is a reflection of the relatively much higher levels of adoption which already exist in that area. Also BANK and DUOX have an important impact. Clearly farmers with only one or zero oxen find this a constraint and are less likely to be using fertiliser. Less important but still large is the role of EXTEN and the family size which we take as a proxy for the labour availability. TOTVAL, ADULT and DEPD are evaluated at their mean values. Results in table 12 show that a targeted policy of addressing literacy, oxen ownership, extension services, access to all-weather roads and access to banking (credit) could have a very substantial impact on fertiliser adoption rates. We note that the earlier studies on fertiliser adoption in African countries mentioned in section 2 also found extension services and credit availability (among others) to be important factors.

Table 8 gives the frequencies of actual and predicted outcomes. We find that for farmers that do not use fertiliser our model would predict a lot of these to be using fertiliser. Obviously there are factors at work which we have not been able to model satisfactorily: credit constraints and shortage of supply/late delivery being the two most serious factors[16]. In table 10 we give the predicted and actual frequencies of adopting fertiliser for the eight geographical areas. The model performs reasonably well in most of the cases. Discrepancies are in some part due to the fact that we evaluated the predictions at the overall mean levels. However, in the main, the results serve to underline the heterogeneous nature of agriculture in Ethiopia.

4.2 Factors Affecting the Level of Fertiliser Consumption

Table 9 gives the parameter estimates of the demand for fertiliser equation[17]. We find that CULTLAND, EXPER, SUPPLY, TOTVAL, OXEN, and PCRA are the most important

[15] Croppenstedt and Mamo (1996) found a negative and statistically significant relationship between the average age of the household members engaged in agriculture and farm productivity of 271 cereal farmers from three regions in Ethiopia. The data are from the Ethiopian Rural Household Survey: First Round - 1994.

[16] Statement made on basis of rankings of fertiliser consumption problems in the four regions as produced in Kuawab (1995).

[17] Correcting for heteroscedasticity in the first stage does not alter the estimates, but does affect their standard errors. The effect is generally quite small.

factors determining the levels of per hectare fertiliser consumption. Of these, the first two contribute 27% and 8% to R^2 respectively. The amount of fertiliser per hectare falls with increasing farm size showing that smaller farmers use this input more intensively. This is a surprising result as access to complementary inputs would be expected to be easier for farmers with larger holdings. The significance of SUPPLY underlines the fact that supply shortages play an important role in limiting the use (and probably adoption) of fertiliser.

Other findings which are perhaps also surprising are the negative coefficients on AGE and SEX. Again we point to the age - strength of household labour relationship as a possible explanation. The negative coefficient on SEX shows that women led households use more fertiliser per hectare *ceteris paribus*. EDUCA is dropped from the final specification as it was very insignificant and results improved when omitting this variable. We conclude that literacy, while important for adoption, does not play a role in determining the level of fertiliser use.

Of interest is the finding that experience is very important in determining the quantity of fertiliser per hectare used. A farmer who adopts fertiliser is likely to increase use substantially (by about 23%) in the second year[18]. The effect wears down as the farmer continues to use fertiliser, but the very strong and positive relationship is very promising indeed. While it does not follow directly, the strong and positive effect of EXPER might suggest that farmers that have tried fertiliser are very likely to continue using it.

The positive coefficient on PCRA shows that farmers are conscious of prices when making input decisions. We can deduce the impact of the subsidy on fertiliser use from our results, using the mean PCRA figure. If the subsidy were removed the cost per 100kg of fertiliser would rise from 178 to 252.25 Birr (1994 prices). This would constitute a drop in the PCRA (at the mean) of 30% and would result in a decreased fertiliser per hectare use of about 9%[19]. Output elasticities with respect to fertiliser are reported to lie within 0.051 and 0.095 for Teff, Wheat, Maize, Barley and Sorghum by Yao (1996)[20]. This implies that the effect on output of a removal of the subsidy would be very small.

As a simple example we calculate that for 100 farmers the subsidy is 8734 Birr (using the mean values in our study for area cultivated and fertiliser consumption). If this subsidy were to be taken away, and assuming that yield of cereals is 1.1 tons (CSA 1995) per hectare, then the loss in output is about 1.9 tons of cereals (for this sample of "average" farmers)[21]. The subsidy

[18]Based on the coefficient on EXPER and a farmer who has one year of experience, initially.

[19]Admittedly one should also consider the impact the subsidy removal would have on fertiliser adoption.

