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ANALISIS SECTORIAL

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AGRICULTURE - COLOMBIA

ANALYTICAL WORKING DOCUMENT # 8

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SUPERVISED CREDIT: ITS IMPACT ON PROFITS, PRODUCTION, FACTOR USE, TECHNICAL CHANGE AND EFFICIENCY OF RESOURCE ALLOCATION IN CORN PRODUCTION IN COLOMBIAN AGRICULTURE

Morris Whitaker* March, 1973

DISCUSSION OF "SUPERVISED CREDIT"

James Riordan** and Thomas Walker**

This Document was produced with Data on 1065 farms and assistance from the Credit Division of INCORA

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INTRODUCTION TO THE ANALYTICAL WORKING DOCUMENT SERIES

Every analytical effort involving various investigators in different institutions and locations faces the difficult problem of interchange of analysis between collaborators. The Analytical Working Document Series was originated to help in reducing that communicati gap. Rather than wait until the analysis has matured, we are circulating the "rough draft" stage. This approach has the advantage of allowing early review and redirection as well a cross-fertilization effects on other research efforts. The obvious disadvantage of the Analytical Working Document Series is that uncorrected and untested materials are circulated. Readers of these draft collections of Preliminary Analytical results should keep in mind their provisional character and use them in the spirit that they were issued. We look forward to the helpful comments which the circulation wasintended to elicit.

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Many people have contributed to this study. Mr. Brandon Robinson and Dr. Samuel Daines of the Sector Analysis Division, Latin American Bureau, U.S.A.I.D., and Mr. James Riordan of the Foreign Development Division, Economic Research Service, USDA, conceived of the need for the study and mobilized necessary resources.

The study was carried out under a tripartite arrangement among the Sector Analysis Division (SAD), the Economic Research Service and Dr. Whitaker. The SAD has recently contracted Economic Research Service to continue and support the Sector Analysis of Colombian agriculture under the direction of Mr. Riordan. SAD requested Dr. Whitaker, in collaboration with Mr. Riordan, to undertake a study of the supervised credit program in Colombia as part of the Sector Analysis.

The work, mainly done at Washington, D.C., was divided into two periods. The first (Nov. 6-22, 1972) was devoted to a brief review of literature and development of the conceptual model. Data needs were defined and during the rest of November, December, and early January, LA/DR/SAD staff prepared the basic data necessary for the analysis.

The second period, (January 8-20, 1973) was spent in refining the set of basic data, estimating the conceptual models, interpreting the results, and some writing. This report was completed at Logan, Utah, while the author carried out his normal responsibilities at Utah State University.

Special thanks are due the Instituto Colombiano de Reforma Agraria (INCORA) for providing the necessary data for the analysis from farm budgets of their borrowers. Thanks are also due Mr. Thomas Walker and Mrs. Kathy Gleason for their competent assistance in data reduction. Also Mr. Walker served as an extremely knowledgeable sparring partner in assessing various interpretations of results, while Mrs. Gleason did necessary programming and computer work.

Finally, the author is indebted to Dr. Jay Andersen of the Economics Department at Utah State University for detailed comments on an earlier draft. However, any errors are the responsibility of the author. Also, the views expressed are those of the author and do not necessarily reflect the position of USAID, USDA, or INCORA.

Note

The principal paper by Whitaker is followed by a short discussion paper prepared in the office of AID where he serves as a consultant and which is responsible for designing the agricultural sector analysis of Colombia.

INTRODUCTION

Background

Between 1960 and 1969, close to U.S. $1 billion was provided to developing countries by Interamerican Development Bank (IDB), International Bank for Reconstruction and Development (IBRD), and United States Agency for International Development (USAID) for credit programs in agriculture. USAID supplied approximately U.S. $221 million of this amount. In addition, USAID has channeled several hundred million dollars of counterpart funds into agricultural credit institutions. Latin America has been the major recipient of this assistance getting 90% of USAID loans and grants, and 75% of IBRD's. Most loans to recipient countries have been made under extremely favorable rates and terms.[1]

The Sector Analysis Division of USAID, Latin American Bureau (LA/DR), in collaboration with the Colombian Ministry of Agriculture, has been engaged in an analysis of the agricultural sector of Colombia as a basis for more efficient utilization of scarce development resources. An integral part of this analysis is concerned with the role of supervised credit in the process of economic growth. However, until now, work has not gone beyond cross tabular analysis of the impact of Colombia's program of supervised credit.

This research is an attempt to provide a more rigorous and quantified assessment of supervised credit in Colombia, based on explicit theoretical models and hypotheses. The research focuses on the impact of a credit program on factor use, production, profits, and technology among small farmers producing one important cereal crop, corn. Also, the research is concerned with the effect of institutional constraints surrounding credit use, on the efficiency of resource use by borrowers. No attempt is made to assess the relative social costs of corn produced with, and without supervised credit, since it is recognized that a subsidy is involved in the use of the credit.

The credit program to be studied is sponsored by INCORA (Instituto Colombiano de Reforma Agraria). In addition, INCORA provides programs in land reform and titling, colonization, cooperatives, and infrastructural development, which are integrated at project levels to provide a complete development package. The credit and technical assistance program started in 1964 with a loan of U.S.$10 million from USAID; in 1966 a second loan of U.S.$8.5 million was made. It is estimated that about 80,000 families have been affected by this program since 1964.[2]

INCORA was created by Law 135 in 1961. Its basic purpose is to administer the land reform legislation contained in Law 135. INCORA is managed by a General Manager named by the president. The central office at Bogota has three staff program divisions besides its administrative arm. These are the Legal Division (land distribution, redistribution and titling), Engineering Division (project works in irrigation, drainage, roads and bridges, land clearing, etc.) and Rural Development Division (cooperatives, community development, supervised credit and technical assistance, and housing). Each program division is headed by a director with appropriate staff and technicians.

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[1] See Dale W. Adams, "Agricultural Credit in Latin America: A Critical Review of External Funding Policy," American Journal of Agricultural Economics, May, 1971, pp. 163-172.

[2] The information in this and the next few paragraphs draws on: James Schwinden and Gerald Feaster, "The INCORA Supervised Credit Program," USAID - Spring Review - Country Program Paper, Colombia, Circulation Draft Copy, October 10, 1972.

These three programs are implemented in the field at the project level. ects are designated by the manager of INCORA and the Social Agrarian Council. Each project has a manager who is on a level equal to the directors of the various programs, but is responsible for designing the mix of programs in the particular project he manages. He reports directly to the General Manager just as Program (Division) Directors do.

Thus, program management and administration are from Bogota, but are strongly influenced by the Project Manager. For example, in the Rural Development Division, there is a Sub-Director for credit. Field personnel in credit are trained in the central office, and then assigned to projects depending on the mix of programs required in a project by the Project Manager.

The thrust of legal and engineering programs in a project may also affect the nature of a supervised credit program. For example, if the engineering program is to provide primary and secondary distribution systems for irrigation, the project manager will likely require a complementary credit program. It is probable that loans would be made only for investment in on-farm distribution systems and in improved seed-pesticide-fertilizer packages that give large increases in yield when used in conjunction with irrigation. In this situation, the direction of the credit program in each project is determined by the project director even though it is administered and managed from Bogota. Further, the use of credit is more than likely tied to a particular set of resources in each project.

Once the mix of programs has been determined, and the general thrust of supervised credit decided on, loans are made in the following manner. Each project is divided into zones for purposes of disbursing loans to farmers. Each zone is headed by a zone chief who supervises four or five field supervisors. It is the supervisor that has contact with the farm families. The supervisors prepare farm plans with the families, and the zone chief reviews the plans.[3]

If approved, disbursement begins. At the same time, supervision begins, as the supervisor visits the borrower's farm to inspect crops, capital improvements, compliance with the loan plan, and to advise the borrower of market conditions and repayment dates. From three to five visits are made on the average to each borrower each year. The results of the first farm plan are jointly reviewed by the supervisor and borrower and used as a basis for a second plan.

Nature of the problem

The problem at hand can be divided into two parts. The first is concerned with quantifying the direct impact of the INCORA credit and technical assistance program on a sample of small farm borrowers producing corn in the program in 1968-1969-1970. The second facet of the problem is to measure the effect of constraints (imposed by INCORA) surrounding credit use, on the efficiency of resource allocation in corn production among INCORA borrowers. Intelligent use of development resources in Colombia requires such evaluation of the INCORA credit program. While some general studies have been made,[4] this is the first known detailed analysis.

The first part of the problem focuses on the impact of the credit program on production and profits of small farmers. When the supply of

[3] Average cost and return data by zone or region and by crop are prepared by the zone chiefs from initial farm plans. These averages are used to assist in preparing new farm plans.

[4] See Dale W. Adams; et al., "Supervised Credit in Colombia's Agrarian Reform: An Evaluative Study," Bogota, Centro Interamericano de Reforma Agraria, 1966; and Schwinden and Feaster, "The INCORA Supervised Credit Program."

credit for working capital for small farmers is substantially increased at a highly subsidized rate, an increase in factor use and production among such producers would be expected. Consequently, the problem is to measure for a sample of small farm INCORA borrowers producing corn such changes in the various resources used in corn production,[5] in total corn production, in profits, and in techniques used to produce corn as INCORA credit and technical assistance are applied. Measuring such changes will provide a basis for evaluating the detailed impact of the credit program on the production milieu for corn among borrowers.

The second part of the problem is concerned with evaluating the effect of an INCORA policy bent on the efficiency of factor use among borrowers producing corn. INCORA's organization and loan policy tends to tie the use of credit to specific factors of production. Under such restrictive institutions, resources would be expected to be less efficiently allocated than if the institutional constraint did not exist. Consequently, an attempt will be made to measure the impact of such a constraint on profits, production, and factor use.

Extant studies of INCORA have not provided this detailed evaluation for two reasons. First, these studies are very general in nature attempting to evaluate a number of facets of the INCORA program. In addition, the existing studies include a detailed history of INCORA and a description of its functional organization. Usually based on cross tabulated material, conclusions about impacts are educated value judgements, with little reliance on explicit conceptual models or quantification of results.

Second, reliable data are not available to make "before" and "after" comparisons. The studies have relied on other more narrow data bases for comparisons, or, for instance, have assumed that differences between budget for the same borrowers in their first, and fifth year with INCORA adequately reflect the program's impact.

Absence of reliable farm budgets for the sample of corn producers using INCORA credit before their entrance into the program, presents another dimension to the problem in this research effort. Either usable data must be generated, or a methodology developed which permits quantification from existing data of the effect of the credit program on the allocation of resources by small farmers. Since it is practically impossible to obtain pre-INCORA data that would be accurate, a part of the problem of this research is to develop a conceptual approach which permits calculation of the impact of INCORA's credit program on production and profits of small farmers, with farm budgets for the sample of farmers after they entered INCORA.

The basic approach is to use linear programming to "simulate" budgets for small farmers that characterize production in the absence of (prior to) INCORA loans.[6] The difference between the current situation and the simulated pre-credit situations may be interpreted as the effect of INCORA.

This conceptual approach is also used in attempting to measure the impact of INCORA's loan policy of tying loans to specific inputs. Linear programming is used to calculate the level of production, profits, and resource use when use of the loans is unconstrained among resources. Differences between the current situation and the programming solution, are interpreted as the effect of INCORA loan policy on the efficiency of resource allocation.

[5] The most important cereal crop in the country.

[6] The model utilizes the production coefficients of farmers after their entrance into the program, to simulate the budgets which reflect absence of INCORA loans.

Objectives of the research

The objectives of this research are:

1. To develop a model to characterize the level of factor use, profit, production, and the mix of technology, for a sample of INCORA borrowers producing corn, before they had access to INCORA credit.
2. To compare the results of the model outlined in objective 1 to the present (determined from a farm sample survey) to measure the impact of the INCORA credit and technical assistance program on factor use, profits, production, and technology.
3. To develop a model to characterize the level of factor use, profits and production, and the mix of technology, for the sample of INCORA borrowers producing corn, with no constraints on how working capital may be used.
4. To compare the results of the model outlined in objective 3 to the present situation to measure the impact of restrictive INCORA loan policies on the efficiency of resource allocation, by measuring differences in the levels of profits, production, and factor use.
5. To economically analyze the results of both models, and set forth conclusions and recommendations, and suggestions for further research.

