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THE IMPACT OF SUPERVISED CREDIT PROGRAMMES ON TECHNOLOGICAL CHANGE IN DEVELOPING AGRICULTURE*

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Restrictions on input use frequently accompany the granting of institutional credit to farmers in developing agriculture. A general economic framework is suggested to analyze the net social benefits of such a policy. The paper discusses the potential for manipulating the policy variables to foster more rapid adoption of new agricutural technology. An empirical analysis of the impact of a supervised credit programme in Guatemala on farm performance and farmer decision-making is presented.

Introduction

The purpose of this paper is to suggest an economic framework in which to analyze the impact of supervised agricultural programmes. Specifically, we focus attention on situations where new technology in the form of a fertilizer-responsive crop variety is available, and it is the concern of some public agency to promote its widespread adoption.

The political economy of rent-seeking entrepreneurs in the commercial farm sector fosters the evolution of public and private institutions which serve their needs [5 and 11]. However, unless appropriate institutions also evolve to serve the small-farm sector, it is likely that its share of the benefits stemming from technical change will continue to be minimal. Pressures for institutional change may be generated by concerns in the non-farm sector to transfer a greater share of the benefits of economic development to the rural poor, and/or by agencies controlling the international transfer of resources. Whichever the source, we see evidence of increasing efforts at least in Colombia, Cuba, Guatemala, Mexico and Peru to evolve institutional structures which aim to serve the small-farm sector and the rural poor. While these institutions take widely differing forms, there appear to be certain

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common issues. Central among these is the concern for expanding agricultural production by the more widespread adoption of biological innovations. In this context, it is commonly believed that . . .

> . . . credit is often a key element in the modernization of agriculture. Not only can it remove a financial constraint but it may provide incentive to adopt new technologies that would otherwise be more slowly accepted[1] [8, p. 1].

During the 1960s almost US $1 billion of foreign funds were provided to Latin America for agricultural credit [1, p. 163]. World Bank lending for agricultural credit currently represents over 50 per cent of its total agricultural operations, and increasingly, these loans are being directed to low income farmers.

It is apparent that . . .

> . . . The large number of small-sized loans coupled with geographical dispersion make small farmer credit considerably more costly to administer *(than lending to large farms)* [8, p. 4].

Traditionally, loans to small farmers have been made at rates below the market interest rates. For example in eight Latin American countries, the average nominal market interest rates were 54 per cent while the institutional loan rates to agriculture were 11 per cent [8, p. 75]. High administrative expenses together with interest subsidies imply subsantial costs to national treasuries. Perhaps partly for this reason agricultural institutions have frequently framed small-farmer credit operations in the context of 'supervised' credit programmes.

An additional reason for the existence of supervised programmes is suggested by the nature of the new crop varieties. Kawano *et al.* [9] note that the evolution of improved cultivars has been accompanied by the need for improved cultural practices. Without adequate weed control, spacing, plant density, seeding dates, etc., the genetic potential embodied in the improved cultivar is often not realizable. The importance of these associated cultural practices led to the notion of a 'technological package', and, we suggest, emphasis on supervision in credit programmes involving the sowing of high-yielding varieties.

While the nature of the 'supervision' varies widely, we focus on plans which have the following characteristics:

(i) Membership is voluntary;
(ii) The farmer must submit a plan of activities indicating the basic physical and financial features of the farm operations for the coming cropping cycle;
(iii) Credit is given *only* if the farmer undertakes to use certain inputs at the rates specified by the extension agent;[2]

[1] In a paper originally prepared for the USAID Spring Review of Small Farmer Credit (June 1973), and subsequently presented as 'Conditions for Success of Public Credit Programs for Small Farmers' at a Ford Foundation Seminar on Rural Development and Employment, Ibadan, Nigeria (April 1973) Millard Long presents an extensive review of the literature related to public agricultural credit schemes, in which he critically examines this premise.

[2] In one case in point, 'the use of fertilizer, fungicides and insecticides is obligatory in accordance with the needs of the crop and the technical recommendations' [2].

(iv) The farmer may select the area he is prepared to sow to the new variety;
(v) The nominal interest rate for the credit is below the market rate;
(vi) Some input prices (notably fertilizer) are subsidized to members of the plan.

