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PEASANT PRODUCTIVITY AND DIFFERENTIATION:
A MICROECONOMETRIC ANALYSIS OF THE IMPACT OF SMALL FARM CREDIT IN NICARAGUA*

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ABSTRACT

An endogenous switching regressions framework is used to structure and identify the impact of credit on small farm food production in Nicaragua. The results which emerge suggest that credit had a positive impact on production. However, the estimated impact is of a form which implies a process of peasant differentiation and unequal growth in the wake of the new opportunities afforded by credit.

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PEASANT PRODUCTIVITY AND DIFFERENTIATION:
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Credit market intervention and credit market liberalization policies have both been justified on the grounds of improving the formal credit market access of small farms. Yet the impact of improved credit access on small farm production is only weakly understood because of identification problems which hamper the measurement and estimation of credit's effects. Consequently, questions about small-farm credit and development strategies remain imperfectly answered. Does improved access to formal credit increase the productivity of small farms? And, if it does, is a pattern of unequal growth and peasant differentiation set in motion which belies the conventional egalitarian rationale for small farm development strategies? Answering these questions faces a set of identification problems common to analysis of any program where participation is purposefully selected rather than randomly assigned.

This paper utilizes an endogenous switching regressions model to structure and resolve underlying identification problems, and it subsequently defines and estimates credit impact measures relevant to questions about small farm development. The model is applied to a farm-level data set collected in Nicaragua in the wake of changes in the rules of credit access which occurred as part of that country's revolutionary project to shift the structure and distributive terms of agricultural growth. The results which emerge, while imprecise, suggest that credit had a positive impact on small farm food production, although not on net income as measured at market prices. The estimated impact is of a form which implies differentiation among small farms as latent non-redistributable farm characteristics are a critical determinate of credit's impact. Before turning to the analysis, a brief review of agricultural credit policy in Nicaragua is presented.

The 1979 ouster of the Somoza regime opened the way for implementation of alternative agricultural development policies in Nicaragua. Among the policies pursued by the new government was an effort to channel credit to the small farm, food producing sector. The initial stage of that effort has been described as "spilling credit in the countryside" (Collins 1982), or more colorfully as "la piñata." More analytically one might describe it as a shift in credit rationing criteria which left borrower self-selection as the main determinate of credit access. Prior to that shift, formal agricultural credit had been concentrated in large farm, export production. Enriquez and Spaulding (1985) report that over the 1960's and 1970's, approximately 90% of agricultural credit went to export production while food crops, which occupied 50% to 60% of the cultivated area, received the residual 10% of disbursed credit. Within Nicaragua's dualistic agrarian structure, this pattern of crop finance is evidence that most small farms received no formal credit.^{1/} Barraclough (1982) reports that in 1978, even after several years of a U.S. sponsored small farm credit program, only 18% of small farms produced with credit. Carter (1985) develops a theoretical model which explains this sort of credit rationing where small farms are largely excluded from unrestricted formal credit markets.

Corresponding to this pattern of unequal credit access, agricultural resources and growth in Nicaragua became concentrated in the large scale, export-oriented sector, while food production was squeezed onto a marginal resource base. Under some interpretations, this agro-export growth model reflected serious distortions in the economy and was responsible for the systematic expropriation, marginalization, and impoverishment of the mass of the rural population.^{2/} With the goal of rectifying those distortions, the Sandinista government undertook the aforementioned shift in credit policy.

Barraclough (1982) cites figures which show a 619% nominal increase in credit to the small farm sector from 1978 to 1980, with 81% of small farms receiving credit in the latter year. The area financed for non-export crops was four times higher in 1980 than in 1977 (Enriquez and Spaulding 1985). While credit allocation was subsequently tightened, there is no doubt that a permanent change in credit rationing criteria was affected. Recent accounts indicate a continued policy of easy access to credit for small farm food production (Kaimowitz, in progress, and Enriquez and Spaulding 1985).

This paper takes advantage of the shift in the rules of credit access to study the impact of formal credit on small farm production. Descriptive statistics reported in Table 1 reveal a positive association between credit access, input use and farm productivity in a sample of small Nicaraguan farms. Per-manzana production and net revenues both average about 20% higher on farms which produce with credit (1 manzana = 0.68 hectares). Possible explanations of this association can be divided into four types based on whether they hypothesize a spurious versus a true credit effect, and whether they concern observable (and redistributable factors) or latent (and non-redistributable) factors. The explanations of why credit recipients produce more are:

1. Spurious/Observable: Credit recipients enjoy on average a more favorable endowment of external resources and market opportunities;
2. Spurious/Latent: Credit recipients are intrinsically more skilled farmers who would produce more even without credit;
3. Credit Effect/Observable: Credit permits producers to overcome working capital constraints and achieve greater returns from given natural resources and market opportunities;
4. Credit Effect/Latent: While credit recipients are relatively skilled farmers, relaxation of credit constraints allows access to technological and economic opportunities where they can earn greater returns to their intrinsic skill endowments.