General approach

The first part of the problem is to measure the impact of INCORA credit for working capital on a sample of small farmers producing corn, using farm budgets for such farmers after they entered the credit program. The basic approach is to use a linear programming model (designated Model A) to determine levels of corn production, profits, factor use, and technology in the absence of INCORA credit for working capital. The difference between the current situation as revealed in the data, and the solution to the program, is the impact of INCORA, under assumptions considered below.

The second part of the problem is to measure the impact of INCORA's loan policy which tends to tie the use of credit to specific factors of production, on the efficiency of resource allocation. The basic approach is to use linear programming to measure profits, production, and factor use, in the absence of restrictive policies, and compare this solution to the current situation.

This is done in two steps. First, the current situation is programmed under the assumption that working capital is restricted to be used for various resources as revealed in the data. This is designated as Model B.1. The second step also involves programming the current situation but with working capital free to be allocated among resources to its most efficient use. This is designated Model B.2. The difference between Model B.2 and Model B.1 is attributed to permitting working capital to be allocated according to efficiency criteria; e.e., it measures the effect

of INCORA's restrictive loan policy on efficiency of resource allocation. Both Models A and B must use the only data available, i.e., farm production coefficients describing production practices of farmers in the sample after entering the program.

An assumption

The proposal to measure the impact of INCORA loans on profits, factor use, etc., by differencing the current situation, and results of a linear programming solution indicative of the past (Model A), may present a problem. Production as measured by the linear programming solution is optimal, i.e., it takes place on the frontier of the production surface. However, it is likely that actual production in the past was somewhere inside the production surface. If so, comparing the results of Model A, with the current situation could lead to underestimates of the impact of INCORA.

Given this rationale, it might seem more reasonable to compare the results of Model A, with the solution to the program of the current situation with restricted use of working capital (Model B.1), since both represent optimal production. If, however, the results of Model B.1 are not much different than the current situation, then it would not make any practical difference whether Model A was compared to the current situation, or Model B.1. To anticipate the results of comparing Model B.1 with the current situation, there is not much difference. Consequently, all comparisons to measure the impact of INCORA credit on profits, etc., are between results of Model A, and the current situation.

Thus, our comparison rests on the assumption (empirically justified) that resources are optimally allocated in the current situation.[7]

Limitations

This study focuses very narrowly on a sample of INCORA borrowers, who were producing corn, and who were in the program in 1968-1969-1970. No other crops or borrowers are considered. The research is only concerned with measuring for the limited sample: a) changes in profits, production, factor use, and technology, due to the infusion of INCORA credit; and b) changes in profits, production, factor use, and technology, that would be expected to occur, if INCORA's restrictive loan policies had been relaxed before making such loans.

While evaluation of the social cost of corn produced under INCORA loans vis-a-vis other corn production, is certainly important, it is not considered here. Also not considered is the question of the impact of INCORA loans on non-borrowers, on other credit institutions, and linkage effects throughout the rest of the economy. Finally, no attempt is made to evaluate organizational and institutional weaknesses beyond that in (b) above.

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[7] Incidentally, the comparison of the current situation with Model B.1 supports Schultz's hypothesis concerning efficiency of resource use in traditional agriculture contained in: Theodore W. Schultz, *Transforming Traditional Agriculture*, New Haven: Yale University Press, 1964.

Model A (absence of INCORA credit for working capital)

Model A is specified as follows:

$$\text{Max } \pi = \sum_{j=1}^{12} c_j X_j \quad \ldots \quad (1)$$

$$\text{Subject to: } \sum_{j=1}^{12} a_{1j}' X_j \leq b_1' \text{ (working capital)} \quad \ldots \quad (2)$$

$$\sum_{j=1}^{12} a_{2j} X_j \leq b_2 \text{ (family labor)} \quad \ldots \quad (3)$$

$$\sum_{j=1}^{12} a_{3j} X_j \leq b_3 \text{ (land)} \quad \ldots \quad (4)$$

$$\text{and } X_j,\ c_j,\ a_{ij}, \text{ and } b_i \geq 0 \quad \ldots \quad (5)$$

where: X_j = hectares of corn produced in technology level j[8]

π = profits or production[9]

c_j = profits or production per hectare of corn produced in technology level j

Diotograno

a_{ij} = input i per hectare of corn produced in technology level j

b_i = total amount of input i available in the absence of INCORA where:

b_1 = working capital,

b_2 = family labor, and

b_3 = land.

[8]The technology classes are defined by grouping farms producing corn into classes according to production practices. See below for a detailed explanation.

[9]Each will be maximized in different problems. That is, we change the behavioral assumption from profit to production maximization to see if it affects the impact of INCORA credit.

While only three constraints are directly used in solving Model A, a sub-set of constraints for resources requiring working capital is used to determine resource use in the absence of INCORA loans. Coincidentally, this sub-set is used to develop the working capital constraint, rather than determining it directly. The working capital constraint (2) given as:

$\sum_{j=1}^{12} a_{1j}' X_j \leq b_1'$, may also be defined by:

$$\sum_{j=1}^{12} \sum_{h=1}^{11} a_{hj} X_j \leq \sum_{h=1}^{11} b_h \quad \ldots \quad (6).$$

That is, working capital is expended for the purchase of specific inputs. Consequently, from the farm budgets, a sub-set of constraints for the h=11 inputs requiring working capital can be defined as follows:

$$\begin{aligned} &a_{11}X_1 + a_{12}X_2 + \ldots\ldots + a_{1,12}X_{12} \leq b_1 \\ &a_{21}X_1 + a_{22}X_2 + \ldots\ldots + a_{2,12}X_{12} \leq b_2 \\ &\ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots \quad (7), \\ &\ldots\ldots\ldots\ldots\ldots\ldots \\ &a_{11,1}X_1 + a_{11,2}X_2 + \ldots\ldots + a_{11,12}X_{12} \leq b_{11} \end{aligned}$$

where the X_j are defined as above, a_{hj} is input h per hectare of corn produced in technology level j, where the input h is a specific input requiring working capital, and the b_h are the amounts of working capital available in the absence of INCORA credit for the purchase of each input. For example, if h=1 is fertilizer, then a_{11} is the amount of fertilizer required per hectare of corn produced in technology level 1, etc., and b_1 is the total amount of working capital available for fertilizer.

However, this set should not be used in solving Model A since before INCORA there was no tying of working capital to fertilizer or any other

input. Consequently, this set of equations must be collapsed into one for working capital as follows:

$$(a_{11} + a_{21} + \ldots + a_{11,1})X_1 + (a_{12} + a_{22} + \ldots + a_{11,2})X_2 + \ldots + (a_{1,12} + a_{2,12} + \ldots + a_{11,12})$$
$$X_{12} \leq (b_1 + b_2 + \ldots + b_{11}) \quad \ldots \quad (8),$$

or: $a_{11}'X_1 + a_{12}'X_2 + \ldots + a_{1,12}'X_{12} \leq b_1' \quad \ldots \quad (9)$

where: $a_{11}' = (a_{11} + a_{21} + \ldots + a_{11,1})$; etc.

Equation (9) is the constraint (2) on working capital, as it existed before INCORA. In this case, farmers are free to allocate working capital among resources requiring it as they wish. Once the program is solved, the coefficients in sub-set (7) are used to determine, for the sample of corn producers, amounts of various resources used (requiring working capital) in the absence of INCORA. This is the purpose for calculating the sub-set (7) in Model A.

A critical assumption of Model A involves the definition of the constraints on working capital (b_h) in sub-set (7). The farm budgets report the total amount spent on each of the 11 inputs requiring working capital, and the amount that came from INCORA loans. The difference is assumed to be the amount of working capital available in the absence of INCORA. Such differences are calculated and summed over all farms for each input within, and then across the various technology classes to define the vector b_h. The sum of the $b_h = b_1'$ is assumed to be the total amount of working capital available for corn production in the absence of INCORA loans.

However, it is possible that the actual amount of working capital is understated by this caluclation, yielding a lower limit constraint on working capital. While the difference between INCORA loans and total expenditures may accurately reflect the farmers provision of his own working capital before INCORA, he likely also had access to other credit, although in smaller amounts than from INCORA. To the extent this is true, profits and production using b_1' as the constraint on working capital will be understated, and the difference between the current situation and the results of Model A, overestimated.[10]

Consequently, another more liberal constraint for working capital is developed based on the following rationale. It is assumed that every family in the sample had, in addition to his own working capital, a subsistence loan of $2,000 pesos from Caja Agraria.[11] This is distributed to corn production in proportion to corn land to total crop and pasture land (17.47%) in the sample, or $349.55. When multiplied by the number in the sample this yields an amount to be added to the lower limit constraint b_1'. This upper limit constraint on working capital is designated b_1''.[12]

This constraint (b_1'') leads to relatively greater levels of profit and production (than b_1'), and thus to more conservative estimates of the impact of INCORA on profits and production.[13]

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[10] That is, the impact of INCORA loans will tend to be overestimated.

[11] His own working capital is as defined above; i.e., the difference between total expenditure on inputs requiring working capital, and that provided by INCORA loans for working capital. Also, all monetary units in this report are in pesos unless specifically noted.

[12] The amount to be added could be overstated for several reasons. First, Caja Agraria credit may go for consumption. Second, not all farms producing corn might get such credit. At the same time, it may be understated because other sources of credit may exist besides Caja Agraria. There is no way to assess the weight of these two effects.

[13] We can indicate that the upper limit estimate of working capital (b_1'') likely leads to lower limit estimates of the impact of INCORA programs on profits, etc. If producers are not profit maximizers then differentials between the current and simulated situations would be even

The constraints on family labor (b_2) and land (b_3) are defined as the total amount of family labor (land) reported used in the production of corn. The rationale for using these constraints is as follows:

> While family labor (land) devoted to other crops might be switched to corn under favorable price relations, we are only concerned with the profit and production maximizing combinations of technologies for producing corn. Interrelationships with other crops are not considered. Consequently, an assumption of the model is the amount of family labor (land) currently used in corn production is the same in the absence of INCORA credit. Also the model assumes that all land, and family labor can be used in any of the technology classes.

Another assumption of the model is that the a_{ij} and a_{hj} are the same for a technology class before and after INCORA credit for working capital is widely used in that class. That is, it is assumed that the technical coefficients are not influenced by tying INCORA loans to the purchase of certain inputs. This may be true for technical coefficients on family labor and land. However, it is likely that farm budgets for corn producers in each technology class before INCORA would yield smaller technical coefficients for inputs requiring working capital.

wider. Also, if the total for working capital is overstated, then the differential would also be wider. However, if the total for working capital is understated, the differential would be narrower. Thus, only to the extent the latter effect is dominant, would estimates of INCORA's impact under the upper limit constraint on working capital not be lower limit.

We need to assume profit maximization in order to suggest the lower limit estimate of working capital (b_1') leads to upper limit estimates of the impact of INCORA. (If farmers are not profit maximizers, profits would be even lower than our simulated results, leading to even wider differentials than we estimated.) However, it is unlikely that farmers had less resources for working capital than under our lower limit estimates of working capital. If they had more, profit levels would rise, and the impact of INCORA would be less than our estimate. Thus, our more liberal estimate of the impact of INCORA is probably an upper limit estimate, if farmers are profit maximizers.