A General Model

A general framework for considering the net social benefits of a supervised credit plan can be constructed as follows:

Let $Z^m(t)$ = Area sown to the new variety in time t with a supervised credit plan;

$Z^n(t)$ = The area which would have been sown to the same new variety in the absence of a supervised credit plan;

$D(t) = Z^m(t) - Z^n(t)$.

This latter quantity is the net gain in area sown to the new variety due to the presence of a supervised credit plan. It is represented by the vertical difference between the two possible 'adoption curves' shown in Figure 1. The relative positions of these curves reflect the expectation that the plan would stimulate adoption of the new variety.

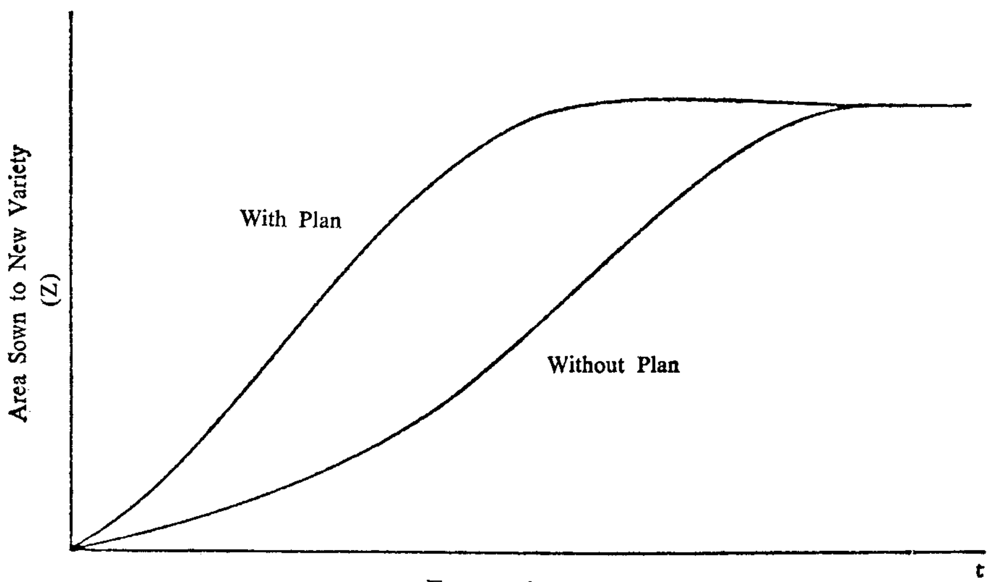

FIGURE 1

Possible impact of credit plan on the area sown to a new variety over time.

Based on this formulation we can write the *Present Value of the Net Social Benefits* (PVNSB) of the plan as:

$$PVNSB = NP.Y(\int_0^\infty D(t)\, e^{-rt}dt) - \int_0^\infty [C(t) + E(t)]e^{-rt}dt. \quad (1)$$

where:

NP = Unit price of product[3] net of variable costs;

[3] A more general model would incorporate a less than perfectly elastic product demand function.

Y = Yield of new variety;
$C(t)$ = Direct programme costs at time t;
$E(t)$ = Costs of resource misallocations induced by the plan at time t, resulting from the requirement to use certain inputs at levels which may not be optimal;
r = Discount rate.

Obviously for the plan to have positive net benefits a necessary condition is that $D(t) > 0$ for at least some t. In the next section we consider the potential influence of some policy instruments for enhancing the area sown (i.e. $D(t) > 0$). We then review some results from a study zone in Guatemala. The costs of resource misallocation will depend on the extent to which farmers take into account the restrictions on input use; we address this question in the final section.

Policy Instruments

The plan can control three policy variables in its attempt to expand the area sown to the new variety; the interest differential, the subsidized price of fertilizer, and the required rate of fertilizer application. We now consider the scope for manipulating these policy variables.

We argue that efforts to expand the area sown by attracting plan membership with subsidized interest rates will tend to be largely self-defeating. The greater the interest subsidy, the greater the excess demand for the limited supply of public funds, and the greater will be the pressure toward equalizing the institutional and commercial rates.