[20]Results by Croppenstedt and Mamo (1996) based on micro-level data suggest an output response coefficient of 0.1980, i.e. much higher those reported by Yao (1996).

[21]1.1*1.73 (average area) =1.90 tons of cereals per farmer. 1.90*100=190 tons of cereals is output for our 100 "average" farmers. If the removal of the subsidy causes a 9% decline in fertiliser consumption and the output elasticity of cereals with regard to fertiliser is 10% then the resulting drop in output would be roughly 1% of 190 tons. Using a response coefficient of 0.198 for the calculations we obtain a drop in output of 3.42 tons.

would pay for credit for about 20 farmers to buy the average amount of fertiliser, i.e. to introduce 20 farmers to fertiliser (less than that due to other costs). If the credit covered the recommended rate of fertiliser application then the resulting gain in output would be around 10 tons[22]. The resulting gain in output would therefore be substantially greater than the loss (also when we use the larger fertiliser response coefficient of 0.1980). Assuming that loans are recoverable[23] (a big assumption given the history of unrecovered loans in Ethiopia) these gains would be cumulative.

Given this perspective one should consider carefully whether money spent on subsidies would not be better allocated to factors that increase adoption rates (one has to keep in mind that credit may not be the only obstacle). We make this statement with the result for EXPER in mind, as it suggests to us that the response of farmers to fertiliser, once they have tried it, is very positive. We do not attempt to calculate the possible costs of increasing literacy rates, of making more oxen available, of providing better extension services, or even of giving farmers access to a bank within a reasonable distance. Nevertheless, the results of this study show that the marginal effects of each of these variables individually is going to have a significant impact on the number of farmers using fertiliser. A longer term strategy would focus on specific issues determined as important in this study (such as farmer literacy) and would thus promote fertiliser adoption and output growth on a more substantial level.

5. Conclusion

In this study we analysed the factors that determine the adoption and the level of fertiliser consumption in Ethiopia in 1994. Fertiliser consumption increased substantially in 1994, relative to 1991 but the average rate of application and the number of farmers using fertiliser is still low. It is also clear that the experience varies markedly from zone to zone. While application rates are low in Tigray and North West Shewa, they are quite high in Arssi, Guraghe, Kembata and Hadiya. Hence one conclusion is that policies need to be designed with regional/zonal variations in mind. An across the board strategy is likely to be less effective than a carefully targeted one.

Important factors influencing fertiliser adoption are: literacy of the farmer; access to all-weather roads; the number of oxen owned by the household; access to banking; and labour availability. If the first four points and extension services were addressed jointly the impact on fertiliser adoption is likely to be substantial. This is particularly so for areas where adoption rates are presently low. The effect of oxen and banking show that credit is going to play an important role in increasing adoption rates in the future.

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[22]100 (recommended rate of fertiliser application) * 1.73 = 173. Then 173*2.52 (price of DAP per kg) = 436 Birr which is the cost of fertiliser per "average" farmer. 8734/436 = 20. Assuming that the gain in output due to 1kg of fertiliser is approximately 3kg, so the increase in output would be about 173*3 = 519kg per farmer and 10380kg for 20 farmers.

[23]Even if the loans were not recoverable, it is possible that the strategy of giving the money away — in an effort to introduce farmers to fertiliser — would be superior to a fertiliser price subsidy.

With regard to the level of fertiliser use, our findings show that experience with fertiliser is a very important factor in terms of increased levels of fertiliser consumption. This ought to be a very encouraging result for policy makers aiming to implement programmes designed to increase adoption rates. Supply problems point to marketing and distribution bottlenecks, which are already a priority for the government. Also important in explaining levels of fertiliser demand are oxen ownership, liquidity, access to banking and credit. Clearly all this helps to underline the pivotal role of credit the absence of which either directly or indirectly constrains farmers. Indirectly because credit may also serve to purchase assets such as oxen which is of importance for adoption and levels of consumption.

We find that the ratio of the price of the main crop to cost of fertiliser is a significant variable and suggests that farmers are indeed price sensitive. Using our results we show that the effect of the subsidy on the level of fertiliser use and crop production is very limited. A policy that would switch funds from a subsidy to one of providing credit for fertiliser would generate substantially greater benefits in the short run, and particularly in the long run, and switch the focus to enhancing adoption rates.

References

ADD/NFIU (1992) 'Results of NPK Fertiliser Trials Conducted on Major Cereal Crops (1988 — 1991)', ADD/NFIU Joint Working Paper No 43, Addis Ababa.