Distinguishing between the spurious versus the credit effects explanations is desirable to evaluate the impact of credit. The distinction between observable versus latent factors is made in part to draw attention to the fundamental identification problem which the analysis faces. This distinction also calls attention to a question of relevance to the evaluation of small farm development strategies. Latent farmer skills and attributes can not be redistributed as can land and market access. Assuming skills are unequally distributed in the population, then if credit effects and growth occur through enhanced returns to such skills, private, small farm growth strategies would be unequalizing, as Putterman (1983) suggests.

Untangling the different explanations of the observed association between credit and production faces several identification problems. The most serious of these results from an informational asymmetry between farmer and researcher. The farmer knows his or her intrinsic farming abilities, and systematically takes them into account in deciding whether to use formal credit. These characteristics of the individual, however, are largely invisible to the researcher who then faces the task of separately identifying the effect of credit from the intrinsic productivity attributes of credit recipients.

The goal of this paper is to resolve the various statistical problems, and to define and estimate measures of credit's impact on the productivity of observable and latent resources. Section 1 provides the theoretical basis for the analysis with a model of small farm decision making. Section 2 traces out a second best resolution of the credit effect identification problem which results from the endogenous determination of credit use, and develops credit effect measures appropriate to Nicaragua's open access credit program. Section 3 implements the model and estimates the impact of credit using a cross-sectional

survey of small farm food producers. Section 4 summarizes the paper's findings and concludes with a discussion about the viability of small farm credit policies.

Section 1 Modelling the Impact of Credit on Small Farm Production

Credit programs such as Nicaragua's presume that lack of access to formal credit constrains the technical and, or allocative efficiency of small farm production. Receipt of credit would therefore be expected to enhance the net revenues obtainable from given resources and market opportunities. This hypothesis can be empirically explored through the net-revenue or pseudo-profit optimum value function which characterizes small farm economic behavior.

The individual's anticipated net farm revenues which correspond to production with and without credit are here denoted π^{*c} and π^{*n} , respectively. These values represent the net income the individual expects to be able to produce given market conditions, and endowments of natural resources and farming skills. The anticipated values for an individual "i" can be written as the sum of two orthogonal components:

$$(1) \quad \begin{aligned} \pi_i^{n*} &= \underline{\beta}' \underline{z}_i + v_i^n \\ \pi_i^{c*} &= (\underline{\beta} + \underline{\delta})' \underline{z}_i + v_i^c, \end{aligned}$$

where the \underline{z}_i are market conditions, prices and resources, and the \underline{v}_i represent returns to individual productivity attributes. This particular partition has been chosen because while the individual knows both the \underline{z}_i and the \underline{v}_i , only the \underline{z}_i are observable to the econometrician. The resulting observable net revenue,

or pseudo-profit regression functions are:

$$(2) \quad \begin{aligned} E(\pi_i^n) &= \beta' z_i \\ E(\pi_i^c) &= (\beta + \delta)' z_i. \end{aligned}$$

← The expectation operators here and throughout the paper are conditional on the observable variables z which include market conditions, prices and fixed inputs. The regression functions are assumed to be linear, or approximated linearly. Alternatively the expectations operators can be considered in the wide sense as best linear predictors.

The net revenue functions are closely related to the profit function of duality theory which has been applied to farm efficiency analysis (e.g., Yotopolous and Lau 1979). Indeed it is useful to think about the net-revenue functions as optimum value functions. However, in deference to the peculiarities of the underlying small farm resource allocation problem, the adjective "pseudo-profit" will be used to distinguish these functions from the profit function and the conventional profit maximization problem which underlies it.

Small farm economic decisionmaking is best considered in a household context which recognizes the simultaneity of production and consumption decisions. As has been ably demonstrated in the literature (e.g. Strauss 1986), farm resource allocation will be unaffected by this simultaneity and will follow the dictates of conventional profit maximization as long as markets for all inputs exist and the farmer can treat all prices as parametrically given. However, for the small farm economy in question, the market for labor, or, more specifically for family labor, is unlikely to fulfill these requirements.