To eliminate the excess demand, non-price rationing mechanisms will, by necessity, evolve. These commonly include nepotism, racial and religious discrimination, and bureaucratic procedures which raise the transactions costs of acquiring a subsidized loan. Such procedures discourage potential applicants, and penalize especially the illiterate. In addition, loan repayment before the stipulated period helps to create the impression of a good credit risk.[4] This can enhance the chance of access to institutional credit in subsequent years, as credit files frequently contain a character reference, which is used as a further basis for the non-price rationing. However, in the absence of a rebate, early repayment simply drives up the real price of the 'apparently subsidized' credit.

Overall, the necessary non-price rationing devices, which can be particularly pernicious and justifiably undermine farmer confidence in future dealings with public institutions, will tend to make the real price of credit equal to the commercial rate. Farmers who do receive a subsidized loan can be viewed as capturing rents to their literacy, family or political connections, etc.[5]

[4] An additional pressure for early repayment can arise from the lack of access to banking services by low income farmers. If it is public knowledge that the farmer has a hoard of cash from crop sales, his life (or at least his cash!) can be at risk.

[5] In the Puebla Project in Mexico organized credit groups were formed, which by exploiting the collective social power of the peasantry facilitated access to low cost institutional credit. However, such rents only accrue as a result of the costly investment 'in learning and becoming organized' [3, p. 145]. In another Mexican plan, farmers were conscious of these high transactions costs, and attributed to them their reluctance to join the plan (R. K. Perrin, pers. comm.).

We now jointly consider the two remaining policy instruments; the required fertilization rate and the subsidized price of fertilizer. Given some fertilizer response coefficient, together with product and fertilizer prices, there will be an optimal rate of fertilization. If the plan requires a rate (R), which differs from this optimal rate (θ), foregone profits will be associated with plan membership. However, the farmer may be prepared to accept this non-optimal recommendation, provided he is sufficiently compensated with a subsidized fertilizer price and/or loan rate.

The required rate (R), is typically generated from experimental results. The traditional wisdom is that such rates will exceed the optimal levels for risk-averse farmers; but even if they were risk-neutral, the more timely and controlled nature of experimental operations would lead to recommendations which overstate the optimal levels for farm (and *farmer*) conditions [6]. Thus, inherent biases exist toward requiring a fertilizer rate greater than the unconstrained optimal rate. As R increases relative to θ then, *ceteris paribus,* the area sown to the new variety through plan participation will decline. Attempts to forestall this by offering the fertilizer at more heavily subsidized rates are quickly frustrated by the evolution of black markets.

While such an outcome may be desirable if viewed as an income redistribution device, the net impact on the area sown to new varieties as a result of a supervised credit plan is likely to be small. Stricter supervision, while perhaps inhibiting the 'illegal' sale of the plan fertilizer, is likely to prove too costly to avoid significant 'slippage' between the plan rate R, and the farmers' preferred rate, θ. In addition, to the extent that plan supervision is adequate to ensure the actual use of rate R, then both programme costs and the costs of resource misallocation are increased. In conclusion, we see little opportunity for manipulation of these three policy variables to achieve higher sowings of new varieties through supervised credit programmes.

Returning to the formulation of the Present Value of Net Social Benefits (1) for a supervised credit plan, it can now be argued that there will be a tendency for these to be negative, or at most zero, as a result of the restriction that plan members use a specified level of an input. This result holds under the assumption that the farmers have perfect information about the 'true' or unrestricted optimum rate of fertilizer application. However, this assumption is not likely to hold when we are concerned with a biological innovation that has, as a principal feature, a response to higher levels of fertilizer. Any time a technological change occurs, a new disequilibrium is thereby created and decision-makers must acquire information about the new production coefficients [7 and 12].

We now explore the conditions under which a supervised credit plan may have positive benefits resulting from an information dissemination function.

Learning and Information Decoding

To this point, we have assumed the optimum rate of fertilizer application was known. We now ask, under what conditions will a loan requiring a given fertilizer rate enable farmers to obtain new and relevant information about the fertilizer response of a new variety, so as to reduce the possibility of making allocative mistakes, and lead to a greater area sown?