This is true to the extent INCORA loans are tied to the purchase of specific inputs. Since the loans are highly subsidized, prices of factors tied to loans will also be, and farmers in a technology class will use more of the subsidized factor than in the absence of INCORA loans when higher market prices would have to be paid for factors. Thus, technical coefficients on factors purchased with INCORA loan proceeds, are likely greater for each technology class, than for technical coefficients for corresponding technology classes before the institution of INCORA loans. To this extent, factor use as determined by the linear program solution and the set of a_{hj} is likely to be overstated, and the impact of INCORA on factor use, understated. The effect on profits and production is not so easily rationalized, since there is no way to assess the impact of overstated a_{hj} on yields or profits.

The linear program is solved under two behavioral assumptions. In the first, it is assumed that the small farmer attempts to maximize profits. In this case, profits are defined as the difference between the payments to all variable factors of production, including family labor, and gross returns. Thus, profit is the return to all fixed factors and land. It is hypothesized that farmers act on this measure of profit, since they are in a short run horizon, i.e., they will remain in production as long as there is any return to the fixed factor.[14] Also, we are concerned about the impact on small farmers of the INCORA loans for working capital rather than for capital goods, and so profits are the return to the fixed factors. We also solve the program assuming small farmers maximize

[14] Land likely does not enter the calculus since it is apparently free to the farmer. Also, it is probable that family labor does not enter the calculus. However, we cost the latter since it is a variable factor of production.

production. Such behavior may characterize farmers producing under subsistence conditions.[15]

The model also assumes corn production can occur in a finite number of technologies (12), but within each technology, production is linear. That is, an x% increase in an input always leads to some constant increase in production within each technology class. Substitution of factors can occur in the model when two or more technologies are used to produce the product.

The technology classes are defined by classifying small farmers in the sample into subsets, depending on characteristics of their production processes. Main characteristics considered in the classification were capital intensity of land preparation, intensity of purchased inputs used, and intensity of labor. These characteristics are defined in Table 1.

Table 1. Production Characteristics for Defining Technology Classes.

Capital Intensity of Land Preparation	Intensity of Purchased Inputs[a]	Labor Intensity
1. Mechanized	1. Null	1. Extensive = 1-9 man days
2. Animal	2. Extensive = 1-100 pesos	2. Moderate = 10-29 man days
3. Human	3. Moderate = 101-300 pesos	3. Intensive = 30-49 man days
____	4. Intensive = 301 or more pesos	4. Very Intensive = 50 or more man days

[a]Refers to fertilizers, herbicides and pesticides, exclusively.

[15]If farmers lack sufficient resources to reach the point of maximum profits, they will maximize production subject to the constraint. As it turns out, profits will also be maximized (or losses minimized) at this point. Thus, the solutions to the two programs may be identical.

Based on these characteristics, the 12 technology classes in Table 2 were defined. Note that 3 x 4 x 4 = 48 production classes of farms can be defined from Table 1. However, this degree of disaggregation was not feasible due to paucity of observations in some of the subclasses. Such subclasses were aggregated so that in some cases, labor intensity was not a factor in defining the technology class (e.g., technologies X_1 through X_5), or the degree of intensity of labor or purchased inputs was reduced from four classes to two (e.g., technology X_4 and/or X_{10}).

Table 2. Characteristics Defining 12 Technology Classes.[a]

Technology Level	Capital Intensity of Land Preparation	Purchased Inputs	Labor Intensity	Number of Observations
X_1	Mechanized	Null & Extensive	All	57
X_2	Mechanized	Moderate	All	93
X_3	Mechanized	Intensive	All	42
X_4	Animal	Null & Extensive	All	36
X_5	Animal	Moderate & Intensive	All	33
X_6	Human	Null	Extensive	164
X_7	Human	Null	Moderate	296
X_8	Human	Null	Intensive	101
X_9	Human	Null	Very Intensive	91
X_{10}	Human	Extensive	Extensive & Moderate	131
X_{11}	Human	Extensive	Intensive & Very Intensive	124
X_{12}	Human	Moderate & Intensive	All	61
				1229

[a]See Appendix A for a brief discussion of how technology classes tend to be concentrated in certain regions.

Model B.1 (current situation with restricted use of working capital)

Model B.1 is specified as follows:

$$\text{Max } \pi = \sum_{j=1}^{12} c_j X_j \quad \ldots \quad (10)$$

$$\text{Subject to : } \sum_{j=1}^{12} a_{1j} X_j \leq b_1$$

$$\sum_{j=1}^{12} a_{2j} X_j \leq b_2$$

$$\ldots\ldots\ldots \quad \text{Factors requiring working capital} \quad \ldots \quad (11)$$

$$\ldots\ldots\ldots$$

$$\sum_{j=1}^{12} a_{11j} X_j \leq b_{11}$$

$$\sum_{j=1}^{12} a_{12j} X_j \leq b_{12} \quad \ldots \text{ Family labor } \ldots \quad (12)$$

$$\sum_{j=1}^{12} a_{13j} X_j \leq b_{12} \quad \ldots \text{ Land } \ldots \quad (13)$$

$$\text{and } X_j, c_j, a_{ij}, \text{ and } b_i \geq 0 \quad \ldots \quad (14)$$

In this model, π, c_j, a_{ij}, and X_j are defined as in Model A and are identical to those in Model A. The set (11) is the same as set (7) but is used explicitly in Model B.1 in place of the one constraint on working capital. Equation (12) is the same as (3); and equation (13) as (4). The constraints (b_i, $i=1,\ldots,13$) however, are different. They are total expenditures for resources including INCORA loans. This model explicitly assumes that the total amount available for working capital $\sum_{i=1}^{11} b_i$ must be used among the 11 factors requiring working capital in the proportions

$$\frac{b_1}{\sum_{i=1}^{11} b_i}; \quad \frac{b_2}{\sum_{i=1}^{11} b_i}; \text{ etc.}$$

The model is solved under the profit maximizing assumption. Finally the model assumes production is linear and substitution occurs only if two or more technologies are used.[16]

The solution to this program may yield greater profits, and production, and a different pattern of factor use, than the current situation. This would imply that even under the restriction on how working capital can be used, and given other resource constraints, that reorganization of production, in different techniques, could increase profits, etc. However, the model assumes perfect knowledge, perfect mobility of factors, and homogeneity of land and other factors of production. Differences between the current situation, and the solution of the model may be explained in terms of imperfect knowledge on the part of farmers, immobility of resources, and heterogeneous factors of production.[17] Thus, such increases are likely not attainable.

Model B.2 (current situation with no restriction on working capital)

Model B.2 is specified just as Model B.1, except the set (11) is collapsed into a single constraint on working capital.

This is done in the same way as it was in Model A, by summing over the columns of set (11) for each j such that:

$$(a_{11} + a_{21} + a_{31} + \ldots + a_{11,1})X_1 + (a_{12} + a_{22} + a_{32} + \ldots + a_{11,2})X_2 + \ldots + (a_{1,12} + a_{2,12} + a_{3,12} + \ldots + a_{11,12})X_{12} \leq b_1 + b_2 + b_3 + \ldots + b_{11} \quad \ldots \quad (15)$$

[16] Other assumptions that applied to Model A do not apply here. These include the assumption about the definition b_i and b_h of Model A, and about the equality of the a_{hj} and a_{ij} in the past and present in that Model.

[17] For example, it is likely that land is not homogeneous as we assumed. That is, part of the land may not be usable in certain technologies. To the extent this is true, the increase implied in the model, is not attainable.

$$\text{or } a_{11}'X_1 + a_{12}'X_2 + \ldots + a_{1,12}'X_{12} \leq b_1' \quad \ldots \quad (16)$$

where $a_{11}' = (a_{11} + a_{21} + a_{31} + \ldots + a_{11,1})$; etc. for $a_{12}', a_{13}' \ldots a_{1,12}'$.

The constraint $b_1' = \sum_{i=1}^{11} b_i$, is the total amount of working capital available, including INCORA loans. Except for restricted use of working capital the model is identical to B.1, and is estimated under identical assumptions and conditions.

The solution to Model B.2 is compared to Model B.1, and the differences are attributed to permitting working capital to be freely allocated according to efficiency criteria. That is, the difference between the current situation and Model B.2, is composed of two parts; the first is that due to permitting production to be reallocated among technologies (that is, due to violation of assumptions of the model) with working capital restricted to be used in a certain way. The second part is that due to unrestricting the working capital.

Model B.1 measures only the former, while Model B.2 measures both. Thus, the difference between these two models measures the latter. This difference may be interpreted as losses in profits and production, and distortions in resource use caused by INCORA's policy of tying working capital to specific resources.

DATA

Farm budgets for INCORA borrowers for each of the technology classes are used to calculate input coefficients, objective function coefficients and constraints for Models A and B.[18] All input coefficients, and objective function coefficients used to solve Model A, are also used to solve Models B.1, and B.2. The only difference between such models is the size of the constraints. Of course, all data represent averages for the samples of farmers in each technology class. Further, in all models the X_j are defined in terms of hectares of corn.

As an illustration, consider technology class X_5 with 33 farms (see Appendix Table B.1). The a_{ij} for the family labor, and land in technology class 5 (a_{25} and a_{35}) are simply the average amount paid to family labor (used in corn production) at the prevailing wage per hectare of corn = \$126.90, and the amount of land in corn production per hectare of land in corn production = 1, since the X_j are defined in hectares of corn.

The technical coefficients on resources requiring working capital ($a_{h5} = a_{15}$ through $a_{11,5}$) are used directly in Model B.1 or are used to define a_{15}' the working capital coefficient for technology class 5 in Models A and B.2.[19] In Model B.2, for example, (Appendix Table B.1), the

[18] Data for each of the technology classes used to solve Models A and B are included in Appendix Table B.1. Additional data on constraints necessary for solving Models B.1, and B.2, are presented in Appendix Table B.2.

[19] All data used are taken from farm budgets without modification except for seeds. In this case, it was felt value of seeds used per hectare in the budgets were substantially underreported. Consequently, the actual value of seeds required per hectare for that technology class as determined from independent surveys was used instead.

first 11 rows are factors requiring working capital. The sum of rows 1 through 11 for column 5 is a_{15}' = \$1003.98 (the technical coefficient for working capital). The average profit coefficient (c_5 = \$940.21 for technology class 5) is calculated by subtracting the sum of a_{15}' and a_{25} (family labor) = \$1130.88 (average cost of variable factors per hectare) from the average value of production per hectare = \$2071.09. When maximizing production, the latter becomes the objective function coefficient, c_5.

Finally, farm budgets report both the total value of expenditures, and the value of loans for each input requiring working capital. The working capital constraints for Model A are developed as follows: within technology class 5, the difference between total expenditures for such an input (e.g., fertilizer) and the amount of INCORA loans for fertilizer, is calculated. When summed over all technology classes this yields b_1 = \$174,583 of the set b_h, h=1, ..., 11; the amount of working capital in the absence of INCORA loans, used for ~~fertilizer~~ seeds. By summing over b_h, h=1, ..., 11; the lower limit amount of working capital b_1' = \$2,036,900 is determined. The upper limit amount b_1'' is determined by adding the share of Caja Agraria loans likely devoted to corn production (\$372,267) to b_1'.[20]

The constraint for each resource requiring working capital in Model B.1 is simply the sum over all technology classes of the total expenditure in each class for a resource (e.g., fertilizer). When summed over all resources, this yields the working capital constraint for Model B.2.

[20] The amount to be added to b_1' is the share of a \$2,000 Caja Agraria loan to each producer devoted to corn production. This is determined as the share of corn land in total crop and pasture land or 17.47% equal to \$344.55 per producer. This, times the number of producers (1065) yields \$372,267. The number of producers is reduced from 1229 to 1065 since technology class 6 is dropped from the model due to inadequate data. (See below).

The constraints on family labor and land are the same in all models, and are simply the total amount of family labor or land reported used in corn production.

Similar calculations as described above for technology class 5 are done for the other technology classes. Due to unreliable data on cost of factors of production for farms in technology class 6, this class was dropped from the model in the actual calculations. Thus, for the objective function and constraints, j=1,2,3,4,5,7,...,12.