While the market for hired labor is typically well defined, family and hired labor are not perfect substitutes in either a technical or an economic sense. They are not perfect technical substitutes because the supervision required to get the same productivity from the same observed units of labor is not the same for the two types of labor. Put differently, family labor includes an inseparable managerial component. Family and hired labor are not economic substitutes because they exhibit distinct opportunity costs. Hired labor comes at the cost of the market wage, while seasonal sales constraints in the local labor markets push the opportunity cost of family labor below the market wage. For these reasons, hired and family labor will be treated as distinct inputs, with the stock of family labor treated as a fixed input, rather than a variable cost of production, in the farm resource allocation problem.^{3/}

Related to this labor market problem is the observation of persistent small farm allocational differences between what can be dubbed intensive peasant production and less intensive semi-proletarian production. The sorts of multiple market failures necessary to permit allocational differences between farms to persist have been discussed in the literature (e.g., Eswaran and Kotwal 1986). Key factors which may explain this allocational difference are: (1) the thinness (sales constraints) of local labor markets; and, (2) the fixed, upfront subsistence costs of full time farming. The first factor suggests that an individual may not be able to marginally allocate labor between on- and off-farm work. Individuals essentially may face a dichotomous choice between a full-time, intensive peasant strategy, and a wage labor strategy. The second factor suggests that some small, particularly tenuous producers may not be able to afford to cultivate their land, or to cultivate it intensively. Faced with a dichotomous strategy choice individuals would be expected to stratify themselves into distinct groups, or classes, based on their access to means of

production.^{4/} The pseudo-profit function will be interpreted as the reduced form optimum value function which corresponds to that underlying choice problem.

It is now possible to detail how credit might affect the parameters of the pseudo-profit functions (1). First, credit might permit a farmer to enhance conventional allocative efficiency by overcoming financial constraints to the purchase and application of the profit maximizing level of, say, fertilizer. Conceptually this sort of effect would shift the farmer along a given production surface to a more intensive, and more profitable, input combination. Such a shift would be econometrically visible as a positive shift in the pseudo-profit function.

A second, related credit effect would occur if credit permits purchase of a new technological package which is best conceptualized as shifting the production surface (i.e., increasing observable technical efficiency). An example might be the purchase of high yielding seeds, which cost only slightly more than the imputed value of traditional variety seeds, but which shift the entire input-output relationship and, with it, the pseudo-profit function. Alternatively, credit might permit the farmer to shift to a more expensive, but more remunerative, cropping mix.

Finally, credit may permit more intensive use of fixed inputs, specifically land, family labor and farming skill. Such an effect could occur through a nutrition-productivity link if credit enhances family consumption levels and productivity. A second way that credit could increase the intensity of resource use is by financing the fixed cost of self-maintenance needed to farm full time. That is, credit might permit a shift to an intensive farming strategy. Credit might also allow the highly skilled producer to realize a greater return on his or her individual attributes by simply increasing production options. Through

any of these three avenues, credit could increase the net revenue obtained from fixed inputs, market conditions and (unobservable) individual skill characteristics. But, in the case of a strategy shift, any increase would be obtained in part through a reallocation of resources away from off-farm uses. Peasantization, as this strategy shift was called in Nicaragua, was a major concern because of apparently major reductions in off-farm labor supply which coincided with the small farm credit program (see Kaimowitz, in progress).

Credit may of course have none of these effects. If credit simply displaces another source of finance (e.g., savings), then it may have no effect on production at all. Alternatively, if credit is treated simply as a welfare program, perhaps because default costs are perceived as minor, then it may have a zero, or even a negative impact on pseudo profits.

When the theoretical concept of household net-revenue is empirically implemented by valuing output at farmgate prices, the pseudo-profit function could also fail to show a positive change even when credit induces allocational changes and production increases. In rural areas with thin or monopolistic food markets, the effective price for self-consumed output may exceed measured farmgate prices. Such a systematic understatement of the value of output would dampen measured credit effects if the household employs resources to the point where their marginal productivity is less than their measured (but not effective) real prices. Similarly, if default rules are weak so that effective input prices are near zero, then credit may lead to an apparent overuse of inputs, and declining measured net revenues, even as production responds.

Because these price measurement problems blunt the analytical sharpness of the pseudo-profit function in practice, a direct approach to the measurement of technical and allocative efficiency effects of credit can be specified.

Paralleling the pseudo-profit expressions (1), a switching regressions specification can be given to farm production y :

$$y_i^{n*} = \beta'_{-p} z_{pi} + v_{pi}^n$$

$$y_i^{c*} = (\beta_{-p} + \delta)' z_{pi} + v_{pi}^n$$

The "p" subscripts indicate production function parameters and variables, and again the partition divides observable from unobservable factors. Parameter differences between y_i^{n*} and y_i^{c*} would indicate shifts in technical efficiency with credit. An analogous switching regressions specification can be written down for variable input allocation equations.^{5/}

Consistent estimation of the pseudo-profit function, and production and resource allocation functions, is complicated by the fact that credit status is endogenously determined in a way that may be systematically related to expected credit effects. The Nicaraguan credit program tried to equalize access to formal credit, but it did not randomly allocate credit to some individuals and not to others. If only high productivity producers chose to use credit, then it becomes problematic to disentangle the effect of credit per se from the intrinsic, unobservable productivity attributes of credit recipients. But, by giving structure to the self-selection process, it is possible to resolve this credit effect identification problem.