Consider the optimum rate of fertilizer θ, to be a random variable. The randomness of θ results from the variability of fertilizer response to seasonal conditions, date of planting and propensity to lodge, etc. Since the supervised credit programme's rate (R) is normally derived under controlled experimental conditions, it is argued that the following conditions are the prior information on which the farmer makes his first decision on the new variety: $R > \theta \geqslant 0$, and ignorance about the distribution of θ. Thus the prior distribution for θ is uniform in $[0, R]$. The risk averse farmer will choose a level of fertilization θ^* such that the probability of applying excess fertilizer is not greater than some value ρ. Hence,

$\theta^* (1/R) \leqslant \rho$, or $\theta^* \leqslant \rho R$, and since $0 \leqslant \rho < 1$, then $\theta^* < R$.[6]

As a result, regardless of the true value of θ and its relation to R, the risk averse farmer will want to choose an initial level which may be much lower than the required rate. Consequently, if forced to apply R units, he may even elect not to experiment with new technology, unless the subsidy for so doing is sufficiently attractive. If he does accept plan membership, his first year in the plan may be considered an experiment. This experiment consists of sowing some land to the new technology at the specified level of fertilization, R. Only in the case that $\theta > R$ will the farmer gain additional information from this experiment; but we have argued that the opposite ($\theta < R$) is likely to be the case, leaving his prior information unchanged.

Rather than place restrictions on input use, the resources of the programme should attempt to enhance learning about the unknown distribution of the true fertilizer response of the new variety. We are aware of two approaches to this: the planting by extension agronomists of numerous demonstration plots; and the free distribution of 'test' amounts of seed and complementary inputs for the farmers themselves to use. Our analysis leads us to favour the latter approach. The former suffers from many of the same limitations as do trials carried out at the experiment station; in particular the level of fertilization used will likely be greater than the optimum.

On the other hand, the 'test package' approach will generate a large sample space under varying input levels and agro-climatic conditions. This, we believe, will lead to information on the distribution of the optimum fertilizer rate and consequently to more rapid adoption of the new technology.

Some Results from a Study Zone

A casual analysis of the data from the study area[7] led us to suspect that the farmers did not in fact take the restriction on fertilizer into

[6] We have used a uniform prior distribution (the usual model in a situation of ignorance [10, p. 46]) for expository convenience. The qualitative essence of this argument holds for any diffuse prior probability distribution where the random variable θ is bounded by R.

[7] In October 1974, a survey was carried out in the colonization area known as La Máquina, situated on the Pacific Coast of Guatemala, near the Mexican

account. As there seemed to be fairly widespread acceptance of the fact that there was no response to fertilizer, we would expect farmers only to accept plan membership if they could limit their fertilizer costs to the real value of the credit subsidy. This requires that the supervision of the fertilizer application at the specified rate be sufficiently lax to permit applications at lower rates. Given the difficulties of policing fertilizer applications it would be surprising if farmers did not have appreciable latitude.

In Table 1 we present a comparison of members and non-members of the credit plan based on selected characteristics of the farms. The 100 farms were chosen at random from a total population of 1,200 (each having 20 hectares of land), and almost all planted a relay system of maize and sesame as their principal activity.

TABLE 1

A Comparison of Selected Characteristics for Members and Non-members of the Supervised Credit Plan: La Maquina, Guatemala, 1973

Characteristics	Unit	Member	Non-Member	Level of Sig. for the Difference
No. of farms	No.	29	71	—
No. of visits made by the extension agent	No.	7·6	0·9	0·01
No. of field days attended	No.	1·4	0·5	0·05
Proportion sowing improved maize varieties to some land	%	17	8	0·05
Proportion fertilizing maize (1st cycle)	%	31	1	0·01
Proportion fertilizing maize (2nd cycle)	%	34	10	0·05
Fertilizer expenditures	$	42·3	5·3	0·01
Expenditures on chemical products per unit output[a]	$/qq	0·15	0·5	0·05
Amount of credit from plan	$	975	0	—

[a] Output was measured in quintals (1 qq = 45 kgs) of maize, converting the output of the interplanted sesame crop to maize equivalents using relative prices.