RESULTS OF THE ANALYSIS

This section presents the results of the analysis. First, the impact of INCORA loans for working capital on factor use, profits, production, and technology for the sample of borrowers, is set forth by comparing the results of Model A with the current situation. Then, the effect of INCORA's restrictive policy tying loans to specific factors on efficiency of resource allocation among borrowers producing corn is presented by comparing the results of Model B.2 with those of B.1.

Impact of INCORA loans on profits, production, factor use and technology

The results of solving Model A (absence of INCORA) are presented in Table 3, along with current levels of factor use, profits, and production for all technology classes.[21] Column 2 of Table 3 is the result of solving Model A when the working capital constraint is defined as the lower limit of working capital available in the absence of INCORA loans ($2,036,906).[22] In this solution, all production takes place in technology level 7 with working capital as a binding constraint, but with excess land and family labor. Technology level 7 is characterized by hand preparation of land, with only moderate (10-29 man days) labor intensity, and no purchased inputs. Also, the profit and production maximization models were identical.

[21] The current levels of factor use, profits, and production by technology class are presented in Appendix Table B.3. Recall that technology class X_6 was dropped from the analysis due to poor data.

[22] This lower limit constraint was defined as the difference between the total expended on resources requiring working capital, and the amount loaned by INCORA to purchase such factors, for the sample.

Table 3. Current Levels of Factor Use, Profits, and Production Compared to the Results of Solving Model A (Absence of INCORA) for Lower and Upper Limits of Working Capital

	Current	Model A Lower Limit[a]	Model A-Upper Limit[b] Profit Max[c]	Model A-Upper Limit[b] Production Max[c]
FACTOR USE	(Current pesos except land)			
Working Capital:	3,790,913	2,036,906	2,409,173	2,409,173
Seeds	241,036	163,026	193,908	183,660
Fertilizers	121,408	0	64,095	0
Pesticides	173,478	0	15,783	0
Rentals[d]	398,618	0	51,099	0
Packing	319,979	198,579	222,665	212,949
Transportation	331,166	318,425	341,867	334,029
Irrigation	1,950	0	454	0
Fuels	2,877	0	0	0
Labor	2,158,203	1,348,384	1,506,657	1,670,111
Other 1	22,720	1,681	5,695	1,958
Other 2	19,478	6,809	6,951	6,465
Family Labor	467,369	331,569	380,164	389,585
Land (hectares)	4,728	4,309	4,728	4,728
PROFITS	3,150,912	2,439,323	2,799,001	2,797,514
PRODUCTION	7,409,189	4,807,798	5,588,337	5,596,272

[a] The lower limit estimate of working capital is the differenc between total expenditures for inputs requiring working capital and INCORA loans to purchase those inptus, summed over all inputs and farms in the sample.

[b] The upper limit constraint includes working capital as defined in the lower limit constraint, plus the share of a Caja Agraria loan of $2,000 devoted to corn production. See the conceptual model (pages 14 and 23) for detail.

[c] When Model A was solved with the lower limit constraint, the profit and production maximization models were identical. With the addition of a small amount of working capital, they are slightly different.

[d] Rentals of machinery and animals.

Data in columns 3 and 4 of Table 3 are the solution of Model A when the working capital constraint is the upper limit of working capital available in the absence of INCORA loans ($2,409,173).[23] In this case, the profit and production maximization models give slightly different results. In the profit maximization model production takes place in technologies 5 and 7, with 329 hectares of corn produced in level 5, and 4,399 in level 7. (Technology level 5 is characterized by use of animal power in land preparation, moderate through intensive use of purchased inputs, and extensive through very intensive labor use.)

In the production maximization model, 4,092 hectares of corn were produced in technology level 7, and 636 hectares in level 8. The latter level differs from the former only in the intensity of labor use; it is intensive utilizing 30-49 man days of labor.[24]

Shadow prices.--In the upper limit variation of Model A as well as the lower limit variation, working capital was a constraint to increased profits and/or production. However, in the upper limit variation, land was also a constraint. The shadow prices for working capital are presented in Table 4 for all variations of Model A. These results suggest that increased working capital would have substantial impacts on profits and production. For example if the lower limit constraint on working capital was operative in the absence of INCORA loans, a 1 peso increase in working capital would have increased profits (as defined) by $1.20, and the value of production by $2.36. If the upper limit constraint on working capital were the effective one, a 1 peso increase in working capital would have increased profits by $.70, and production by $1.84.

Table 4. Shadow Prices on Working Capital

(Current Pesos)	Lower Limit	Upper Limit
Profit Maximization	1.20	.70
Production Maximization	2.36	1.84

The shadow price on working capital in the profit objective function may be interpreted as the gross rate of return on a marginal unit of working capital. For example, the gross rate on 1 peso of working capital in the lower limit model is 120%, and 70% in the upper limit model.[25] If the rate of interest required to add the unit (peso) of working capital is subtracted from the gross rate, we have the net rate of return on the marginal unit of working capital.

The relatively large gross rate of return to working capital even under the upper limit constraint, suggests that infusions of working capital would increase profits and production. It also suggests that working capital provided via the market was in short supply, and likely carried a fairly high rate of interest. It is not surprising when INCORA extended loans for working capital at what must have been highly subsidized rates, that there was an excess of demand for such loans.[26] Even after the provision of INCORA credit it is likely that the shadow price on such working capital remained fairly large.[27]

[23] The additional $372,267 available for working capital over and above the lower limit constraint defined in footnote 22, is the share of a Caja Agraria loan of $2,000 devoted to corn production and assumed given to every borrower in the sample. See pages 14 and 23 for more detail.

[24] The solution of Model A with the upper limit constraint on working capital is presented in Appendix Table B.4.

[25] The lower shadow price or gross rate of return in the upper limit model illustrates the law of diminishing returns to the factor of production, working capital, as more units of it are added.

[26] See Schwinden and Feaster, "The INCORA Supervised Credit Program," p. 40.

[27] This point is substantiated below.

Impact on profits and production.--Data are presented in Table 5 on the impact of INCORA loans for working capital, on profits, production, and factor use. Column 1 is the difference between the current situation, and the results of Model A (absence of INCORA loans) based on the lower limit constraint on working capital and under both profit and production maximizing behavior (results are identical). This leads to a liberal estimate of the impact of INCORA since less working capital means relatively lower profits, production, and factor use. Hence, the differential between the current situation, and the results of Model A-lower limit is wider, than if working capital were greater. Columns 2 and 3 are the difference between the current situation and the results of Model A under the upper limit constraint on working capital, leading to more conservative estimates of the impact of INCORA. Column 2 is the impact assuming corn producers maximize profits, and Column 3 assuming they maximize production.

The provision of INCORA credit has had a substantial impact on profits, production, and factor use. (There is little difference in the effect of profit or production maximizing behavior on the conservative estimates of the impact of INCORA on profits or production. However, factor use is quite different.) The analysis indicates profits have increased by approximately $350,000 to $712,000 for the sample of borrowers, depending on whether INCORA increased available working capital by $1,381,740, or $1,754,007. This is an increase in profits of 13% to 29%.

Note that the difference between the liberal and conservative estimates of the impact of INCORA credit on profits, suggests a very high marginal product or rate of return for initial loans. That is, increasing credit for working capital by $372,217 from $2,036,906 to $2,409,173 (Table 3), increases profits by $359,678, or almost by 1 peso for every peso of

Table 5. Impact of INCORA Loans on Factor Use, Profits, and Production, or Difference Between Current Situation and Results of Model A (Absence of INCORA)

	Liberal Estimate[a]	Conservative Estimate[b]	
		Profit Max	Production Max
	(Current pesos except land)		
FACTOR USE			
INCORA Loans for Working Capital:	1,754,007	1,381,740	1,381,740
Seeds	78,010	47,128	57,376
Fertilizers	121,408	57,313	121,408
Pesticides	173,478	157,695	173,478
Rentals[c]	398,618	347,519	398,618
Packing	121,400	97,314	107,030
Transportation	12,741	-10,701	-2,863
Irrigation	1,950	1,496	1,950
Fuels	2,877	2,877	2,877
Labor	809,819	651,546	488,092
Other 1	21,039	17,025	20,762
Other 2	12,669	12,527	13,013
Family Labor	135,800	87,205	77,784
Land (hectares)	419	0	0
PROFITS	711,589	351,911	353,398
PRODUCTION	2,601,391	1,820,852	1,812,917

[a]The difference between the current situation and the results of solving Model A, using the lower limit estimate on working capital. Column 1 - Column 2 of Table 3.

[b]The difference between the current situation and the results of solving Model A, using the upper limit estimate of working capital. Column 1 - Column 3 of Table 3 for profit maximization case, and Column 1 - Column 4 for production maximization case.

[c]Rentals of machinery and animals. Hereafter referred to in the following tables as Rentals M & A.

working capital. Increasing working capital by $1,381,740 from $2,409,173 to the current level, increases profits by an additional $351,911 or by only $.25 for each peso (assuming profit maximization).

Infusion of INCORA credit for working capital increased production of corn by $1,821,000 to $2,601,391 or by 33% to 54%, depending on whether upper or lower limit estimates of working capital were used in the Model A. Once again, initial loans have a much greater marginal impact on production, just as they did on profit. Increasing working capital by $372,267 from the lower limit, increases production by $780,534 or by 2 pesos for every one of working capital. Going from the upper limit level on working capital to the current level (by $1,381,740), increases production by $1,820,852, or by only 1.3 pesos per peso of working capital.

Impact on factor use.--Factor use has changes substantially due to INCORA loans for working capital. This is illustrated in Table 6 where the distribution of factors requiring working capital are presented for the current situation and the results of solving Model A. (Recall that the solutions to Model A represent patterns of factor use under various assumptions about the level of working capital in the absence of INCORA loans for working capital.)

The most notable divergence between the simulated and current patterns of factor use is the greatly increased share of working capital devoted to fertilizers, pesticides, and rentals of machinery and animals. There are also increases in the share of working capital for irrigation, fuels, other 1, and other 2. At the same time, there is a rather sizeable decrease in the share of working capital devoted to transportation, and to a lesser extent, to labor. Thus, a major impact of INCORA loans has been to cause use of fertilizer and pesticides and rentals of machinery and animals in corn production to increase from very close to zero in the absence of INCORA loans, to over 18% of working capital after the extension of such loans.

Table 6. Distribution of Factors Requiring Working Capital Under Current Situation as Compared to the Results of Model A (Absence of INCORA)

		Current	Model A Lower Limit	Model A-Upper Limit Profit Max	Model A-Upper Limit Production Max
Working Capital	Amount[a]	3,790,913	2,036,906	2,409,173	2,409,173
	Share	100%	100%	100%	100%
Seeds		6.4	8.0	8.0	7.6
Fertilizer		3.2	0	2.7	0
Pesticides		4.6	0	.7	0
Rentals M & A		10.5	0	2.1	0
Packing		8.4	9.7	9.2	8.8
Transportation		8.7	15.6	14.2	13.9
Irrigation		.1	0	0	0
Fuels		.1	0	0	0
Labor		56.9	66.2	62.5	69.3
Other 1		.6	.1	.2	.1
Other 2		.5	.3	.2	.3

[a]Current pesos.

Source: Table 3.

The decline in the share of labor as a proportion of total working capital is not a cause for serious concern. Recall the level of working capital is substantially greater in the current as compared to the simulated situation (by $1,381,740 or $1,754,007 depending on the assumption). The decline in the share of labor as working capital increases only suggests the rate of growth in working capital is greater than that of labor use, not that labor use declines absolutely. Similarly, the increase in fertilizers, pesticides, and rentals is greater than that of working capital, so that their share increases.

This is illustrated in Table 7 where percentage increases in factors requiring working capital are presented for the liberal and conservative estimates of the impact of INCORA. For example, in the liberal estimate[28] working capital increases by 86 percent (from $2,036,906 to $3,790,913). However, use of hired labor increases by only 60% (from $1,348,384 to $2,158,203). Thus, the share of labor declines from 66.2% to 56.9% of total working capital.