Credit status can be represented by the binary variable D_i which equals one if individual "i" has credit and equals zero otherwise.^{6/} Determination of credit status can be modelled as the following self-selection process:

$$(3) D_i = \begin{cases} 1, & \text{if } \pi_i^{c*} + \gamma_i^* - \pi_i^{n*} > 0 \\ 0, & \text{otherwise.} \end{cases}$$

The term γ_i^* is the individual's valuation of anticipated non-production costs and benefits of credit.^{7/} The credit decision rule (2) thus states that the individual who anticipates positive net benefits will apply for, and receive, credit. Recall that the π^* represent the outcome of an underlying optimal choice problem. If optimal strategy and resource allocation are unaffected by credit, then $\pi_i^{c*} = \pi_i^{n*}$, and the sign of γ_i^* alone would determine credit self-selection.

Like anticipated net-revenues, individual "i's" anticipated value of non-production costs and benefits of credit, γ_i^* , can be expressed as the sum of orthogonal components: one component systematically related to observable variables; and, a second component known to the individual farmer but which appears to the econometrician as unobserved heterogeneity:

$$\gamma_i^* = \underline{\gamma}' \underline{x}_i + v_i^{\gamma},$$

where the \underline{x}_i 's are the observable variables which linearly predict γ_i^* . Using this formulation and expression (1), the individual's net anticipated gains from credit, $\pi_i^{c*} + \gamma_i^* - \pi_i^{n*}$, can be rewritten as

$$(4) \quad \underline{\delta}' \underline{z}_i + \underline{\gamma}' \underline{x}_i + v_i^c + v_i^{\gamma} - v_i^n = \underline{\delta}' \underline{z}_i + \underline{\gamma}' \underline{x}_i + v_i,$$

where $v_i = v_i^c + v_i^{\gamma} - v_i^n$. With the addition of stochastic terms, $\underline{\varepsilon}_i$, to represent deviations between anticipated and realized outcomes, actual pseudo-profits can be written as:

$$(5) \quad \begin{aligned} \pi_i^n &= \pi_i^{n*} + \varepsilon_i^n = \underline{\beta}' \underline{z}_i + u_i^n \\ \pi_i^c &= \pi_i^{c*} + \varepsilon_i^c = (\underline{\beta}' + \underline{\delta})' \underline{z}_i + u_i^c, \end{aligned}$$

where $u_i^n = v_i^n + \varepsilon_i^n$ and $u_i^c = v_i^c + \varepsilon_i^c$.

The statistical difficulties created by endogenous self-selection can now be developed. Expected pseudo-profits conditional on credit status and the observable variables can be written as:

$$(6) \quad E(\pi_i | D_i) = \underline{\beta}' \underline{z}_i + D_i (\underline{\delta}' \underline{z}_i) + D_i E(u_i^c | D_i=1) + (1-D_i) E(u_i^n | D_i=0)$$

where the notation indicating conditioning on \underline{z}_i has been suppressed. Because credit status (D_i) has not been randomly assigned to individuals irrespective of skill (embodied in the u_i), the naive OLS regression of π_i on \underline{z}_i and D_i will not in general yield unbiased estimates of the structural parameters $\underline{\beta}$ and $\underline{\delta}$. Using equations (3) and (4), the conditional expectations on the RHS of (6) can be rewritten as

$$(7) \quad \begin{aligned} E(u_i^c | D_i=1) &= E(u_i^c | v_i > -(\underline{\delta}' \underline{z}_i + \underline{\gamma}' \underline{x}_i)) \\ E(u_i^n | D_i=0) &= E(u_i^n | v_i < -(\underline{\delta}' \underline{z}_i + \underline{\gamma}' \underline{x}_i)). \end{aligned}$$

These terms are not in general zero because of the heterogeneity components common to v_i and u_i^n and u_i^c . The omission of these non-zero conditional expectation terms in the naive OLS regression of π on \underline{z} and D will cause the usual omitted variable bias problems for the estimation of $\underline{\beta}$ and $\underline{\delta}$.

