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The effects of credit policy and fertilizer subsidy on farmers' input choices, production, and income are examined with a multiseason decision-making model. Stochastic production technology, risk-neutral and risk-averse decision rules, short-term savings consumption behavior, and a dual financial market are considered. Results indicate the risk-neutral rule is more consistent with actual choices than risk-averse rules. Estimated yields increased 21% to 30% from joint credit and fertilizer subsidies. Benefits are greater on irrigated than on rainfed farms. A substantial default rate in the institutional market reduces credit program benefits.

Key words: credit policy, fertilizer subsidy, Philippines, rice, risk aversion, simulation.

Credit and fertilizer subsidies are used by policy makers in many developing countries, including the Philippines. Their effects on farmer choice of inputs, production, and income on mono-crop rice farms in Central Luzon are examined in this paper. Prior to 1973/74, few Philippine rice farmers had access to institutional credit, primarily because of high collateral requirements imposed by private banks (Sacay). A series of typhoons in 1972 reduced the rice crop by 16% over the previous three-year average, and during the same year (1972) the entire country was brought under a land reform program that was expected to restrict severely the credit traditionally provided by landlords to share-tenants. Attempting to boost rice production, the government increased the flow of low-cost credit to rice farmers in 1973/74 through a program called Masagana 99 (World Bank, chaps. 6, 7).

During Masagana 99's initial year, farmers were allowed to borrow up to 900 pesos per hectare (P/ha) per six-month season. In 1974/75 the loan limit was increased to P1,200/ha (P7.30 = US$1.00 between 1973 and 1979). These production loans are available at an effective interest rate, including service charges and discounting, of approximately 16% per year. In 1974/75, over 40% of national rice area was financed under Masagana 99, but financing declined to about 10% in 1977/78. A major cause of this decrease was the frequency of defaults on Masagana loans, disqualifying farmers from further borrowing under the program.

The primary alternative source of production loans is the informal financial market. Credit availability in this sector varies, but surveys conducted by the International Rice Research Institute (IRRI) indicate a range of effective credit ceilings of P300–P600/ha in Central Luzon. Informal market interest rates vary from 30% to 100%, with average rates of 45% to 50% (Rosegrant 1978, Manto and Torres).

The Philippine government also has subsidized fertilizer prices. A two-tier fertilizer-pricing system was established in 1973, when fertilizer supplies in the international market were growing tight and world prices were increasing rapidly. A subsidized price was established for rice and other food crops, with a higher price for export crops, set to reflect import and marketing costs. This system continued until 1975/76, after which a uniform, subsidized price applied to all crops (table 1).

Rice production increased at more than 5%

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Table 1. Prices of Nitrogen and Phosphorus Fertilizer (₱/kg) for Rice and Export Crops and Subsidies, Philippines

Crop Year	Price for Rice Production		Price for Export Crops		Rice Production Subsidy[a]	
	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
1973/74	2.15	2.56	3.82	4.22	1.67	1.66
1974/75	4.38	3.83	7.07	6.48	2.69	2.65
1975/76	3.97	3.84	6.24	6.34	2.27	2.50
1976/77	3.68	4.09	3.68	4.09	0.72	1.21
1977/78	3.68	4.09	3.68	4.09	0.22	0.51

Source: Fertilizer and Pesticide Authority, Republic of the Philippines.
[a] Equal to the difference between the price for rice production and for export crops 1973/74 to 1975/76; equal to import plus marketing costs less sale price for 1976/77 and 1977/78.

per year in the Philippines during the 1970s (U.S. Department of Agriculture [USDA]). Obviously, many factors contributed; an important question is the contribution of credit and fertilizer subsidies. Evaluation of these policy instruments can be either normative or positive. Comparison of credit program participants with nonparticipants in three Luzon provinces shows that the former borrowed roughly twice as much and spent about 50% more on rice production inputs than the latter (Herdt and Rosegrant). However, the relatively small samples studied and the effects of differences in weather, quality of irrigation, and technology prevent one from causally linking the policies with the observed differences. Also such comparisons cannot separate the effects of credit from fertilizer subsidies. Modeling the decision process within a normative framework is an alternative that meets these objectives.