CSA (1995) 'Agricultural Sample Survey: 'Report on: Area and Production for Major Crops' *Statistical Bulletin*, 132.

Coady, D.P. (1995) 'An Empirical Analysis of Fertiliser Use in Pakistan', *Economica*, 62: 213-234.

Croppenstedt, A. and A. Mamo (1996), 'An Analysis of the Productivity and Technical Efficiency of Cereal Growing Farmers in Ethiopia: Evidence from Three Regions,' Mimeo, Centre for the Study of African Economies, Oxford University.

The Economist (1995) 'Ethiopia: A Green Revolution?', November 25th.

Falusi, B. (1974) 'Multivariate Probit: Analysis of Selected Factors Influencing Fertiliser Adoption Among Farmers in Wester Nigeria,' *Nigerian Journal of Economic and Social Studies*, 16: 3-16.

Green, D.A.G. and D.H. Ng'ong'ola (1993) 'Factors Affecting Fertiliser Adoption in Less Developed Countries: An Application of Multivariate Logistic Analysis in Malawi', *Journal of Agricultural Economics*, 44: 99-109.

Heckman, J. (1976) 'The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models,' *Annals of Economic and Social Measurement*, 5: 475-492.

Kuawab (1995) *Fertiliser Marketing Survey: Descriptive Analysis of the Findings*, Ethiopia: Kuawab Business Consultants.

World Bank (1993, 1994, 1995) *World Development Report*, New York: OUP.

Yao, S. (1996) 'Determinants of Cereal Crop Productivity of the Peasant Farm Sector in Ethiopia, 1981 — 87', *Journal of International Development*, 8: 69-82.

Yatchew, A. and Z. Grilliches (1985) 'Specification Error in Probit Models', *Review of Economics and Statistics*, 67:134-139.

Table 1

Descriptive Statistics of the Variables Used in the Probit Stage

Variables	Range	Mean	Standard Deviation
DUPU*	0-1	0.62	-
AGE (years)	17-97	43.89	13.25
SEX	0-1	0.93	-
EDUCA	0-1	0.34	-
TOTVAL (Birr)	0-4000	176.59	376.46
ADULT	4.04	1-21	1.99
DEPD	0-8	2.11	1.44
DUOX	0-1	0.51	-
OXEN	0-25	1.69	1.64
EXTEN	0-1	0.32	-
ACCESS	0-1	0.92	-
BANK	0-1	0.56	-
CULTLAND (hectare)	0.02-12.50	1.73	1.27

*DUPU = 1 if farmer purchased some Fertiliser, 0 otherwise.

Table 2

Descriptive Statistics of the Variables Used in the Fertiliser Demand Equation

Variables	Range	Mean	Standard Deviation
FERTILISER (kg/hectare)	2.00-300.00	68.22	43.83
AGE (years)	17-97	43.62	12.99
SEX	0-1	0.93	-
TOTVAL (Birr)	0-4000	224.65	419.59
CULTLAND (hectare)	0.10-10.00	1.73	1.20
OXEN	0-25	1.66	1.57
ADULT	1-21	4.23	2.03
DEPD	0-8	2.23	1.48
SPKNOW	0-1	0.88	-
EXTEN	0-1	0.34	-
ACCESS	0-1	0.90	-
SUPPLY	0-1	0.41	-
PCRA	0.449-1.404	0.803	0.267
BANK	0-1	0.65	-
CREDIT	0-1	0.63	-
EXYIELD	0-1	0.61	-
EXPER (years)	1-45	9.62	7.00
DISTANCE (minutes)	0-720	142.97	123.35

Table 3

Rate of Application of Fertiliser (DAP) for the Four Regions (% of farmers)

Dap Rate: kg/ha	Tigray	Amhara	Ormo	Souther Peoples	National
Up to 10	2.6	2.1	2.7	0.4	1.8
11-25	11.8	22.4	15.8	3.8	13.4
26-50	35.8	39.1	35.1	20.5	31.4
51-99	6.6	23.2	24.8	30.1	25.6
100	42.1	7.9	13.1	27.0	17.1
101-150	1.4	3.8	5.5	10.5	6.5
151-200	-	1.3	2.7	6.3	3.5
201-300	-	0.2	0.3	1.4	0.7

*Source: Kuawab (1995)

Table 4

Distribution of Fertiliser Application by Crop

Crop	Land covered by	Dap application to
Teff	33.28	39.91
Maize	17.52	16.23
Sorghum	3.93	2.12
Wheat	14.35	17.58
Barley	14.95	15.25
Millet	3.73	2.52
Others	12.23	6.39

Source: Central Statistics Authority (CSA, 1995).