This OLS bias resulting from borrower self-selection is exactly the credit effect identification problem discussed before. Farmer skill is a key element of unobserved individual heterogeneity which is likely to both enhance π^{*c} and to increase anticipated gains from credit, making selection for credit ($D=1$) more likely. This systematic relationship between credit status and the individual heterogeneity component of the pseudo-profits error structure creates the consistency problem for OLS estimation. Under an OLS procedure, the productivity enhancing effect of farmer skill is likely to be confounded with the effect of credit. A similar problem applies to naive OLS estimates of production and resource allocation functions.^{9/} Section 2 now goes on to develop an approach to the estimation and measurement of the impact of credit in the presence of endogenous self-selection.

Section 2. Estimation and Definition of a Counterfactual Measure of the Credit Effect

The fundamental econometric problem induced by endogenous self-selection is lack of information on individual attributes which affect both the credit decision and farm productivity. As a second best solution, distributional assumptions can be made to substitute for the latent information. Following the sample selection literature, it is possible to separately identify the effect of individual heterogeneity and obtain consistent estimates of the structural parameters in (5) conditional on assumptions about the error structure $(v_i, u_i^n, u_i^c)'$. The assumption employed here is that $(v_i, u_i^n, u_i^c)'$ are distributed trivariate normal. Under this specification, the conditional expectations in (7) become:

$$(8) \quad \begin{aligned} E(u_i^n | D_i=0) &= \sigma^n E(v_i | D_i=0) = \sigma^n \lambda_i^n \\ E(u_i^c | D_i=1) &= \sigma^c E(v_i | D_i=1) = \sigma^c \lambda_i^c, \end{aligned}$$

where

$$\lambda_i^c = \frac{\phi(\xi_i)}{\Phi(\xi_i)},$$

$$\lambda_i^n = \frac{\phi(\xi_i)}{1-\Phi(\xi_i)},$$

$$\sigma^c = \frac{\text{Cov}(v, u^c)}{V(v)}, \quad \sigma^n = \frac{\text{Cov}(v, u^n)}{V(v)}, \quad \xi_i = [(\delta' z_i + \gamma' x_i) / \sqrt{V(v)}], \quad \text{and } \phi(\cdot)$$

and $\Phi(\cdot)$ are the standard normal density and cumulative density functions, respectively, defined over the observable variables which determine credit status.

With this specification, the complete endogenous switching regressions model becomes

$$D_i = \begin{cases} 1, & \text{if } \pi_i^c - \pi_i^n + \gamma_i^* = \underline{\delta}'z_i + \underline{\gamma}'x_i + v \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(9) \quad \begin{aligned} E(\pi_i | D_i = 1) &= (\underline{\beta} + \underline{\delta})'z_i + \sigma^c \lambda_i^c \\ E(\pi_i | D_i = 0) &= \underline{\beta}'z_i + \sigma^n \lambda_i^n. \end{aligned}$$

Maximum likelihood (ML) methods are one way to estimate the parameters of this system. Alternatively, consistent but less efficient estimates can be derived using the two stage methods popularized by Heckman. While there are a priori reasons for preferring the ML estimates (see Nelson, 1984), the two stage procedure is utilized here.

After using a first stage probit estimate of ξ_i to construct $\lambda^c(\hat{\xi}_i)$ and $\lambda^n(\hat{\xi}_i)$, consistent estimates of $\underline{\beta}$ and $\underline{\delta}$ may be obtained through separate OLS regressions of the two conditional pseudo-profit functions in (9) using the appropriate subsample for each regression. Alternatively, the following expression can be utilized to define a single unconditional regression function:

$$(10) \quad E(\pi_i) = E(\pi_i | D_i = 1) \text{Prob}(D_i = 1) + E(\pi_i | D_i = 0) \text{Prob}(D_i = 0).$$

Substituting from (8) above and noting that $\text{Prob}(D_i = 1) = \Phi(\xi_i)$, equation (10) can be rewritten as:

$$(10') \quad E(\pi_i) = \underline{\beta}'z_i + \underline{\delta}'z_i \Phi(\xi_i) + (\sigma^c - \sigma^n) \Phi(\xi_i).$$

The parameters of this unconditional pseudo-profit function can be consistently estimated by doing OLS on the entire sample using first stage probit estimates of ξ_i to construct $\phi(\hat{\xi}_i)$ and $\phi(\hat{\xi}_i)$ for use as regressors (see Madalla 1983).