The normative framework is a multiseason model incorporating stochastic production technology, risk-neutral and risk-averse decision rules, short-term savings/consumption behavior, and a dual financial market with institutional and informal sectors. Systematic behavioral assumptions govern allocation of funds within the model.

A problem with modeling credit use is that fungibility of credit permits program funds to be diverted from their intended purpose into other enterprises or consumption (Von Pischke and Adams). Diversion to alternative enterprises is a minor problem in the Central Luzon area of this analysis—IRRI farm surveys show that rice occupied 88% of the total cropped land of rice farmers in 1979, and that livestock enterprises were minimal.[1] Some diversion to consumption probably does occur despite the dispersion of credit in the form of chits redeemable in kind. However, credit regulations make this difficult to detect.

Between 1973/74 and 1975/76, rice farmers could have sold fertilizer intended for rice to the unsubsidized sugar sector, but this opportunity was limited by the small area planted to sugar in Central Luzon. Following termination of the two-tier price system, there was little opportunity for arbitrage. Adequate supplies of fertilizer were available at prevailing prices. Thus, the model estimates an upper limit of the likely production impact and provides a basis for separating the impact of fertilizer subsidies from credit subsidies.

The Model of Farmer Decision Making

Previous microlevel analyses of the impact of credit policy on farm decision making have utilized mathematical programming models (Naseem, Ladman, and Whitaker). The Ladman and Whitaker models are static, one-period models; all three models have deterministic production relationships and a single credit market. The dynamic model presented here incorporates stochastic production relationships and a dual credit market that is characteristic of rural areas in the Philippines and most developing countries.

Operation of the Model

The flow chart in figure 1 outlines the model. Initially, output and input prices and initial

[1] Rice farm labor income accounted for 90% of farm earnings and 75% of household labor earnings in another study conducted in three rice-growing municipalities of Central Luzon in 1974 (Guino). Still another study showed that in 1978 rice provided 85% of farm income in Laguna province of Luzon (Smith and Gascon).

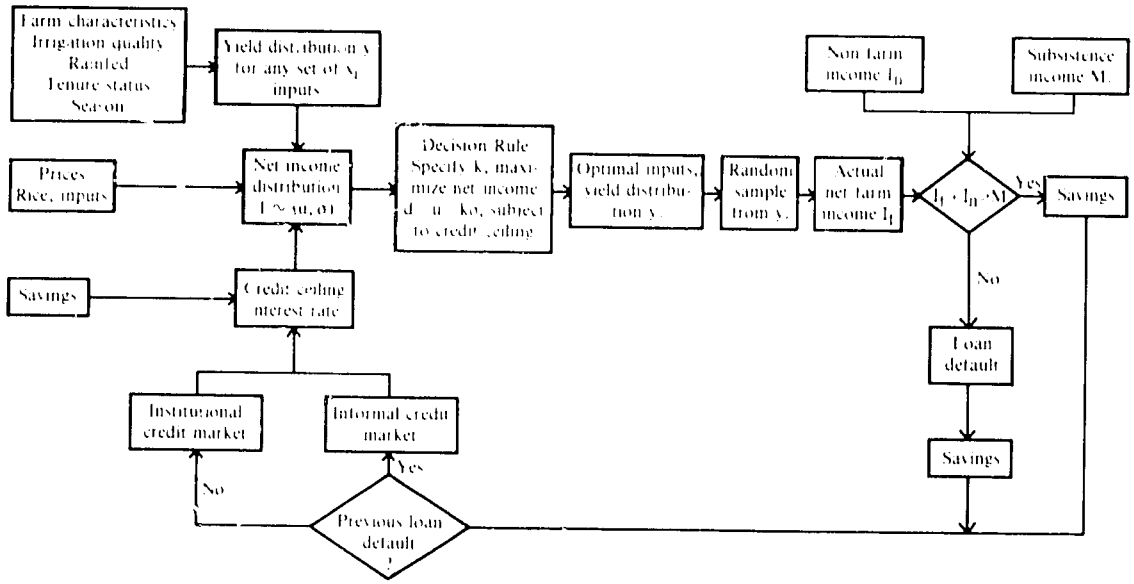

Figure 1. Flow chart of farm decision-making model

savings are set and farm characteristics specified to determine a yield distribution for any set of inputs. The financial market in which the farm borrows determines its interest rate and credit ceiling. The net income distribution for any input level can then be computed and optimal input levels chosen by the specified decision rule, subject to the credit ceiling.