Plan members constituted 29 per cent of the sample, receiving on average almost eight visits by the extension service, and borrowing $975 in credit.[8] This credit was applied to the hiring of machinery for land preparation, seed and chemical products, and labour for hand-weeding and harvesting.

The impact of plan membership on fertilizer use is clearly apparent in Table 1, with 31 per cent of plan members using fertilizer (indicating a 69 per cent total 'slippage' in the supervision), against 1 per cent of non-members. If we accept $5·30 as the 'optimal' fertilizer expenditure, then $(42·30 − 5·30) = $37·00 is the cost of being a member in

border. The survey was conducted in collaboration with the Instituto de Ciencias y Tecnología Agrícola (ICTA), in Guatemala, under the leadership of Drs. R. K. Waugh and E. Martínez of that institution.

[8] All monetary values are in Guatemalan Quetzales, which are equivalent to U.S. dollars.

terms of 'wasted' fertilizer. This represents the amount the farmers would be prepared to pay for 'buying' the right of access to $975 of subsidized credit. This implies an interest differential of 3·8 per cent. The market interest rate was of the order of 20 per cent, meaning that the real price of the subsidized credit was nearer 16 per cent than the nominal 8 per cent offered to plan members.

TABLE 2

A Comparison of Selected Criteria of Farm Performance for Members and Non-members of the Supervised Credit Plan: La Maquina, Guatemala, 1973

Criterion	Unit	Member	Non-Member	Sig. of the Difference
Total return to land, family labour and management	$	3,712	2,975	NS
Cash return to land, family labour and management	$	2,978	2,375	NS
Total return per family worker	$	1,996	1,670	NS
Total return per capita	$	562	501	NS
Yield of maize (1st cycle)	qq/Mz[a]	25·2	27·2	NS
Yield of maize-sesame system	qq/Mz	55·3	50·1	NS
Estimated value of per capita food consumption	$	352	320	NS

[a] Mz = 1 Manzana = 0·64 Ha.

In Table 2 we present a comparison based on seven criteria of farm performance. Membership of the plan made no significant difference to any of the performance criteria. We conclude that the plan was effective in visiting farmers and providing credit, together with forcing some unprofitable use of fertilizer, without having any apparent impact on output.

The finding that there was no significant impact on yields (Table 2) from plan membership is supported by the results of a more comprehensive survey of 1,600 farmers in Guatemala, reported by Daines [4]. His sample was specifically drawn to compare the input use and performance of members of the supervised credit plan with non-members. He reports that . . .

> . . . It is commonly thought that credit, especially when granted by an official agency such as BANDESA, is synonymous with the adoption of yield-improving technology. At the national level in our sample, this hypothesis was borne out only in the case of one farm size class, the 3-5 hectare group. In all others and in the average for all farm sizes the increase was slight, and in some cases a decrease in yields was reported [p. 27].

An Empirical Test of the Restriction on Fertilizer use

In this section we attempt a more rigorous test of whether or not members of the credit plan did in fact take the restriction on fertilizer use into account in their decision-making. Such an analysis underlies any efforts to measure the resource misallocation induced by the plan.

Without supervision, a farmer would select his optimal input mix $X^0 = [X_1^0, X_2^0, \ldots, X_n^0]$ as the levels of n variable inputs. If the level of X_k is forced by a plan requirement, so that $X_k = \bar{X}_k$, then his actual input mix will be $X^a = [X_1^a, X_2^a, \bar{X}_k, \ldots X_n^a]$ where, only if all the pair-wise elasticities of substitution between the inputs are zero, will $X_i^0 = X_i^a$ except for $i = k$. In order to test whether the restriction on fertilizer use influenced the farmers' input we fitted the factor share equations corresponding to a transcendental logarithmic production function of the general form:

$$\ln(Q) = \beta_0 + \sum_i \beta_i \ln(X_i) + 1/2 \sum_i \sum_j \beta_{ij} \ln(X_j) \qquad (2)$$

Based on an examination of the farm plans drawn up for the members of the credit programmes, the *planned* quantity of fertilizer was calculated, yielding the restriction that

$$F > 8{\cdot}26A \qquad (3)$$

where:

$F =$ Fertilizer expenditures;
$A =$ Area of maize.