Given that consistent estimates of the structural parameters can be obtained, it remains to define an appropriate measure of the credit effect. The term $\underline{\delta}'\underline{z}$, where \underline{z} are some average characteristics, is an obvious candidate. This measure would show the unconditional effect of credit on production:

$$(11) E(\pi_i^c) - E(\pi_i^n) = \underline{\delta}'\underline{z}_i.$$

That is, (11) shows the expected effect of credit if it were randomly assigned to farms without any intervening systematic selection or conditioning on the basis of the unobserved individual characteristics. If the policy issue were whether or not to break an existing credit selection regime and to effectively randomize rationing rules, then this unconditional measure would be of interest. In Nicaragua, however, a major policy change occurred prior to collection of the data. Credit access had already been equalized, so the question of what the effect of credit would be if the remaining self-selection regime were interrupted or randomized is not particularly interesting. Of greater interest is evaluation of the effect credit has on the production of those individuals who systematically choose to use it under the open access rules of the Nicaraguan credit program. The unconditional measure $\underline{\delta}'\underline{z}$ is inappropriate for this evaluation as can be seen by contrasting (11) with the credit effects anticipated by an individual producer. Individual i 's anticipated production gain from credit is from (1):

$$\pi_i^{c*} - \pi_i^{n*} = \underline{\delta}'\underline{z}_i + v_i^c - v_i^n.$$

That is, the anticipated production gain from credit is composed of an observable systematic component ($\underline{\delta}'\underline{z}_i$) plus additional gains (or losses) the individual expects to be able to realize with credit from unobservable productivity attributes ($v_i^c - v_i^n$). Note that if individual skill and ability have the same impact on production with and without credit, then $v_i^c = v_i^n$ and all individuals would anticipate the same effect ($\underline{\delta}'\underline{z}_i$) regardless of their latent productivity characteristics.

A measure which captures the total impact of credit on the production of those individuals who choose to use it can be defined using what Tunali (1985) calls the "counterfactual expectation". The counterfactual expectation of what pseudo profits would (counterfactually) be without credit for an individual who actually is a credit recipient is defined as $E(\pi_i^n | D_i=1)$. Note that given \underline{z} , conditioning on $D_i=1$ is equivalent to conditioning on the individual's unobserved productivity characteristics. Using the counterfactual expectation the following conditional measure of the credit effect can be defined:

$$(12) \quad E(\pi_i^c | D_i=1) - E(\pi_i^n | D_i=1).$$

The first term is the expectation conforming to the actual situation and the latter term is the counterfactual expectation of the individual's pseudo-profits in the absence of credit. Using equations (5) and (8), expression (12) can be rewritten as:

$$(12') \quad \underline{\delta}'\underline{z}_i + (\sigma^c - \sigma^n) \lambda_i^c.$$

The first term, $\underline{\delta}'\underline{z}_i$, captures the unconditional credit effect. The second term is additional returns expected to unobservable individual productivity

attributes. The symmetry between the two components of the credit effect is plainly visible. The parameter $\underline{\delta}$ measures differential returns to observable resources, while $(\sigma^c - \sigma^n)$ measures differential returns to unobservable endowments whose level is estimated by λ_i^c .

Separate identification of these two components of the credit effect can be quite important for an overall evaluation of small farm development strategies. As mentioned in the introduction, observable endowments and unobservable individual attributes differ in the degree to which they can be redistributed. Large returns to individual productivity attributes would suggest that small farm strategies, even in the context of equalizing asset redistribution, set in motion a process of unequalizing growth and small farm differentiation. The "good" farmers would profit, while the rest would be left behind as unsuitable raw material for economic development. The credit effect measure (12') permits some inference on the much debated question of peasant differentiation.

A final possible measure of the credit effect is the naive OLS estimate which would result from estimating the omitted variable pseudo-profit function which ignores the endogeneity of credit status. While the resulting parameter estimates (denoted $\tilde{\delta}$) are inconsistent estimates of $\underline{\delta}$, the naive OLS credit effect, $\tilde{\delta}'\underline{z}$, does yield useful information. While it confuses (in the omitted variable sense) structural credit effects with the effects of unobserved individual productivity attributes, it does estimate how much more a self-selecting individual produces with credit than an observationally identical individual produces without credit. As Tunali (1985) formally shows, the naive OLS credit measure, $\tilde{\delta}'\underline{z}_i$ estimates

$$(13) \quad \underline{\delta}'\underline{z}_i + \sigma^c(\lambda^c(\xi_i) - \lambda^n(\xi_i)).$$

Because it controls for observable exogenous conditions, it indicates how much of an (apparent) credit effect there is to identify net of differences in observable exogenous conditions and fixed endowments.

Finally, it should be noted that the procedures outlined here can be applied to the production and input allocation functions to yield efficiency effects estimates which are consistent with endogenous self-selection. As with the counterfactual measure of credit's affect on net revenues (12'), estimates of credit's impacts on technical efficiency or allocative logic will have two components. The unconditional component estimates changes in efficiency which would be expected for a randomly selected individual. The second component indicates additional changes which would be predicted for a self-selecting individual who enjoys a favorable endowment of latent productivity attributes.