The actual yield is generated by random sampling from the yield distribution corresponding to the optimal input level, and actual net income is computed. If net income plus nonfarm income is greater than subsistence requirements, savings are carried forward to the next season to begin another iteration. If total income is less than subsistence, the farm defaults on its loan and, if necessary, borrows from the informal credit market to cover subsistence requirements. Savings is computed, and the next iteration begins with the farm denied access to the institutional market because of default. If total income exceeds subsistence requirements, the farm remains in the institutional market and begins the next iteration.

To solve the model for mean input use, yield, and income over several seasons, the decision/outcome process is represented as a finite Markov chain process (Chung, Feller). The states $a_1, a_2, \ldots, a_m$ in the Markov process are determined by savings level and financial market access. Any state a_i determines input choice when the decision rule is specified and parameter values (such as rice price and input costs) are set. Input choice implies a yield distribution, which is used to compute the row of transition probabilities p_{ij}, $j = 1, \ldots, m$ of moving from state a_i at the start of one season to a_j at the start of the following season. Computation of transition probabilities for all a_i provides the Markov transition matrix. Specification of the distribution of farms across states in the initial season then permits solution of the model for the mean values of input use, yield, and income in any subsequent season.

Farm Characteristics

Farms are differentiated by tenure status (fixed or sharecrop rent), irrigation quality, seepage and percolation rates, and season of operation. The latter three define a water regime. The water regime determines the distribution of moisture stress in the production function (described below), thereby determining the frequency distribution of yield for any input level.

Prices

The prices of rice and the inputs (nitrogen, phosphorus, insecticide, and herbicide) can be set in the model to represent any desired policy mix. Actual prices of nitrogen and phosphorus are jointly determined by the prices of major fertilizer products containing these nutrients. This is reflected in the model by con-

straining the ratio of nitrogen to phosphorus at 2:1.

Decision Rules

Decision rules which have been utilized in modeling farmer behavior have been reviewed elsewhere (Anderson). A safety-first rule, to maximize the net returns which can be obtained with a fixed confidence level, is used here because it permits consistent specification of a range of attitudes toward risk (Dillon and Scandizzo, Moscardi and de Janvry, Roumasset). When the shape of the net income distribution is known, the decision rule is to maximize d, where $d = u - k\sigma$, and u is expected net income, σ is the standard deviation of net income, and k is the risk-aversion coefficient.

The coefficient k specifies the safety-first confidence level, or level of probability along the cumulative distribution of net income. For a given distribution, the larger the value of k, the greater the degree of risk aversion. If $k = 0$, the decision rule is risk neutral.

Income Allocation

Income is allocated between consumption and savings. Levels of subsistence consumption and nonfarm income are set, and income allocation behavior is specified as a marginal propensity to consume out of income in excess of subsistence consumption requirements:

$$I_t = I_f + I_n,$$
$$C = M + a(I_t - M),$$
$$S_t = S_r + I_t - C,$$

subject to $I_t \geq M$, where I_t is total income, I_f is farm income, I_n is nonfarm income, C is consumption, M is the subsistence consumption level, a is the marginal propensity to consume, S_t is total savings carried forward to the following production season, and S_r is savings from the previous season retained after purchase of inputs.

When total income is less than subsistence consumption, the constraint is not met, and consumption cannot be determined by the relationship above. In order to make up the consumption deficit and meet subsistence consumption requirements, the farmer fails to repay either all or part of any production loan he has obtained. Deficit-reducing behavior is determined in the financial market.

Financial Market

Farms face a capital constraint set by the level of internally generated savings and by the availability of credit from the financial market. Total spending on fixed and variable costs in a given season cannot exceed savings brought forward plus new borrowing. The maximum amount of credit available and its cost can be set within the model to reflect any desired credit policy.