Table 7. Percentage Increase in Use of Factors Requiring Working Capital for Liberal and Conservative Estimates of INCORA's Impact.

	Liberal Estimate[b]	Conservative Estimate[c]	
		Profit Max	Production Max
Working Capital:	86%	57%	57%
Seeds	48%	24%	31%
Fertilizer	a	89%	a
Pesticides	a	999%	a
Rentals M & A	a	680%	a
Packing	61%	44%	50%
Transportation	4%	-3%	-1%
Irrigation	a	330%	a
Fuels	a	a	a
Labor	60%	43%	29%
Other 1	1252%	299%	1060%
Other 2	186%	180%	201%

[a]The base is zero (Table 3), so no percentage increase can be calculated.

[b]The liberal estimate refers to the difference between the current situation and the result of solving Model A (absence of INCORA) with the lower limit constraint on working capital. For example, use of seeds increased 48% between production characterized in the results of Model A-lower limit, and the current situation.

[c]The conservative estimate refers to the difference between the current situation and the results of Model A (absence of INCORA) with the upper limit constraint on working capital.

Source: Tables 3 and 5.

[28]The liberal estimate of the impact of INCORA has been defined as the difference between the current situation and the results of solving Model A (absence of INCORA) with the lower limit constraint on working capital. That is, when working capital is lower limit, profits, etc., will be smaller than if working capital were upper limit. Thus, the difference between Model A-lower limit, and the current situation is greater (more liberal) than between Model A-upper limit and the current situation.

Data on how the increase in working capital made available through INCORA loans is distributed among factors requiring working capital is presented in Table 8 for liberal and conservative estimates of INCORA's impact. The major proportion of INCORA loans are expended for labor even though the share of labor in total working capital declines. In fact, the share of INCORA loans going to labor are greater than the share going to fertilizers, pesticides, and rentals combined, for the profit maximizing cases of both estimates. The use of labor in the results for Model A is so large that even though its use grows more slowly than use of modern inputs as INCORA loans are made, the largest proportion of the INCORA loans

Table 8. Percentage Distribution of INCORA Working Capital Loans Among Factors Requiring Working Capital by Liberal and Conservative Estimates.

	Liberal Estimate[a]	Conservative Estimate[a]	
		Profit Max	Production Max
INCORA Loan for Working Capital:	100%	100%	100%
Seeds	4	4	4
Fertilizer	7	5	9
Pesticides	10	11	12
Rentals M & A	23	25	29
Packing	7	7	8
Transportation	1	-1	0
Irrigation	0	0	0
Fuels	0	0	0
Labor	46	47	35
Other 1	1	1	2
Other 2	1	1	1

[a]See notes b and c, Table 7.

Source: Table 5.

was spent on labor. The data suggest that of all factors, only transportation might be expected to decline, as working capital increases.

Note the pattern of use of INCORA loans for factors is much different in the production maximization model than the profit maximization for the conservative estimate. Much less of the loan is devoted to labor, while more is devoted to fertilizers, pesticides and rentals. If corn producers are production maximizers, labor use is not increased by supervised credit as much as if they were profit maximizers. (It is important to note that the level of profits is almost as great in the production maximum as the profit maximization model.)

In summary, increases in working capital via INCORA loans, increases use of all factors of production, with the possible exception of transportation. Use of modern factors; e.g., fertilizers, pesticides and machinery and animal rentals increases much more rapidly than increases in working capital. As a result, they go from insignificant levels of working capital in the absence of INCORA loans, to over 18% of current working capital (Table 6), and account for over 40% of the increase in working capital, i.e., the INCORA loans (Table 8).

Although the share of labor in total working capital declines as INCORA loans are made, the absolute amount of labor used increases substantially. In fact, hired labor still requires 57% of the amount of current working capital (Table 6), and 35-47% of INCORA loan proceeds were used to hire labor depending on the assumptions (Table 8). This reflects both the large amount of hired labor used in the absence of INCORA loans, and the fairly rapid increases in demand for labor to implement use of modern inputs as INCORA loans are made.

Impact on technology.--The impact of INCORA loans on the level of technology will be illustrated by using only the results of Model A (absence of INCORA) with working capital at the lower limit. In that program of the absence of INCORA loans, 4309 hectares of land were used in technology level 7 to produce $4,807,798 of corn, and profits of $2,439,323, or production per hectare of $1,115.64 (Table 3, Column 2). However, with the addition of $1,754,007 to working capital via an INCORA loan, all technology classes were used. Production and profits increased to $7,409,189 and $3,150,912, respectively.[29] The actual levels of factor use and hectares of land in corn production under current conditions are presented in Appendix Table B.3 by technology class.

The total increase in profits, production and factor use are presented in Table 5, Column 1. However, this is the aggregate effect of the INCORA loan and masks some important shifts. Data are presented in Table 9 on the amount of factors, profit, etc., that are produced in new technologies (other than level 7) after the INCORA loans increased working capital by $1,754,007 from the lower limit constraint. For example, there are 4,728 hectares of land in current use, with 1,521 of them in level 7. This means there are 3,207 hectares of land using new technologies brought into existence (i.e., the technology levels) by the INCORA loans. Similar interpretations hold for the difference for any row between total current, and level 7 current. Note the large share of resources used in new technology levels, and the high proportion of profit and production earned in the same new technologies.

Part of the resources used or profits and production earned in new technologies have come from switching resources from technology level 7 to new technologies, as INCORA loans became available. The difference between

[29] That is, the pattern of production after the INCORA loan is represented in the current situation.

Table 9. Factor Use, Profits, and Production in New Technologies and Share of Total

	Current		Difference = New Technologies[a]	Share of Total (%)
	Total	Level 7		
	(Current pesos except land)			
FACTOR USE				
Working Capital:	3,790,913	718,793	3,072,120	81
Seeds	241,036	57,530	183,506	76
Fertilizers	121,408	0	121,408	100
Pesticides	173,478	0	173,478	100
Rents, M & A	398,618	0	398,618	100
Packing	319,979	70,072	249,907	78
Transportation	331,166	112,361	218,805	66
Irrigation	1,950	0	1,950	100
Fuels	2,877	0	2,877	100
Labor	2,158,203	475,830	1,682,373	78
Other 1	22,720	600	22,120	97
Other 2	19,478	2,400	17,078	88
Family Labor	467,369	117,010	350,359	75
Land (hectares)	4,728	1,521	3,207	68
PROFITS	3,150,912	860,800	2,290,112	73
PRODUCTION	7,409,189	1,696,597	5,712,592	77

[a]This is the amount of factor used (profit, production) in all the technology levels besides 7. For example, consider land. There were 4,728 has. in use in all technology levels, 1,521 in level 7, for a net used in the new technologies of 3,207. Note that 3,207 is composed of 2,788 has. (Table 10) that were formerly used in technology level 7 before INCORA credit, and 419 has. of new land brought into production (Table 5).

the results of Model A (absence of INCORA loans) with the lower limit constraint on working capital where all production was concentrated in level 7, and the current level 7, is the change (decrease) in level 7 induced by the INCORA loan (Table 10).

For example, there were 4,309 hectares in corn production in level 7 in Model A-lower limit. However, in current level 7, there are only 1,521 hectares of land in production, or 2,788 were switched to other technologies for producing corn as INCORA loans were made. This, added to the 419 hectares of additional land brought into production (Table 5) yields the

Table 10. Change in Factor Use, Profits and Production in Technology, Level 7

	Model A-Lower Limit (Level 7)[a]	Current Level 7	Difference (Decrease)
	(Current pesos except land)		
FACTOR USE			
Working Capital:	2,036,906	718,793	1,318,113
Seeds	163,026	57,530	105,496
Fertilizers	0	0	0
Pesticides	0	0	0
Rents, M & A	0	0	0
Packing	198,579	70,072	128,507
Transportation	318,425	112,361	206,064
Irrigation	0	0	0
Fuels	0	0	0
Labor	1,348,384	475,830	872,554
Other 1	1,681	600	1,081
Other 2	6,809	2,400	4,409
Family Labor	331,569	117,010	214,559
Land (hectares)	4,309	1,521	2,788
PROFITS	2,439,323	860,800	1,578,523
PRODUCTION	4,807,798	1,696,597	3,111,201

[a]It will be recalled that all production was concentrated in Level 7 in the simulation.

total in new technologies, or 3,207 hectares (Table 9). Similarly, of the $2,036,906 used in working capital, $718,793 is still used in level 7, but $1,318,113 has been shifted to use in new techniques. This, added to the additional amount made available by INCORA, $1,754,007 (Table 5), is the total amount of working capital available for use in new technologies ($3,072,120, Table 9).

Thus, increases in profits and production from new technologies are due to both a) the increase in working capital from the INCORA loan; and b) the shift in working capital (in existence before the INCORA loan) to more modern techniques. However, it is important to recognize that it is

the provision of the loan that makes it profitable to shift resources previously in use in less modern technologies into new techniques of production.

Effect of INCORA loan policy on efficiency of resource allocation

Program of current situation with restricted use of working capital.-- The results of solving Model B.1 are presented in Table 11. This is the linear program of the current situation (with INCORA loans) under the behavioral assumption of profit maximization, and assuming working capital is restricted to be used among the 11 factors requiring it as revealed in the data. Production takes place in this solution in technology levels 2, 4, 5, 7, and 8, with the majority in levels 7 and 8.

The difference between the current situation and the results of Model B.1 (restricted working capital) is presented in Table 12. Profits are increased by $299,025 or 9.5%, and production increased slightly. However, of available working capital ($3,709,913) only $3,524,246 is used, leaving $266,667 as slack. Also, family labor is not all used up.

Thus, increases in profits and production can occur using fewer resources, if production were in the technology levels in the program solution rather than the current pattern. However, it is unlikely that such shifts will occur due to immobility and heterogeneity of resources, and imperfect knowledge. For example, the model assumes resources are completely mobile. Since technology levels tend to be concentrated in specific regions of the country, resources may have to be moved physically from one location to another to produce in the technology classes suggested in the program. Such mobility may not be possible for a variety of reasons.

Table 11. Results of Programming Current Situation with Working Capital Restricted to be Used for Certain Inputs (Model B.1)

	Level 2	Level 4	Level 5	Level 7	Level 8	Total
			(Current pesos except land)			
FACTOR USE						
Working Capital:	743,127	253,547	365,409	940,660	1,221,495	3,524,246
Seeds	47,024	11,298	30,449	75,287	74,211	238,269
Fertilizers	45,714	4,702	70,990	0	0	121,408
Pesticides	50,901	1,974	17,481	0	0	70,359
Rents, A & M	227,350	57,455	56,596	0	0	341,404
Packing	57,981	21,884	22,103	91,706	62,720	256,394
Transportation	24,384	28,352	18,631	147,051	81,453	299,873
Irrigation	0	1,448	502	0	0	1,950
Fuels	2,877	0	0	0	0	2,877
Labor	263,610	125,565	144,248	622,694	1,002,179	2,158,302
Other 1	12,039	867	4,408	776	932	19,021
Other 2	11,245	0	0	3,144	0	14,390
Family Labor	45,501	25,442	46,187	153,121	192,197	462,449
Land (hectares)	469	242	364	1,990	1,635	4,728
PROFITS	556,322	187,361	342,199	1,126,499	1,237,547	3,449,937
PRODUCTION	1,344,946	466,108	753,794	2,220,280	2,651,239	7,436,385

Table 12. Current Situation Compared to Results of Model B.1 (Restricted Working Capital)

	Current	Model B.1	Differences[a]
	(Current pesos except land)		
FACTOR USE			
Working Capital:	3,790,913	3,524,246	-266,667
Seeds	241,036	238,269	-2,767
Fertilizers	121,408	121,408	0
Pesticides	173,478	70,359	-103,119
Rentals M & A	398,618	341,404	-57,214
Packing	319,979	256,394	-63,585
Transportation	331,166	299,873	-31,293
Irrigation	1,950	1,950	0
Fuels	2,877	2,877	0
Labor	2,158,203	2,158,302	0
Other 1	22,720	19,021	-3,699
Other 2	19,478	14,390	-5,088
Family Labor	467,369	462,450	-4,919
Land (hectares)	4,728	4,728	---
PROFITS	3,150,912	3,449,937	+299,025
PRODUCTION	7,409,189	7,436,386	27,197

[a]Using current as the base, the difference is Model B.1 less current.