Section 3 now turns to the empirical specification and estimation of the model and the effect of the 1980-'81 Nicaraguan credit program.

Section 3 Empirical Analysis of the Nicaraguan Credit Program

In late 1981, a survey of the Nicaraguan small farm sector was taken to explore the impact of the post-1979 shift in agricultural credit. The survey was undertaken by the agrarian reform research branch of the Nicaraguan agricultural ministry. Descriptive analyses of the data are presented in Stanfield (1982) and CIERA (1982). These data are used here to estimate the model established in Section 2.

The 1981 survey was intended to provide a representative sample of the country's small scale producers. In practice, only those producers who had at some time dealt with the National Development Bank (BND) were sampled.^{9/} Sampling was stratified by regions, with heaviest sampling in those areas where

small holder production is concentrated. Within each region, the list of local farms maintained by the BND was used as the sampling frame. On this basis, household structure and retrospective production data from 1227 farms were collected in late 1981.

The present analysis has been restricted to these farms engaged primarily in food production.^{10/} This restriction was pragmatically dictated by the need to avoid observations where large unmeasured production activities could obscure the impact of credit. But restricting analysis to this subset of producers may understate the impact of credit. Those farms which produce primarily food probably have a relatively weak economic and resource base. According to CIERA (1984) they, among small producers, are the least likely to effectively use credit. In addition, a major avenue by which credit can affect production is by breaking financial constraints to lucrative, but working capital-intensive crop mixes. Unfortunately, producers who shifted production in this fashion are left out of the analysis. Inference is thus restricted to a subset of probably least favored producers.

Table 1 presents descriptive statistics on the 582 producers selected for the analysis using this food production criterion. All figures refer to the primera (spring) crop season, 1981. As can be seen, the sample is nearly evenly split between farms that received credit for that season and those that did not. Primera output per cropped manzana averaged 23% higher on those farms with credit, and use of fertilizer and other intermediate inputs was 59% higher. Cropping intensity also registered a slightly higher average on credit farms. These production intensity differences, which translate into average net revenues per cultivable manzana that are 20% higher on credit farms, seem to support the notion that credit was an important constraint on small farm production. However, these measures do not account for differences in objective

conditions faced by credit and non-credit farmers (e.g., soil quality and market access), nor the phenomena of endogenous credit self-selection whereby intrinsically more productive farmers may be those who receive credit. To untangle these multiple influences and distinguish between the competing hypotheses discussed in the introduction, we turn to estimation of the model and measures developed in the previous sections.

Empirical implementation of the model in Section 1 requires specification of the pseudo-profit function. Included in the specification used in the analysis which follows are three types of independent variables: (1) normalized price variables, (2) stocks of fixed inputs and (3) regional dummies. The price variables for each observation are the reported harvest wage rate and a fertilizer price, both deflated by the index of the unit's reported output prices.^{11/} The fixed inputs are the number of resident adults (as a measure of family labor stock), the amount of cultivable land and the value of non-fixed farm assets. Finally, dummy variables were introduced for the six departments from which the observations were drawn. These regional variables are meant to capture differences in market access, and soil and climatic characteristics which are not otherwise measured.

Pseudo-profits, or net revenues, are defined as the market value of corn and bean production less intermediate input and hired labor costs, all deflated by the output price index. Pseudo-profits are specified as a linear function of the independent variables plus the squares and cross-products of the price and fixed input variables. This quadratic expansion is a second order approximation to an arbitrary functional form (see Fuss, McFadden and Mundlak, 1978). Use of more parsimonious logarithmic specifications was ruled out because approximately 10% of the observations had negative values for net revenues.

Table 2 presents naive OLS estimates of the profit function which ignore the endogenous determination of credit status. A full switching regression specification is reported together with an additive shift version which restricts all elements of $\underline{\delta}$ to zero except for the coefficient of the constant term, δ_0 . The additive shift estimate shows that pseudo-profits increase 263 cordobas with credit, while the switching regressions specification shows a 61 cordoba naive credit effect valued at the mean of the \underline{z} variables for credit recipients. Compared to sample average net revenues of 3221 cordobas, these point estimates suggest that net revenues would be between 2% and 8% higher on a self-selecting farm producing with credit. In neither case are the estimates precise enough to permit rejection of the hypothesis that the (naive) credit effect is zero, as the 95% interval estimates range from -621 to 1047 and -1073 to 1195, respectively. In the well defined sense of expression (13), these naive estimates are also consistent with the hypothesis that, controlling for observable fixed inputs and exogenous conditions, farms with credit produce economically significantly greater amounts of net revenues.