Money can be borrowed from either institutional lenders or informal money lenders. All farms begin the first season with access to the institutional market for credit at a specified interest rate up to a maximum loan limit. The farm continues to borrow from the institutional market unless, because of low production caused by stochastic events, it can no longer both repay the loan and meet subsistence requirements. When this occurs, the farm defaults on its institutional loan and supplements consumption with the proceeds from the loan default up to the subsistence consumption level, allocating any additional funds between consumption and savings. If proceeds from the loan default are not sufficient to make up the difference between income and subsistence consumption, the farm borrows from the informal credit market, the farm's only other source of credit.

When the farm is in the informal market, the method for meeting subsistence requirements reflects the better enforcement of repayment and lack of alternative funding sources. In case of low production, the farmer only delays payment on the proportion of the production loan needed to achieve the minimum consumption. No additional consumption is allowed, and no savings are generated. The portion of the loan on which payment is delayed is carried over to the next season and repaid from income, along with any new production loan taken out at the beginning of the next season.

Production Function and Yield Distributions

At the core of the model are the frequency distributions of yield estimated from a highly disaggregated production function incorporating managed inputs and environmental variables. The production function is of the form:

$$y = f(x_i, v_j, q_r),$$

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where $i = 1, \ldots, s$; $j = 1, \ldots, n$; $r = 1, \ldots, p$; y is yield; x_i are managed inputs (nitrogen, phosphorus, insecticide, and weed treatment); v_j are stochastic variables (solar radiation, stress days, and insect infestation index) not under farmer control and of unknown value at the time of the decision about the x_i; and q_r are variables not under farmer control but with known values (clay content). Table 2 shows the production function estimated from 674 observations taken from response experiments in farmers' fields in Central Luzon in two wet and two dry seasons. In these experiments, inputs not included in the production function were held at levels comparable to actual farm practices in the area.

The independent variables explain 72% of the variation in yields, and all variables are significant at the 0.01 level except for insecticide, which is significant at the 0.05 level.[2] Both insect infestation and insecticides are included because the usual practice is to apply insecticide after initial infestation. Labor is not included in the production function because it was held constant in the experimental plots except for that associated with applying the specified managed inputs. Labor is therefore a direct function of managed inputs.

Typhoon damage, the most impertant stochastic variable left out of the production function, was excluded because no typhoon damage was experienced on the experimental plots. In order to account for the impact of typhoon on yield variability, the production function was adjusted using a typhoon damage index computed from farmers' subjective estimates:

$$y' = (1 - t) f(x_i, v_j, q_r),$$

where t is the percentage yield loss from typhoons.

Given a production function of this form, the frequency distribution of y' for any x_i, q_r can be estimated from the joint frequency distribution of the stochastic variables t, v_j (Anderson, Dillon, Hardaker; de Janvry; Byerlee and Anderson). Lack of information about the conditional distributions of the stochastic variables precludes analytical solution of the joint frequency distribution of the variables. However, if it is assumed that the stochastic variables are independently distributed, a discrete approximation of the frequency distribution of y' for any x_i and q_r can be obtained by repetitively sampling from the frequency distributions of t and v_j and then computing point estimates of y' from the production function.[3] With sufficient iterations, 1,000 in this case, stable estimates of the moments of the distrubution of y' can be obtained and continuous frequency distributions fit using Pearson's system (Day, Elderton and Johnson).

In order to estimate the yield distributions, frequency distributions were estimated for solar radiation, insect damage, typhoon damage, and stress days, the latter under a range of water regimes representing different qualities of irrigation and drainage.

Solar radiation distributions were estimated from 1966–75 data drawn from research station records in Central Luzon. The frequency

[2] Multicollinearity is a potential problem in the production function since some variables appear in more than one term and some of the independent variables (nitrogen × solar radiation and nitrogen squared, stress days and nitrogen × stress, and stress days and solar radiation × stress) are highly correlated. However, multicollinearity is not harmful unless it causes high standard errors and lack of significance in the regression coefficients (Kmenta, Johnston). This is not the case here.