If knowledge of available techniques is not perfect, some farmers will fail to adopt optimal production practices, and imperfect knowledge of product and factor prices will have the same effect. Finally, if resources are not homogeneous production or profits cannot reach the level implied in the program. The model assumes land is homogeneous and that any technique can be used. If physical or locational characteristics of land dictate otherwise, profits and production suggested in the program cannot be reached.

Thus, the difference between the current situation and Model B.1 represents increases in profits and production that would occur if resources were perfectly mobile and homogeneous, and knowledge perfect. The fact that profits only increase by 9.5% in the program over the current situation suggests that corn production is quite efficiently organized in the country, given the restrictions on how working capital can be used, as imposed by INCORA.[30]

Program of current situation with unrestricted use of working capital.--The results of programming the current situation, under profit maximization, but with the restrictive assumption about working capital dropped (Model B.2), are presented in Table 13. This model explicitly assumes working capital can be used for any resources requiring working capital. In this case, all production is concentrated in technology levels 2, 5, and 7, with the majority in level 5.

The difference between the current situation and Model B.2 are presented in Table 14. This difference is due to both: (a) assuming all resources are homogeneous and perfectly mobile, and knowledge is perfect; and (b) assuming that working capital is not required to be used for certain resources, but can be allocated to its most efficient use. In this case, since all resources are used in both the current and programmed models, but resource use is not increased, increases in production are equal to increases in profits.

Inefficient resource use due to restrictive loan policy.--Model B.1 measures only the increase in profits, etc., due to having perfect factor mobility and homogeneity, and perfect knowledge while working capital is restricted to be used in a specific way, and Model B.2 measures the additional effect of permitting working capital to be freely allocated. Consequently, the difference between Model B.2 and Model B.1 may be

[30]This result supports Schultz's hypothesis that resources in traditional agriculture tend to be efficiently organized. That is, for our country-wide sample very little increase in profits on production could be obtained by reallocating resources. See Schultz, *Transforming Traditional Agriculture*.

Table 13. Results of Programming Current Situation with Unrestricted Working Capital (Model B.2)

	Level 2	Level 5	Level 7	Total
	(Current pesos except land)			
FACTOR USE				
Working Capital:	783,967	1,925,838	1,080,108	3,790,913
Seeds	49,608	160,560	86,448	296,616
Fertilizers	48,226	374,340	0	422,566
Pesticides	53,700	92,179	0	145,879
Rentals M & A	239,845	298,436	0	538,281
Packing	61,167	116,553	105,301	283,021
Transportation	25,725	98,243	168,851	292,820
Irrigation	0	2,649	0	2,649
Fuels	3,035	0	0	3,035
Labor	278,097	760,637	715,007	1,753,741
Other 1	12,700	23,241	891	36,833
Other 2	11,861	0	3,610	15,474
Family Labor	48,001	243,546	175,820	467,369
Land (hectares)	523	1,919	2,285	4,728
PROFITS	586,896	1,804,451	1,293,498	3,684,844
PRODUCTION	1,418,859	3,974,836	2,549,427	7,943,121

Table 14. Current Situation Compared to Results of Model B.2 (Unrestricted Working Capital)

	Current	Model B.2[a]	Difference[b]	% Change
		(Current pesos except land)		
FACTOR USE				
Working Capital:	3,790,913	3,790,913	--	0
Seeds	241,036	296,616	55,580	23
Fertilizers	121,408	422,566	301,158	248
Pesticides	173,478	145,879	-27,599	-16
Rentals, M & A	398,618	538,281	139,663	35
Packing	319,979	283,021	-36,958	-12
Transportation	331,166	292,820	-38,346	-12
Irrigation	1,950	2,649	699	36
Fuels	2,877	3,035	158	5
Labor	2,158,203	1,753,741	-404,462	-19
Other 1	22,720	36,833	14,113	62
Other 2	19,478	15,474	-4,004	-21
Family Labor	467,369	467,369	--	0
Land (hectares)	4,728	4,728	--	0
PROFITS	3,150,912	3,684,845	533,933	17
PRODUCTION	7,409,189	7,943,121	533,933	7

[a]All production is in technologies 2, 5 and 7.

[b]Using current as the base, the difference is Model B.2 less current.

interpreted as the effect of INCORA's restrictive loan policy on profits, production, and use of resources.

These differences are presented in Table 15. This comparison suggests that profits would be greater than the current situation by $234,908 (7.5%), and production by $506,735 (6.8%), if INCORA would have not restricted loans for working capital to use of certain resources.

Although there is apparently a substantial change in resource use, this is more difficult to document. First, in Model B.1, under the tying of working capital to specific resources, less working capital was used than in the current situation. In Model B.2, with no restriction on

Table 15. Impact of INCORA Policy of Tying Working Capital to Resources, on Profits, Production, and Factor Use

	Model B.2 Unrestricted Use of Working Capital	Model B.1 Restricted Use of Working Capital	Difference
		(Current pesos except land)	
FACTOR USE			
Working Capital:	3,790,913	3,524,246	266,667
Seeds	296,616	238,269	58,347
Fertilizers	422,566	121,408	301,158
Pesticides	145,879	70,359	75,520
Rentals,	538,281	341,404	196,877
Packing	283,021	256,394	26,627
Transportation	292,820	299,873	-7,053
Irrigation	2,649	1,950	699
Fuels	3,035	2,877	158
Labor	1,753,741	2,158,203	-404,462
Other 1	36,833	19,021	17,812
Other 2	15,474	14,390	1,084
Family Labor	467,369	462,450	4,919
Land (hectares)	4,728	4,728	--
PROFITS	3,684,845	3,449,937	234,908
PRODUCTION	7,943,121	7,436,386	506,735

working capital, all available working capital was used. This implies that freeing working capital so that it can be allocated to its most efficient use increases the level of working capital in use.

However, in the current situation, all working capital available is used up. In this situation, freeing working capital from use for specific factors would not increase the total amount available. The impact on resource use will be somewhat different than revealed in our model because of this. That is, our model measures, for restricted and unrestricted use of working capital, differences between profits, production, and factor use when all factors are homogeneous, mobile, and the information system is perfect. This is an approximation of the effect of removing INCORA's restrictive policy in the current situation.

The comparison does suggest, however, that there will be a shift in resource use from labor to more modern factors of production if working capital could be freely allocated. Labor use declines absolutely by 19% from the current level, while fertilizer use increases by 248%, rentals by 49%, and pesticides by 44%.

The shadow price on working capital in Model B.2 is still $.51. This suggests that the addition of INCORA loans to the lower and upper limit constraints did reduce the gross return to working capital.[31] However, the rate of interest on INCORA loans is only 11% suggesting an excess demand for INCORA loan funds, if the shadow price accurately measures the opportunity cost of capital.

[31]See pages 27-28 above.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

There are three general sets of conclusions which can be drawn from the above analysis. First, INCORA loans for working capital for the sample of borrowers producing corn increased profits and production, modified the pattern of resource use, and induced technical change. Second, INCORA's policy of tying loan proceeds to purchase of specific inputs limited profits and production for the sample of borrowers, and led to a more labor intensive production process, than if working capital had been freely allocated. Finally, apparent shortages of agricultural credit, as evidenced by requests for INCORA loans that exceed available funds, may be explained by divergences between the shadow price of working capital, and the rate charged for INCORA loans.

Increased profits and production are due to INCORA credit.--INCORA loans to the sample of small farmers were directed to modern inputs and new production technologies. This apparently reflects the tying of loan proceeds to resources and techniques deemed desirable by project managers. Also, it reflects the technical assistance component of INCORA credit, with such assistance proffered at the farm level by the credit supervisor during his periodic visits.

In any case, use of modern inputs (fertilizers, pesticides, and machinery and animal rentals) increased from 0% (or from 5.5% depending on the assumption about the level of working capital in the absence of INCORA) of working capital in the absence of INCORA loans to over 18% of working capital with INCORA loans. That is, from 40% to 50% (depending on

the assumption) of INCORA loans were devoted to the purchase of these modern inputs.

At the same time, there was a definite shift to more modern technologies to produce corn. While corn production in the absence of INCORA loans was either wholly or mainly (depending on assumptions) in the lowest technology level, after such loans, most production, and factor use was concentrated in more modern technologies. In fact, 27% of total corn production was on mechanized farms. Not only were INCORA loans devoted to more modern inputs and techniques, but flexibility introduced by these loans enabled farmers to devote much of the working capital in existence before INCORA to the more modern inputs and techniques of production.

Use of labor also increased by 29% to 60% (depending on the assumptions). This rate was less than the rate of increase in working capital (from INCORA loans) and much less than the rate of increase in modern factors, so the share of working capital devoted to labor fell as INCORA loans were made. However, the relatively large share of working capital devoted to labor in the absence of INCORA loans, and the modest growth rate in labor use as INCORA loans were made, led to substantial portions of such loans being devoted to labor. It is estimated that from 35% to 46% of INCORA loan proceeds were used to hire labor (depending on the assumptions). This reflects the complementarily between labor and the modern inputs.

The increase in use of modern factors, and shift to new technologies led to increases in yields, and hence production. It is estimated that production increased by 33% to 54% depending on assumptions. Increases in costs were less than increases in revenues, so that profits were increased by 13% to 29%.

INCORA's restrictive loan policy leads to inefficient allocation of resources.--Profits and production would have been even greater if INCORA had not followed the policy of restricting the use of loans to purchase certain factors of production. It is estimated that production would have been increased by 6.8% and profits by 7.5% if recipients of INCORA loans had been free and able to allocate them to their most efficient use.

Evidence at hand also leads to the conclusion that INCORA's restrictive loan policy led to use of more labor, and less modern inputs, than if working capital would have been freely allocated. That is, when working capital (including INCORA loans) is freely allocated in Model B.2, labor use is reduced absolutely by $404,462 or 19%, and use of modern inputs increased. This suggests that INCORA subsidized the use of labor relative to other factors of production encouraging economy in their use. If INCORA loans had been unrestricted, use of modern inputs would have increased more rapidly than they did, and would have been a larger share of INCORA loan proceeds, and of total working capital. At the same time, labor use would have increased much more slowly, and would have been a smaller share of loans, and working capital.

Excess demand is not evidence of credit shortage when shadow price exceeds INCORA price.--Requests for INCORA loans have far exceeded loan funds.[32] As Adams has pointed out in a recent paper, this phenomenon is used to argue that agricultural credit is in short supply and thus is a bottleneck to more rapid agricultural development.[33] On this basis, it might be argued that such credit ought to be expanded.[34] However, as

[32] See Schwinden and Feaster, "The INCORA Supervised Credit Program," p.40.

[33] Adams, "Agricultural Credit in Latin America."

[34] Schwinden and Feaster, "The INCORA Supervised Credit Program," pp. 41-42.

Adams indicates, this assertion is certainly open to question and alternative suppositions.

The analysis in this study suggests the MVP of working capital is at least $.51, i.e., the shadow price on working capital in Model B.1 (unrestricted use of working capital in the current situation). As has been mentioned this may be interpreted as the gross rate of return on working capital. The nominal interest charge on INCORA loans is only 11% during the period 1968-1970.[35]

Thus, there is a sizeable divergence between the market price of working capital (as measured by the shadow price), and the institutional price. It is obvious that there will be a large number of people desiring to borrow at this price. The apparent "shortage" of agricultural credit in Colombia is revealed for what it is; a disequilibrium between supply and demand at an institutional price for working capital much below the market price.