Introducing the following additional notation:

$Q =$ Production of maize;
$S_1, S_2 =$ Dummy variables to allow for differences in the level (although not the rate) of response between sub-zones;
$H =$ Cost of labour;
$O =$ Other costs, principally for machinery rental, but including other chemical products;

we can write the production function (2) as:

$$\begin{aligned}\ln Q = {} & \beta_0 + \beta_1 S_1 + \beta_2 S_2 + \beta_4 \ln(H) + \beta_5 \ln(F) + \beta_6 \ln(O) + \\ & \beta_7 \ln^2(A) + \beta_8 \ln^2(H) + \beta_9 \ln^2(F) + \beta_{10} \ln^2(O) + \\ & \beta_{11} \ln(A).\ln(H) + \beta_{12} \ln(A).\ln(F) + \beta_{13} \ln(A).\ln(O) + \\ & \beta_{14} \ln(H).\ln(F) + \beta_{15} \ln(H).\ln(O) + \\ & \beta_{16} \ln(F).\ln(O) + \varepsilon \end{aligned} \qquad (4)$$

Letting:

$\pi =$ Profits:
$P_t =$ Rental price of land,

we have the following profit function:[9]

$$\pi = PQ - P_t A - H - F - O \qquad (5)$$

which is to be maximized subject to the restriction (3), which we introduce, following Spann [13], with a Lagrangian multiplier λ. The first order conditions for a maximum of (5) are given by

$$PQ_A - P_t + 8{\cdot}26\,\lambda = 0 \qquad (6a)$$
$$PQ_H - 1 = 0 \qquad (6b)$$
$$PQ_F - 1 - \lambda = 0 \qquad (6c)$$
$$PQ_O - 1 = 0 \qquad (6d)$$
$$-(F - 8{\cdot}26A) = 0 \qquad (6e)$$

Immediately we can note that if λ is significantly different from zero then the conditions for unconstrained profit maximization ($MVP_i = P_i$)

[9] We continue with the assumption of an infinitely elastic product demand curve.

are not met. The aim of the following derivation is therefore to arrive at estimable equations to enable hypothesis testing about λ.

The first partial derivatives of (4) with respect to A and F are respectively:

$$\delta \ln Q/\delta \ln A = Q_A \cdot A/Q = \beta_3 + 2\beta_7 \ln(A) + \beta_{11}\ln(H) + \beta_{12}\ln(F) + \beta_{13}\ln(O) \quad (7)$$

$$\delta \ln Q/\delta \ln F = Q_F \cdot F/Q = \beta_5 + 2\beta_9 \ln(F) + \beta_{12}\ln(A) + \beta_{14}\ln(H) + \beta_{16}\ln(O) \quad (8)$$

Replacing the definitions of Q_A and Q_F from (6a) and (6c) into (7) and (8) gives:[10]

$$\mu_A = b_1 + b_2\ln(A) + b_3\ln(H) + b_4\ln(F)_5 + b_5\ln(O) + b_6S_1 + b_7S_2 + \epsilon_A, \text{ and} \quad (9)$$

$$\mu_F = b_8 + b_9\ln(A) + b_{10}\ln(H) + b_{11}\ln(F) + b_{12}\ln(O) + b_{13}S_1 + b_{14}S_2 + \varepsilon_F \quad (10)$$

where:

μ_A, μ_F = The factor shares of land and fertilizer respectively in the value of total output.