Table 2. Yield Response Function for Modern Rice Varieties in the Philippines (kg/ha)

Variable	Regression Coefficient	t-value
Intercept	1079.83**[a]	7.86
Nitrogen × solar radiation[b]	0.91*	12.75
Nitrogen squared	−0.06*	−5.98
Stress days[c]	110.68*	6.70
Phosphorus (kg/ha)	3.81*	4.12
Weeding dummy 1[d]	160.11	2.68
Weeding dummy 2[e]	297.94*	5.30
Insect infestation index (% infestation)	−7.87*	−3.23
Insecticide (P)	1.47**	2.12
Percentage of clay	28.40*	11.83
Nitrogen × stress	−0.39*	−5.06
Solar radiation × stress	−8.95	9.47
R^2 adjusted	0.72	

Source: Wickham, Barker, Rosegrant, p. 226.
[a] Single asterisk means coefficient significant at 0.01 level, double asterisk means coefficient significant at 0.05 level.
[b] Solar radiation measured in kilocalories cm² during the period 45 days before harvest to harvest.
[c] From 60 days after transplanting to 20 days before harvest.
[d] One application of herbicide.
[e] One application of herbicide plus one handweeding.

[3] The independence assumption appears reasonable. Regressions among solar radiation, stress days, and insect damage using the response function data resulted in insignificant coefficients and R^2s of 0.08 or less. The typhoon damage distribution was computed using a 1975 IRRI farm survey. Using this data, regressions among typhoon damage, drought damage (a proxy for stress), insect damage estimates, and solar radiation gave insignificant coefficients and a maximum R^2 of .11

distribution for the insect infestation index was computed from the 674 observations over the four seasons from which the production function was estimated. The typhoon damage index was computed from farmers' estimates of typhoon damage over five crop years in Central Luzon.

A water balance model was used to generate frequency distributions of stress days for good, average, and poor irrigated sites and for rain-fed conditions, each with high, medium, and low seepage and percolation rates. The water balance model simulates weekly irrigation and rainfall. It is based on sampling from distributions of irrigation flows for sites in Central Luzon and from the distribution of rainfall recorded at Cabanatuan City, Nueva Ecija, 1949–74. Stress days are computed as a function of weekly water flows and losses from the site. Repeated iteration of the model produces a stable estimate of the distribution of stress days for any quality of irrigation and soil type (Rosegrant 1976, 1978; Wickham, Barker, Rosegrant; Wickham).

In the wet season, maximum expected yields and their standard deviations are similar for all qualities of irrigation, while rain-fed maximum expected yields are 13% lower (table 3). In the dry season, the difference between maximum yields with low and high quality irrigation is 1.3 t/ha. High quality irrigation reduces the standard deviation of yields by 30%.

The Impact of Risk Aversion

The importance of risk aversion for farmer input choices is the subject of continuing debate. Binswanger (using an experimental gambling approach with real payoffs) found attitudes highly concentrated at intermediate or moderate risk aversion. Dillon and Scandizzo (using mental experiments) report values of the risk-aversion coefficient k (from the decision rule, maximize $d = u - k\sigma$) ranging from −0.6 to 1.8, with a mean of 0.9. About 30% of their sample farmers were highly risk averse ($k > 1.5$). Neither study assessed risk attitudes in actual production decisions.

Moscardi and de Janvry estimated a corn production function, and computed the value of k which would account for the difference between actual nitrogen use and the expected income-maximizing level. The mean value of k is 1.12 with a range of 0.0 to 2.0 and a high concentration of strong risk aversion ($k > 1.2$). However, their production function did not include environmental variables such as solar radiation and moisture stress. In addition, their assumption that risk explains all the shortfall from optimal nitrogen use ignores the possible impact of constraints such as limited credit.

Roumasset explains actual nitrogen use of two samples of Philippine rice farmers using risk-neutral and risk-averse decision rules with a production function adjusted for major losses. He finds that the risk-neutral decision rule explains actual nitrogen use better than risk-averse rules.

To test the impact of risk aversion in this model, alternative decision rules were defined by specifying the risk-aversion coefficient k. Risk-neutral, moderate risk-averse, and strong risk-averse rules were tested. In the neutral case, $k = 0.0$. In the moderate case, k was set to maximize net income with probability of 0.20 on the cumulative frequency distribution of net income. The strong risk-averse rule maximizes the net income with probability 0.10 on the cumulative distribution.