Our results support Adams contention that loan requests in excess of funds is not a valid basis for concluding that there is a shortage of credit and hence a bottleneck to development.

In this situation, the existence of more requests for loans than funds, is not an economic basis for deciding if credit ought to be expanded. If the Government of Colombia (GOC) is concerned with efficiently allocating development resources, the rate of return to this use of the funds needs to be compared to alternatives (from the point of view of society, since it is involved in providing the service). Even if such requests existed when the institutional price was equal to the market price (indicating strong demand for loan funds), one would need to know the relative return from alternative forms of investment of the government's development resources.

Alternatively, the goal of society may be subsidization of a group in society, at the expense of efficient use of public resources. Or it may be a joint goal of subsidization of a group, and maintenance or increases in the level of per capita production (i.e., a limit on how much "inefficiency" will be tolerated). The goal of INCORA and the GOC apparently was to transfer income to a certain group (thus, leading to a more egalitarian distribution of income), to concomitantly increase employment, and also to increase production. From our results, they have been fairly successful among INCORA borrowers producing corn.

The INCORA loans involved a real subsidy to the farmer, if the shadow price of working capital ($.51) is the market price and gross rate of return. This suggests that if 1 peso of INCORA working capital were added, it would increase profits (as defined above) by $.51. However, $.40 of this would be a transfer from the GOC to the farmer, since the cost to him is only $.11. Also, INCORA has tended to subsidize the use of hired labor more than other resources. This (if INCORA borrowers tend to hire labor from each other) in conjunction with the subsidy, should have led to improvement in the relative income position of INCORA borrowers vis-a-vis society.

Adams indicates another argument often put forth to support the idea of a shortage of agricultural credit is that technical change has a high credit propensity.[36] While Adams found mixed results to support that assertion, our results strongly support it. The results indicate that the addition of INCORA loan funds did induce a great shift to more modern technologies, and out of traditional ones.

[35] Ibid., p. 49.

[36] Adams, "Agricultural Credit in Latin America."

Policy implications

The ideas presented here must be considered in light of the very narrow focus of this research report, and the assumptions underlying the analysis. With this caveat in mind, there are some general policy implications which follow from the results of this study. First, supervised credit, if administered in a similar manner and setting as was INCORA credit, may be expected to increase profits, production, and employment, and lead to adoption of more modern inputs and techniques of production. Second, requiring supervised credit to be used to purchase specific inputs will lead to an inefficient allocation of resources. Finally, the existence of excess demand for agricultural credit is not necessarily an indication that such credit is a limiting factor to agricultural development. If resources are directed to supervised credit, upon the premise of excess demand when the institutional price of credit is much less than the market price, such resources are very likely to be inefficiently used.

Supervised credit and agricultural development.--Governments or international lending agencies, who are anxious to increase profits, production, and use of modern factors and technology in agriculture of LDC's, may be encouraged by the experience of INCORA borrowers. However, there are several points to be kept in mind before investing in supervised credit as the panacea for agricultural backwardness. First, INCORA credit was integrated into a much larger package of land reform and infrastructural development, and had a very strong component of technical assistance, with credit loans tied to use of modern factors, and techniques. Second, the cost of credit was very highly subsidized. It is likely that production responses and shifts to more modern techniques would have been much less pronounced if farmers had been required to pay the opportunity cost of the credit.

While we have no direct evidence on this point, it is likely that some subsidy may be required to induce technical change. More critical is the length of time required for the subsidy before production under the new technique is self-sustaining at market prices. If the subsidy is relatively large, there is a risk that producers will revert back to less modern, but more profitable practices, as soon as subsidies stop.

Consequently, international lending agencies, and/or governments, who are considering investment in supervised credit as a means of agricultural development, should consider these aspects of INCORA's experience. While the models suggest production, profits, and employment did increase rapidly, the environment was unique and heavy subsidies were involved. The cost to society of any credit program needs to be considered relative to alternative ways of stimulating agricultural production.

Restricted use of supervised credit and inefficient resource allocation.--Any government or lending agency making loans for supervised credit or credit programs should be aware that tying the credit to the purchase of specific factors will likely lead to inefficient allocation of resources. While doing so may serve objectives other than efficiency, it would seem desirable to know the social cost of achieving the stated objective, in terms of foregone production or profits. For example, if maximizing employment is the objective, it would seem important to calculate the marginal cost (in terms of production foregone) of adding one more unit of employment. Such analysis may lead to society allocating resources most efficiently, then supporting the unemployed via a direct subsidy based on taxation of the now greater production.

Excess demand and credit bottleneck.--Lending agencies and governments should be very cautious in assuming that excess of requests for loans from

a supervised credit program over available funds indicates a bottleneck to agricultural development. If additional resources are committed for expanding supervised credit programs on the basis of this kind of evidence, it is likely that such resources will be inefficiently utilized. When the market price for credit is greater than the institutional price, such demand will always exist. Even when the institutional price is market determined, there is no *a priori* way to translate strong demand for institutional credit into the idea that lack of credit is a deterrent to agricultural development. In this case, before scarce development resources are committed, the government or agency involved should consider alternatives that might have higher payoff to society. However, strong demand for credit (as implied in a rising market price), suggests that the marginal product of such credit is relatively high.

Suggestions for further research

This study has been concerned only with INCORA borrowers producing corn, and has utilized some restrictive assumptions. In order to assess the impact of entire INCORA credit program, this research needs to be expanded in at least four major areas. First, a sample of all INCORA borrowers should be included, not just those producing corn. Second, an attempt should be made to assess the impact of INCORA loans for capital items. Third, the study should be expanded to consider the opportunity costs of producing crops via INCORA loans, and trade offs between efficiency and employment, or efficiency and improved income distribution. Finally, the impact of INCORA loans on non-borrowers, other credit institutions, and linkage effects should be researched.

Study all borrowers and crops.--A similar model to the one used in this study could be used to program the production milieu of all borrowers in the absence of INCORA loans. Activities (n of them) representing technology classes could be defined for each of m crops, as could profit coefficients and constraints in the absence of INCORA loans. Land constraints could be more carefully defined, with physical characteristics considered. This could also be true with respect to family labor, recognizing mobility problems. This would lead to an objective function of (m·n) variables. Such a model would consider interrelationships between all crops and techniques, and the enlarged and more realistic set of land, and family labor constraints.

Consider loans for fixed capital.--This model could be expanded to consider the role of INCORA loans for both working capital, and for fixed capital. In the model described directly above, profits might be defined as in this study, i.e., the return to land, management, and fixed resources. However, fixed resources could also be costed out and included as a constraint. In this way, a constraint could be developed for annual fixed capital services. This would permit analysis of not only INCORA's working capital but also of fixed capital, and relative profitability to the farmer. This is important considering around 50% of all INCORA loans go for fixed capital.[37] Also, it would permit a determination of changes in profits, production, and resource use, when profits are the return to land and management, which is likely to be the long run decision model for farmers.

The social costs of crops produced with INCORA.--The question of the social (opportunity) cost of producing corn with INCORA credits has not been included in this study. Given the limited resources of the GOC, it would be desirable to assess the cost of producing corn with the highly

[37]Schwinden and Feaster, "The INCORA Supervised Credit Program," p. 30.

subsidized INCORA credit relative to corn produced under market conditions, even under other than efficiency goods. In this regard, the trade offs between efficiency and increased employment, and efficiency and the more equal income distribution should be assessed. That is, the cost to society (in foregone production or profits) of creating one job, or one unit decrease in the distribution of income (i.e., in the variance of income), via INCORA credit needs to be determined as a basis for better public decision making.

Other more global impacts of INCORA

Finally, the effect of INCORA on non-borrowers, on other credit institutions, and linkage effects needs to be considered. It is possible that demonstration effects on neighbors may be sizeable although evidence so far is to the contrary.[38] It is not known to what extent INCORA has taken business away from other firms or has inflenced their practices. Finally, strong linkages to other subsectors and sectors, could indicate the viability of INCORA credit, if such multipliers were greater than if credit were supplied via the market.

[38]See Adams, et al., "Supervised Credit in Colombia's Agrarian Reform.

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APPENDIX A:

Distribution of Technology Classes by Regions

APPENDIX A:
Distribution of Technology Classes by Regions

Data are presented in Appendix Table A.1 showing the distribution of the technology classes by region. By reading down the columns, one gets an idea of the distribution of the technology class among the regions. In every case, technology classes tend to be concentrated in a small number of regions. For example, 42% of the farms in technology class X_1 are located in Bolivar (131) with 18% and 19% in Tolima #2 (732), and Valle #2 (762), respectively, for a total of 79% in these three regions.

By reading across the columns, the distribution of technology classes within a region can be determined. Once again, each region tends to have small number of technology classes. For example, in Bolivar (131), 69% of the farms are in technology class X_1, and 23% in technology class X_2 for a total of 92% in these two classes. The only possible exception seems to be Cundinamarca #1 (251) where the 253 farms are fairly evenly distributed across six technology classes using only human power.

Thus, we conclude, that there is little variation in technology within a region, and most technology classes are concentrated in a few regions. That is, technology class X_1 tends to be found in only 1 or 2 of the regions, etc.

Table A.1. Distribution of Farms in Sample by Region and Technology Class.

Technology Class/Regions	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	No. of Farms
Antioquia	0	0	0	0	0	2	14	11	11	6	0	12	56
Bolívar	24	8	0	0	0	0	0	0	2	0	1	0	35
Boyaca	0	2	1	18	14	4	6	3	3	1	3	7	62
Magdalena Medio	1	11	2	0	0	5	7	9	1	13	1	0	50
Cauca	0	0	0	0	0	0	0	0	0	0	0	0	0
Cauca (El Charco)	0	0	1	0	0	0	6	4	5	2	16	2	36
César (Pailitas)	0	0	0	0	0	8	41	5	1	16	0	2	73
Córdoba	2	7	0	0	0	0	0	0	0	0	1	1	11
Cundinamarca #1	0	0	0	4	0	1	63	41	19	37	77	11	243
Cundinamarca #3	0	0	0	2	0	1	2	2	3	0	2	2	14
Cundinamarca #4	0	0	0	0	1	1	0	3	2	0	1	3	11
Choco	0	0	0	0	0	4	10	2	0	14	0	3	33
Huila	1	4	1	0	0	0	6	4	0	0	0	0	16
Magdalena Medio	0	0	0	0	0	0	3	6	2	0	0	0	11
Meta	0	0	0	3	2	7	13	2	0	3	1	1	32
Narino	0	0	0	8	7	1	1	3	39	1	10	9	79
Norte de Santander (Abrego)	0	0	0	0	1	0	1	0	0	1	0	1	4
Norte de Santander (Tibú)	0	0	0	0	0	2	2	0	0	3	0	0	7
Pereira	0	0	0	0	0	0	8	0	0	1	0	0	9
Santander	0	0	0	1	8	30	29	3	2	16	1	3	93
Tolima #1	1	6	0	0	0	0	0	0	1	0	1	0	9
Tolima #2	10	15	18	0	0	1	0	3	0	2	7	2	58
Tolima #3	0	1	12	0	0	0	0	0	0	0	0	0	13
Valle #1	7	17	2	0	0	1	0	0	0	1	0	0	28
Valle #2	11	22	5	0	0	2	2	0	0	0	0	1	43
Arauca	0	0	0	0	0	18	18	0	0	1	0	0	37
Caqueta	0	0	0	0	0	76	64	0	0	23	2	1	166
Number of Farms	57	93	42	36	33	164	296	101	91	131	124	61	1229

APPENDIX B:

Data for Models A and B, The Current Situation, and Miscellaneous Results

Table B.1. Data for Linear Programming Models A, B.1, and B.2. Excepting Working Capital Constraints for B.1, and B.2.[a]