Let $W_1 = (1 - 8{\cdot}26\lambda/P_t)$ and $W_2 = (1 + \lambda)$, then:

$b_1 = \beta_3/W_1$ $\quad$ $b_8 = \beta_5/W_2$
$b_2 = 2\beta_7/W_1$, $\quad$ $b_9 = \beta_{12}/W_2$
$b_3 = \beta_{11}/W_1$, $\quad$ $b_{10} = \beta_{14}/W_2$
$b_4 = \beta_{12}/W_1$ $\quad$ $b_{11} = 2\beta_9/W_2$
$b_5 = \beta_{13}/W_1$ $\quad$ $b_{12} = \beta_{16}/W_2$

Equations (9) and (10) constitute a system of factor share equations (seemingly unrelated) which can be used to test λ. In addition, the equations are not independent since:

$b_9 = \beta_{12}/W_2$, from (10);

but

$\beta_{12} = b_4W_1$, from (9);

so that we have the following restriction:

$$b_9 = b_4 \frac{(1 - 8{\cdot}26\lambda/P_t)}{1 + \lambda}$$

or $b_9 = b_4k$

This restriction is used to test the null hypothesis that the plan's requirement does not influence the farmers' input levels.

The seemingly unrelated structure [11] was estimated by *OLS*.

$$\begin{bmatrix} \mu_A \\ \mu_F \end{bmatrix} = \begin{bmatrix} \ln A & \ln H & \ln F & \ln O & S_1 & S_2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \Omega & 0 & 0 & 0 & \ln H & \ln F & \ln O & Z_1 & Z_2 \end{bmatrix} \beta + \begin{bmatrix} \varepsilon_A \\ \varepsilon_F \end{bmatrix} \quad (11)$$

where:

$\Omega = kM\ln(A)$;

$M = 1$ for plan members and zero otherwise.[11]

[10] We have included the dummy variables in the estimating equations [9] and [10].

[11] We include the dummy variable M, as the restriction on fertilizer use only applies to members of the plan.

β is the vector $[b_1, b_3, b_4, b_5, b_6, b_7, b_{10}, b_{11}, b_{12}, b_{13}, b_{14}]$ and each of the other vectors contain 100 elements.

Obviously we cannot formulate the vector Ω in the data matrix of (11) without first knowing the value of λ. To avoid this problem we first estimated the system iteratively with respect to different values of λ (and hence k); we selected that value of λ which minimized the error sums of squares.[12] The second step was to estimate the system with λ set equal to zero. In both the estimations, we assumed (without testing) the usual characteristics of the error structure: normality, independence and common variance.

A summary of the results is presented in Table 3.

TABLE 3

Summary of Regression Results

Restriction	Observations	R^2	Error Sums of Squares
$b_9 = b_4 \cdot k$(i.e. $\lambda \neq 0$)	200	0·7424	0·4316
$b_9 = b_4$ (i.e. $\lambda = 0$)	200	0·7421	0·4321

To test the following hypothesis,

Null: $H_n : \lambda = 0$

Alternative: $H_a : \lambda \neq 0$

we formed an F statistic based on the restricted and unrestricted error sum of squares [14, p. 144] whose calculated value did not permit us to reject *the null hypothesis that the farmers do not take into account the restriction on fertilizer use.*

We conclude that although the farmers in the plan use some fertilizer as the price for obtaining the cheap credit, there has been sufficient slippage in the system so that they are apparently not altering their overall input levels as a result of the plan's restriction. Hence the social cost of resource misallocation is limited only to the fertilizer used by the plan members in excess of the amount used by non-members.

Summary

This paper presents a general framework for examining the net social benefits of supervised credit programmes to accelerate the adoption of a new fertilizer-responsive seed variety. A static profit-maximizing approach is implicitly used to consider the extent to which manipulation of policy variables in a supervised credit programme would lead to a greater area sown to the new variety. The problem of learning about the fertilizer responsiveness of the new variety is then considered. It is concluded that, in general, adoption of the new technology will not be accelerated if membership of a credit plan entails restrictions on input use. We finally present some results from a study zone, and an econometric approach to testing the hypothesis that farmers do not take

[12] Examination of k reveals that it is asymptotic to $-0{\cdot}5$ as $\lambda \rightarrow \pm \infty$. In fact, we restricted our search to $(-100 \leqslant \lambda < +100)$, concentrating after some preliminary runs on $(-2 \leqslant \lambda \leqslant +10)$, and found $\lambda = 2$ gave a minimum error sums of squares.

into account a restriction on input use. We found no evidence to reject this hypothesis, indicating that the imposition of non-optimal fertilizer rates is evaded by rational farmers.

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