Because the yield distributions, and therefore the net income distributions, have different shapes for different farm types, the value of k which specifies a given confidence level on the cumulative distribution also varies. For moderate risk aversion, k has a range of 0.62 to 0.94, with a mean value of 0.80. In the strong risk-averse case, k has a mean of 1.44 and a range of 1.34 to 1.53.

Comparison of model results with actual input use and yields suggests that the risk-neutral assumption better explains input choices than risk aversion. Model parameters,

Table 3. Yield-Maximizing Nitrogen Level, Maximum Expected Yield, and Standard Deviation of Yield, Three Qualities of Irrigation, from Estimated Yield Distributions

Season	Irrigation Quality	Yield-Maximizing Nitrogen (kg/ha)	Maximum Expected Yield (kg/ha)	Standard Deviation of Yield (kg/ha)
Dry	High	152	3,747	555
Dry	Medium	140	3,092	704
Dry	Low	124	2,455	781
Wet	High	128	2,977	833
Wet	Medium	124	2,972	828
Wet	Low	124	2,958	828
Wet	Rainfed	112	2,592	794

Note: Other inputs set at high levels: 60 kg/ha phosphorus, 2 applications of insecticide, 1 application of herbicide, and 1 hand-weeding; average soil quality.

such as prices, costs, credit ceilings, and sharing rates, were set at mean or representative values for Central Luzon, 1971/72–1977/78. The model was run for nine years (18 crop seasons), generating a distribution of farms between institutional and informal credit markets comparable to the actual distribution in Central Luzon, 1971/72–1977/78.[4]

The strong risk-averse rule generates input use and yields far below the actual levels for both irrigated and rain-fed farms (table 4). Moderate risk aversion is relatively consistent with actual results only for irrigated farm nitrogen use with the P600/ha informal loan ceiling. In all other instances, the moderate risk-averse rule produces input choices and yields considerably lower than the actual levels. Hence, the risk-neutral rule is used to examine credit and fertilizer subsidies.

The Impact of Credit and Fertilizer Policy

A subsidized credit program with increased loan ceilings, similar to those under Masagana 99, and a fertilizer subsidy comparable to that of the Philippine government were evaluated for crop years 1973/74 (the first year of Masagana 99) through 1977/78. Model parameters such as farm size, nonfarm income, wages, rents, herbicide and insecticide prices, and sharing rates were set at representative values for Central Luzon. Farm prices of rice were set at their annual prevailing level.

Fertilizer prices were set for successive runs of the model at the annual subsidized and unsubsidized rates derived from table 1. Financial market variables were set to simulate the presence or absence of a Masagana-type credit program. For model runs simulating existence of a credit program, all farms were assumed to begin in the institutional market, with a loan ceiling of P1,200/ha and an interest rate of 16% per year. The farms continue to borrow in the institutional market until default, after which they enter the informal market.

Interest rates in the informal market were set at 48% per year with maximum loan limits at P300/ha and P600/ha for alternative runs. For model runs simulating the absence of a subsidized credit program, all farms were assumed to borrow only from the informal market.

Three policies were evaluated: both the credit program and the fertilizer subsidy, the credit program with no fertilizer subsidy, and fertilizer subsidy with no credit program. In each case, the estimated impact of the policies is compared with the case of no government intervention; that is, with no credit program and no fertilizer price subsidy.

[4] Reported results are aggregated across 42 farm types: 9 irrigated types operating in wet season only plus 9 irrigated types operating in both wet and dry season plus 3 rain-fed wet season types, each then stratified by tenure status (fixed payment, share tenancy). Results are weighted by the estimated area distribution of these farm types in Central Luzon. The results are not sensitive to moderate shifts in the area distribution (Rosegrant 1978).