Set a_{ij} = Factors Needing Working Capital:	Activities = Technology Class X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	Constraints b_j & b_i	
Seeds	94.23	94.80	96.68	46.51	83.66	37.83	45.48	32.28	48.63	32.99	64.83	174,583		
Fertilizers	1.97	92.16	250.14	19.36	195.05	0.00	0.00	0.00	4.83	4.03	88.81	37,479		
Pests	35.83	102.62	185.26	8.13	48.03	0.00	0.00	0.00	57.59	57.91	111.64	83,308		
Pests MA	415.29	458.34	514.90	256.53	155.50	0.00	0.00	0.00	0.00	0.00	0.00	100,937		
Packing	102.68	116.88	207.43	90.09	60.73	46.08	38.37	72.97	53.64	67.04	51.48	225,010		
Transportation	35.87	49.16	85.80	116.72	51.19	73.89	49.83	116.68	62.60	74.57	64.84	300,719		$= b_j$, $j=1, \ldots, 11$.
Irrigation	3.60	0.00	1.95	5.96	1.38	0.00	0.00	0.00	.24	0.00	0.00	1,100		
Fuels	1.87	5.80	.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,417		
Labor	402.92	531.44	738.85	516.92	396.33	312.89	613.10	780.31	290.13	651.27	467.78	1,867,488		
Other 1	22.55	24.27	17.80	3.87	12.11	.38	.57	.32	1.71	.76	7.27	16,318		
Other 2	.4.05	22.67	33.90	0.00	0.00	1.58	0.00	.64	.34	0.00	0.00	9,507		
a_{1j} = Working Capital	1,124.27	1,498.15	2,133.70	1,042.79	1,003.98	472.66	747.27	1,003.21	500.63	888.57	854.89	2,036,906		$= \sum_{j=1}^{11} b_j = b_1$
a_{2j} = Family Labor	123.67	91.73	58.14	104.74	126.90	76.99	117.58	145.10	81.63	137.81	104.17	(2,400,173)$=b_1$ = 467,340		$= b_2$
a_{3j} = Land	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4,728.66		$= b_3$
c_j = Profit Objective Function	272.77	1,121.55	908.48	770.32	940.21	566.04	757.09	725.78	545.82	712.55	674.81			
c_j = Production Objective Function	1,520.71	2,711.42	3,100.32	1,918.85	2,071.09	1,115.64	1,621.94	1,894.09	1,126.68	1,738.93	1,633.87			

[a]See Table B.2 for working capital constraints for Models B.1, and B.2.

Appendix Table B.2. Additional Data on Constraints Necessary to Solve Models B.1, and B.2[a]

Models	Working Capital Constraints Current pesos
Model B.1	
Seeds	241,036
Fertilizers	121,408
Pesticides	173,478
Rentals M & A	398,618
Packing	319,979
Transportation	331,166
Irrigation	1,950
Fuels	2,877
Labor	2,158,203
Other 1	22,720
Other 2	19,478
Model B.2 (Total)	3,790,913

[a]All other data for Models B.1, and B.2, including a_{ij}, c_j, and land and family labor constraints are contained in Appendix Table B.1.

Table 8.3. The Current Situation

FACTORS	Total	X_1	X_2	X_3	X_4	X_5	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Working Capital	3,790,913	227,935	588,435	437,650	87,595	58,011	718,793	263,621	313,857	413,267	844,456	137,493
Seeds	241,836	20,118	37,234	19,825	3,963	4,854	57,539	16,816	18,899	48,968	20,713	16,288
Fertilizers	121,488	488	36,198	51,284	1,625	11,279	0	0	0	4,896	2,478	14,155
Pesticides	173,478	7,265	40,387	37,962	662	2,775	0	0	0	21,828	38,484	17,915
Rents[b]	298,618	84,196	180,034	106,564	19,850	8,985	0	0	0	0	0	0
Packing	219,979	28,411	45,918	42,528	7,560	3,589	70,872	13,536	22,830	44,281	41,976	8,266
Transportation	231,166	7,272	19,308	17,580	9,795	2,958	112,361	17,580	36,588	51,674	45,690	10,439
Irrigation	1,958	778	9,888	400	509	80	0	0	0	286	0	0
Fuels	2,877	488	2,277	200	608	00	0	0	0	0	0	0
Labor	2,158,283	81,647	286,730	151,479	45,288	22,908	475,238	216,288	244,128	239,508	289,058	75,229
Other 1	22,728	6,595	9,531	3,458	300	700	600	288	188	1,418	464	1,179
Other 2	19,478	822	8,906	6,950	000	000	2,400	0	288	288	0	0
Family Labor	447,368	25,873	36,028	11,928	8,798	7,132	117,018	41,488	51,658	66,888	84,443	16,733
Land (Hectares)	4,727.66	282.74	292.78	285.02	83.02	57.78	1,528.74	332.78	312.85	825.48	612.74	168.83
PROFITS	3,158,911.58	55,301.39	448,522.41	186,256.96	64,645.27	54,325.73	860,799.66	267,847.22	227,041.22	448,905.28	436,665.62	168,400.28
PRODUCT	7,409,189	288,308.88	1,044,982.89	635,628	161,838	1.8,648	1,496,287	572,188	282,147	938,884	1,868,518	262,646

[a]Based on the sample of 1,068 INCORA borrowers producing corn.

[b]Rentals of machinery and animals.

Appendix Table B.4. Results of Solving Model A with Upper Limit Constraint on Working Capital

	Part A. Profit Maximization			Part B. Production Maximization		
	Level 5	Level 7	Total	Level 7	Level 8	Total
FACTOR USE						
Working Capital	329,917.88	2,079,254.96	2,409,173	1,934,058.55	475,114.27	2,409,173
Seeds	27,491.51	166,416.06	193,907.57	154,795.06	28,865.32	183,660
Fertilizers	64,095.38	0	64,095.38	0	0	0
Pesticides	15,783.14	0	15,783.14	0	0	0
Rentals M & A	51,098.86	0	51,098.86	0	0	0
Packing	19,956.49	202,708.22	222,664.71	188,552.91	24,395.65	212,949
Transportation	16,821.55	325,045.80	341,867.35	302,347.54	31,681.91	334,029
Irrigation	453.48	0	453.48	0	0	0
Fuels	0	0	0	0	0	0
Labor	130,238.00	1,376,418.75	1,506,656.75	1,280,302.08	389,808.98	1,670,111
Other 1	3,979.47	1,715.63	5,695.10	1,595.83	362.41	1,958
Other 2	0	6,950.50	6,950.50	6,465.14	0	6,465
Family Labor	41,700.61	338,462.91	380,165.53	314,827.71	74,757.36	389,585
Land	328.61	4,399.05	4,727.66	4,091.86	635.80	4,727.66
PROFITS	308,962.41	2,490,038.26	2,799,001	2,316,156.43	481,357.82	2,797,514.39
PRODUCTION	680,580.88	4,907,756.14	5,588,337	4,565,042.69	1,031,229.45	5,596,272

DISCUSSION OF

Supervised Credit: Its Impact on Profits, Production, Factor Use, Technical Change, And Efficiency of Resource Allocation In Corn Production In Colombian Agriculture

by

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and

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Having worked closely with Dr. Whitaker at various stages of his analysis, we wish first of all to commend him for his write-up of the study, particularly for his clear elaboration of the models employed and the complex of assumptions underlying them. We have certain qualms over phraseology used in the paper but for the purposes of this discussion, let us focus solely on overall methodology and on the three general sets of conclusions drawn from the analysis.

Methodology

Quite apart from substantive results, perhaps the major contribution of the study is a methodological one. Presence of reliable "before" and "after" data is commonly regarded as a necessary condition for analyzing credit impacts. But what Dr. Whitaker's analysis indicates is that "after" data alone may suffice. In fact, in at least one sense, use of "simulated" absence-of-credit budgets[1] is preferable to a strict "before" and "after" comparison--since the results of the latter type of analysis could well be biased by the vagaries of one of the two production periods considered.

Conclusions

We have no disagreement with Dr. Whitaker concerning INCORA's substantial impact on corn profits and production, factor use and technical change. With regard to INCORA's tendency to tie inputs to certain resources, however, it is not clear to us that if working capital had been permitted to be freely allocated by the farmers in the sample, increases in profits and production would have resulted.

On the basis of the differences between Models B.2 and B.1, it is indeed tempting to infer that the INCORA policy of tying loans to specific inputs was the sole cause of the reduction in profits and production associated with these differences. However, the paper fails to mention how inputs were tied and furthermore, it is known, in fact, that loans were not explicitly tied to labor. Moreover, to the extent that INCORA loans were tied, they seem to have been tied to precisely the modern inputs suggested by the differences between B.2 and B.1.

That corn farmers in the INCORA program could have been somewhat

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[1] In clarification, it should perhaps be noted that although it may be tempting to visualize the budgets derived for Model A as pre-INCORA budgets, these budgets do not, strictly speaking, represent how the sample of corn-producing borrowers probably allocated resources prior to their entrance into the INCORA program but, hopefully, how they would have allocated resources in 1968-70 if INCORA credit had not been available to them.

more "efficient" in the use of resources seems clear.[2] The real issue, however, hinges on the question of what we mean by "efficiency" in this context. In a static world, there would of course, under the assumption that small farmers are "efficient," be no need for a credit agency to tie its loanable funds to specific resources. But in a context of rapid technological change--the context encompassed by the study, one would naturally expect farmers' knowledge of and experience with modern input packages to be quite limited and, moreover, "rational" reluctance on their part to adopt what they regard as high-risk production practices. In this context, then, a context in which an adjustment period is most likely required before farmers are comfortable with and convinced of the benefits springing from use of these packages, it may be worthwhile for the credit agency in question to use the mechanism of loan-tying to induce the shift to these practices and reduce the time of this adjustment.[3]

We would conclude therefore that while, again, INCORA corn farmers probably could have allocated resources in a different manner so as to yield higher production and profits, it is unclear that resources should have been permitted to be freely allocated by the farmer. Given farmers' risk aversion and lack of knowledge and experience, perhaps even less modern inputs would have been used.

Concerning the issue of whether excess demand is evidence of credit shortage when shadow price exceeds INCORA price, the argument that "the apparent 'shortage' of agricultural credit in Colombia is revealed for what it is: a disequilibrium between supply and demand at an institutional price for working capital much below the market price," (page 50) stands in need of qualification.[4]

The argument presented rests on the assumption that the market price can be measured by the shadow price. The going market price for working capital in Colombia in 1968-70, however, was in the range of $ .20 to $ .25, substantially below any shadow price for working capital derived for corn producers in the analysis.[5] Hence, at least for corn production, there would seem to have been a genuine excess demand for loanable funds. Two conclusions therefore follow. First, INCORA need not have subsidized credit but could have provided funds to corn farmers at the going market price with substantial gains in profits and production and changes in factor use and technology. Secondly, substantially more funds could have been provided at the market rate with beneficial effects (in terms of profits and production).

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[2]We should note, however, that as stressed on pages 9 and 10, the differences between B.1 and the observed situation are not really that great--thus buttressing confidence in the model's validity and confirming the hypothesis that INCORA corn farmers are quite "efficient." Furthermore, if the differences between B.2 and B.1 can be legitimately interpreted as measures of INCORA "inefficiency," INCORA too seems, overall, to have allocated its resources in an "efficient" manner.

[3]In the instance of INCORA, it may actually have been the case that the high percentage of INCORA loans used to defray labor costs was the result of superisors' attempts to entice farmers to use modern inputs. And hence, it could actually be argued that maybe INCORA should, if possible, have had a more restrictive loan policy--or, more concretely, that more credit for improved practice inputs should have been extended in specie and less liquid capital for the financing of man-days of labor. Such a policy, as a by-product, might also have diminished the farmers' dependence on the institution (INCORA) as a provider of wages for labor and thus induced more savings from the beneficiaries as such.

[4]Dr. Whitaker is actually in full agreement with what follows.

[5]Thus, the degree of subsidization by INCORA was not as high as might be gathered from a superficial reading of the paper.