Table 5

Market Participation and Fertiliser Adoption

Reasons	National percentage
Produce for the market	2.0
Produce for self	44.0
Produce for self and market	41.3
Produce for additional income	9.8
Other	2.9

*Source: Kuawab (1995)

Table 6

Rankings of Reasons for Preferring One Supplier Over Another

Reasons	**Ranking**
Sells on credit	1
Charges lower prices	2
Does not cheat	3
Is efficient and delivers on time	4
Deliver near to farm	5
Other	6

*Source: Kuawab (1995)

Table 7

Probit Coefficient Estimates of the Fertiliser Adoption Equation

Variable	Coefficient	T-ratio's (Absolute values)
CONSTANT	-2.7059	4.925***
LN(AGE)	0.090	0.920
SEX	0.0917	0.920
EDUCA	0.4925	6.610***
LN(TOTVAL)	0.0700	5.484***
LN(ADULT)	0.3068	4.254***
LN(DEPD)	0.1747	3.246***
DUOX	0.3788	5.089***
EXTEN	0.2197	3.410***
ACCESS	0.5488	5.435***
BANK	0.3734	5.453***
DU1	1.9918	7.867***
DU2	1.1678	6.452***
DU3	0.5697	3.711***
DU4	1.0029	4.592***
DU5	1.3298	6.512 ***
DU6	-0.2142	1.405
DU7	-0.1874	1.099

***, * and ** indicates statistical significance at the 1, 5 and 10% levels respectively.

Log-likelihood: -2534
Restricted Log-likelihood: -3284
$X^2(21)$: 1499
PSEUDO-R^2=70
COUNT R^2=74

Table 8

Frequencies of Actual and Predicted Outcomes

		Predicted	
		0	1
Actual	0	981	901
	1	369	2691

Table 9

Coefficient Estimates of the Fertiliser Demand Equation

Variables	Coefficient	T-ratio's (Absolute values)
CONSTANT	3.4813	15.907***
LN(AGE)	-0.1727	4.996***
SEX	-0.0860	2.228**
LN(TOTVAL)	0.0285	7.096***
LN(CULTLAND)	-0.5788	33.367***
LN(OXEN)	0.1486	6.468***
LN(ADULT)	0.0452	1.982**
LN(DEPD)	0.0383	1.938*
SPKNOW	0.1435	4.799***
EXTEN	0.0851	3.634***
ACCESS	0.1291	3.397***
SUPPLY	-0.2027	9.942**
PCRA	0.2942	5.898***
BANK	0.0801	3.320***
CREDIT	0.0627	2.791***
EXYIELD	0.0318	1.575
LN(EXPER)	0.2324	16.428***
LN(DISTANCE)	-0.0129	1.218
DU1	0.3035	2.860***
DU2	0.1677	1.891*
DU3	0.4044	4.841***
DU4	0.3904	3.801***
DU5	0.2393	2.375**
DU6	0.3711	4.343***
DU7	0.3143	3.122***
λ	-0.1579	2.125**

***, ** and * denotes statistical significance at the 1, 5 and 10% levels, respectively.
Adjusted R^2=43

Table 10

Predicted and Actual Frequencies of Fertiliser Adoption

	DU0	DU1	DU2	DU3	DU4	DU5	DU6	DU7
Actual	0.28	0.88	0.70	0.62	0.65	0.65	0.25	0.17
Predicted	0.31	0.94	0.76	0.54	0.70	0.80	0.25	0.25

Table 11

Marginal Effects for Variables in the Probit Model

Variables	DU0	DU1	DU2	DU3	DU4	DU5	DU6	DU7
EDUCA	0.18	0.06	0.15	0.19	0.16	0.13	0.16	0.16
DUOX	0.13	0.05	0.12	0.15	0.13	0.11	0.12	0.12
EXTEN	0.08	0.03	0.07	0.09	0.08	0.06	0.07	0.07
ACCESS	0.18	0.09	0.19	.022	0.20	0.17	0.15	0.15
BANK	0.13	0.05	0.12	0.15	0.13	0.11	0.12	0.12
TOTVAL	0.03	0.01	0.02	0.03	0.02	0.02	0.02	0.02
ADULT	0.11	0.04	0.10	0.12	0.11	0.09	0.10	0.10
DEPD	0.06	0.02	0.06	0.07	0.06	0.05	0.06	0.06