Table 4. Actual and Simulated Mean Input Use and Yields for Modern Varieties, Central Luzon, 1971/72 to 1977/78

		Informal Market Loan Ceiling					
		Nitrogen (kg/ha)		Other Inputs (P/ha)[a]		Yield (kg/ha)	
Decision Rule	Farm Type	300	600	300	600	300	600
Actual[b]	Irrigated	57		251		2,437	
Actual	Rain-fed	38		172		1,753	
Model results							
Risk neutral	Irrigated	54	67	227	281	2,216	2,429
Risk neutral	Rain-fed	37	42	166	208	1,745	1,897
Risk averse							
Moderate	Irrigated	44	53	158	178	2,085	2,163
Moderate	Rain-fed	24	29	110	121	1,575	1,610
Risk averse							
Strong	Irrigated	28	35	124	135	1,910	1,973
Strong	Rain-fed	9	9	80	80	1,412	1,412

[a] Phosphorus, insecticide, herbicide, and weeding labor.
[b] Yields from the Bureau of Agricultural Economics. Input levels computed from five International Rice Research Institute surveys, two Bureau of Agricultural Economics surveys, and two Department of Agriculture (Special Studies Division) surveys.

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Combined Credit Program and Fertilizer Subsidy

The combined impact of the credit program and fertilizer subsidy is large with either informal credit market loan limit (table 5). With a P300/ha loan limit in the informal market, the combined credit program and fertilizer subsidy is estimated to increase the average nitrogen use on irrigated and rain-fed farms by 43 kg/ha, other input use by P129/ha, yields by 510 kg/ha (30%), and income by P131/ha (29%). For the P600/ha informal market loan ceiling, the estimated combined impact is reduced, but still impressive: average increases of 38 kg/ha in nitrogen use, P90/ha in other inputs, 393 kg/ha (21%) in yields, and P118/ha (25%) in income.

Irrigated farms are considerably more responsive to combined credit and fertilizer policies than rain-fed farms. They also gain higher benefits. The reasons for their higher responsiveness are to be seen in the separate effects of the credit program and fertilizer subsidy.

Credit Policy

The credit program alone produces substantial gains for irrigated farms but considerably lower benefits for rain-fed farms. For the P300/ha case, for example, irrigated farms increase yields by 22% and income by 14% due

Table 5. Estimated Increases in Input Use, Yield, and Income Due to Credit Program and Fertilizer Subsidy, 1973/74 to 1977/78

Policy	Farm Type	Nitrogen (kg/ha)	Other Inputs (P/ha)	Yield (kg/ha)	Income (P/ha)
		Informal Market Loan Limit of P300/ha[a]			
Credit program with fertilizer subsidy	Irrigated	49	162	619	158
	Rain-fed	30	69	308	81
	Average[b]	43	129	510	131
Credit program, no fertilizer subsidy	Irrigated	22	127	397	67
	Rain-fed	7	41	114	34
	Average[b]	17	103	298	56
Fertilizer subsidy, no credit program	Irrigated	14	−13	106	55
	Rain-fed	14	− 5	102	38
	Average[b]	14	−10	105	49
		Informal Market Loan Limit of P600/ha[a]			
Credit program with fertilizer subsidy	Irrigated	42	115	466	142
	Rain-fed	30	45	257	74
	Average[b]	38	90	393	118
Credit program, no fertilizer subsidy	Irrigated	13	78	221	49
	Rain-fed	6	12	50	28
	Average[b]	10	54	127	35
Fertilizer subsidy, no credit program	Irrigated	30	47	311	85
	Rain-fed	6	33	207	39
	Average[b]	27	35	274	69

[a] Estimated increases are computed relative to case of no credit program and no fertilizer subsidy.
[b] Average of irrigated and rain-fed farms, weighted by area harvested in Central Luzon.

to implementation of a credit program without fertilizer subsidy, while the yield and income benefits for rain-fed farms are 7% and 9%, respectively.

Irrigated farms gain higher benefits from a credit program that releases a binding credit constraint because they can utilize higher input levels more profitably than rain-fed farms. Lower moisture stress in both seasons, and the high solar radiation and lack of typhoons in the dry season increase the marginal productivity and optimal level of nitrogen and other inputs on irrigated farms, leading to larger benefits than on rain-fed farms.

Additional runs were made to estimate the impact of reducing interest rates from 48% to 16% without increasing the availability of credit. The independent impact of such a reduction in interest rate is relatively modest: an average increase for irrigated and rain-fed farms of 5 kg/ha in nitrogen, 3% in yields, and 6% in income with the P600/ha loan limit, and 3 kg/ha nitrogen, 2% in yield, and 3% in income with the P300/ha loan limit.

The maximum interest rate impact occurs when credit is not constraining, so farmers can respond fully to price. Sensitivity tests using the model with no credit constraint show a maximum increase in yields of 5% and in incomes of 10% caused by a reduction in the interest rate from 48% to 16%. When the credit ceiling is binding, price changes are not effective. Instead, an interest rate reduction works by increasing the amount of inputs which can be financed for a given amount of credit by increasing income and savings available to finance inputs. This effect is smaller than the price impact, and causes a reduced interest rate effect when a binding loan constraint holds for some or all farms.

Default Rates

The model predicts average annual default rates on institutional market loans of 9.7% with the fertilizer subsidy and 10.6% without. As of the 1977/78 crop year in the simulated credit program, only 66% of the farmers were eligible for institutional credit in the subsidized fertilizer case and 63% in the unsubsidized fertilizer case. With a P300/ha informal market loan limit, the average yield loss due to default in 1977/78 was 8% and income was reduced by 6%. For the P600/ha informal loan limit case, the reductions in benefits due to default were approximately half as large.

Fertilizer Subsidy

The separate impact of a fertilizer subsidy in the absence of a credit program is highly dependent on the availability of credit in the informal market. With the P300/ha loan limit (which is binding on most farms), the decrease in the price of fertilizer (due to the subsidy) permits 14 kg/ha more fertilizer to be used by increasing the amount financed within the loan limit. Other input use decreases by P10/ha because a small amount of the other inputs are replaced by fertilizer which, because of the subsidy, becomes relatively more profitable. The net yield benefits of the fertilizer subsidy are 6%, with incomes increasing by 11%. Irrigated and rain-fed farms get approximately the same benefits.

With the P600/ha informal credit limit (which is nonbinding on many farms), the fertilizer subsidy boosts fertilizer use through the price impact, increasing marginal returns and optimal fertilizer levels. It also permits more fertilizer to be financed through loans. The impact of the subsidy on fertilizer use is nearly double that of the P300/ha loan limit case. With the higher loan limit, irrigated farms get 50% higher yield benefits and double the income benefits of rain-fed farms due to the higher productivity of fertilizer on irrigated farms.

Conclusions and Implications

Following the very poor harvest of 1972/73, the Philippine government instituted subsidized credit and fertilizer policies. Between 1972/73 and 1977/78, Phillipine rice production increased by 56% and rice yields increased by 38% (USDA)—an outstanding achievement, but one which could not be attributed only to government credit and fertilizer policies. Our analysis, using a dynamic model of farmer decision making, shows that credit and fertilizer policies could have induced at most a yield increase of 21%–30% for a set of farms representative of those in Central Luzon. The model correctly projected relatively large default rates from the government credit program. These occur because subsistence consumption has priority over loan repayment in years of low production caused by unfavorable weather and pest infestations. Assuming a risk-averse, safety-first decision rule resulted in poorer model validation than the alternative risk-neutral profit-maximizing behavioral rule.

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The impact of a credit program that reduces interest rates and increases credit limits is larger when credit availability in the informal market is lower. The greatest impact of the credit program is in releasing the credit constraint; the independent impact of interest rate reduction is small. This confirms Adams' suggestion that higher interest rates, if they attract substantially more funds into rural financial markets, would be preferable to subsidized low interest rates and would not likely reduce production significantly.

The substantial default rate on institutional market loans causes a major reduction in long-term benefits of the credit program, reducing the number of farms with access to the institutional credit market. These defaults also reduce the effectiveness of the fertilizer subsidy since its impact increases as the availability of credit increases.

When the informal market loan limit is P300/ha, the fertilizer subsidy alone contributes less than 20% of the total yield increase attributable to the joint credit/fertilizer program. With an increase in informal market credit availability to P600/ha, the yield benefits of fertilizer subsidy alone expand to 70% of combined program benefits, even with the high interest rate in the informal market. This confirms the importance of increasing the quantity of credit to farmers so that they can utilize yield-increasing inputs.

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