Table 12

Joint Marginal Effect for EDUCA, DUOX, EXTEN, ACCESS, BANK

DU0	DU1	DU2	DU3	DU4	DU5	DU6	DU7
0.61	0.33	0.60	0.69	0.64	0.56	0.55	0.56

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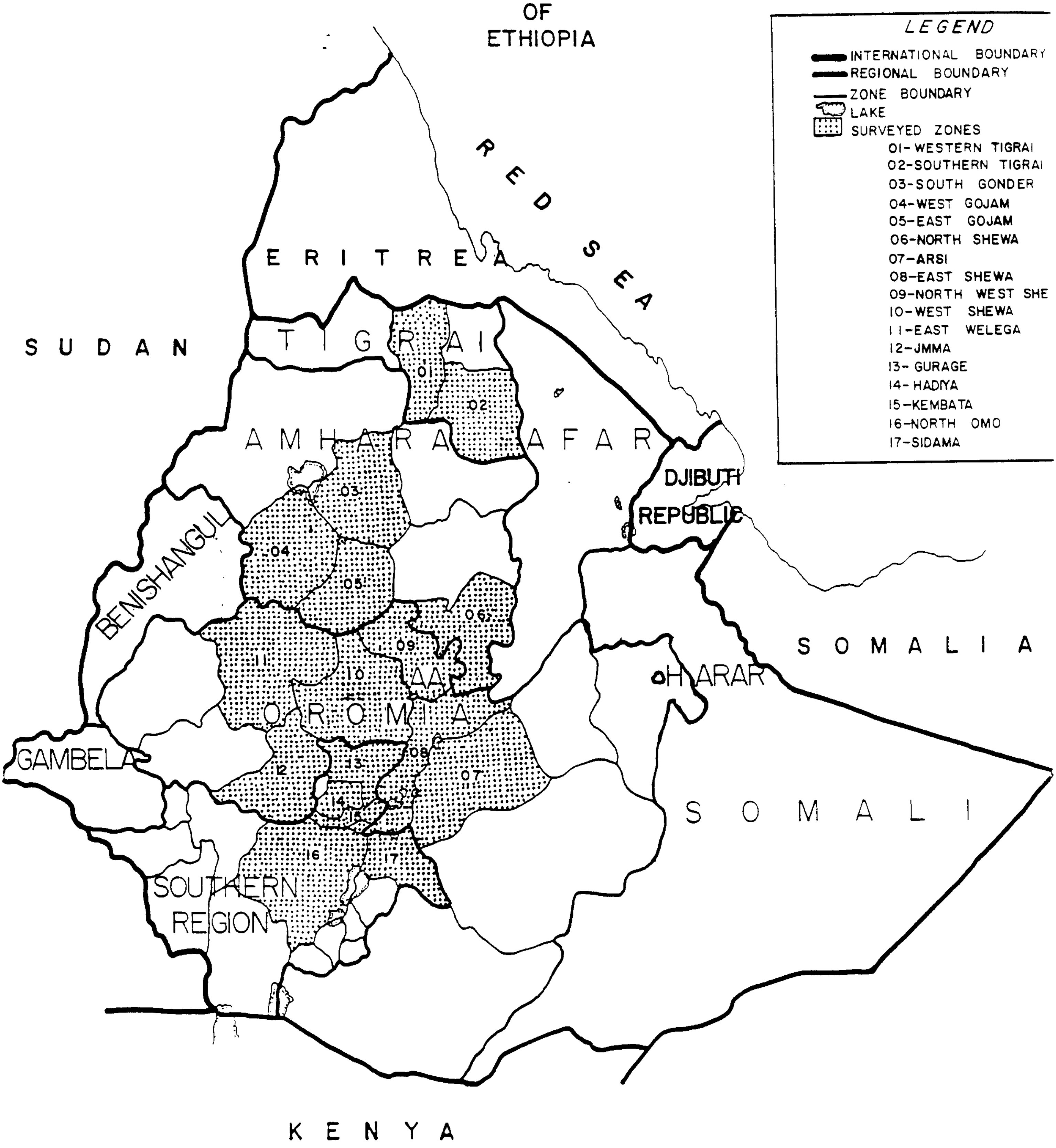

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