As discussed before, these estimates can not identify whether the estimated differential reflects the effect of credit, or whether it reflects an intrinsic productivity differential which these farmers would enjoy even in the absence of credit. The two stage endogenous switching regressions procedure outlined in Section 2 does permit this identification. For its empirical implementation, the first-stage probability of self-selection has been specified as a function of the pseudo-profit function variables in their quadratic approximation form, plus the following additional variables hypothesized to affect the anticipated non-production costs and benefits of credit, γ^* :

1. A dummy variable set equal to 1 if the head of household is literate;
2. A tenure dummy variable which equals 1 if the farm unit is held under a legally secure form of ownership;

3. A dummy variable set equal to 1 if the farm unit had received formal credit prior to the revolution;
4. A dummy variable equal to 1 if the individual farm had no credit arrears; and,
5. A dummy variable set equal to 1 if the farmer was a member of a cooperative.

This latter variable would be expected to increase the probability of credit self-selection as co-op membership reduced the interest rate and transaction costs of receiving credit. The credit arrears variable would be expected to have a negative impact if credit arrears increase the likelihood of capital loss. To the extent that pre-revolutionary credit experience reduces the learning costs associated with credit application and use, this variable would be expected to have a positive impact on selection probability. Finally, the literacy dummy would be expected to be positively associated with credit, while secure tenure could arguably either discourage (because of risk of capital loss) or encourage credit self-selection. Omitted from this specification is any measure of the consumption value of credit, for which no reliable variable was available.

In the interest of saving space, only the five non-pseudo profit function variables are reported in Table 3. Of these five variables, only the co-op dummy is statistically significant. It shows the expected positive impact on the probability of credit self-selection. The variables not reported in Table 3 were nearly all individually economically and statistically insignificant. The joint hypothesis that all coefficients are zero is rejected, however, as two times the log likelihood ration is 87 while the 5% critical value (χ^2 , 30 degrees of freedom) is 44. No distinctive regional effects were shown by the regional variables. Family labor stock does have a large and statistically significant estimated positive impact on the probability of credit selection.

Table 4 reports estimates of the conditional (9) and the unconditional (10') pseudo-profit regression functions. Results are reported for the full switching regressions specification and for the additive shift specification which restricts all elements of $\underline{\delta}$ to zero except the constant term, δ_0 . The table only includes the estimated parameters and measures needed to evaluate the credit effect hypotheses.

As in Table 2, the switching regression estimates of $\underline{\delta}'\underline{z}$ are evaluated at the mean characteristics of (\bar{z}) of credit recipients. The mean value of $\lambda^c(\hat{\xi}_1)$ is 0.69. The alternative estimators all yield broadly similar results. The anticipated credit effect (12') is imprecisely estimated as approximately -2300 cordobas. Moreover both the unconditional effect of credit and the effect of credit on returns to unobservable skills are estimated to be negative. To the extent that these figures are taken seriously as point estimates, they indicate that credit has no positive effect on net revenue relative to what net revenues would counterfactually be without credit. That is, the point estimates suggest that the descriptive association between credit and production performance is a spurious result of the fact that those who produce with credit face a more favorable environment and are intrinsically better producers even without credit. It is tempting to conclude that credit was chosen by these individuals for non-production reasons, and that credit had none of its intended economic impacts.^{12/}

However, as discussed earlier, the use of farmgate prices to value self-consumed output may lead to a systematic understatement of pseudo-profits from the producing household's point of view. Direct estimates of the technical efficiency of the production function and the allocative logic of intermediate input use in fact lend support to the notion that this valuation problem masks the impact of credit on production. Tables 2 and 4 report estimates for a

Cobb-Douglas production function and an equation which specifies intermediate input allocation as a function of exogenous conditions. The production function specifies output as a function of quantity measures of cultivated land, intermediate inputs, labor days, and traction inputs. The allocation equation specifies intermediate inputs per-manzana as a log linear function of the price variables and the fixed inputs of cultivable land, family labor and non-fixed farm assets.^{13/}

The naive OLS estimates reported in Table 2 can be interpreted as comparisons of the performance of producers who are identical in all respects except in their credit choice and latent characteristics (see expression (13)). The production function shows a 16% technical efficiency advantage for the producer with credit. Producers with credit are also estimated to use 25% more intermediate inputs per manzana.

The estimates in Table 4 identify what portion of these technical efficiency and allocative differences are credit effects, and which simply reflect advantages which producers who choose credit would enjoy even if they produced without credit. The anticipated effect of credit on technical efficiency for the average credit recipient (in the sense of (12')) is estimated to be almost zero (.03). That is, credit recipients seem to be 16% more technically efficient with, or without credit. The effect of credit on intermediate input use, however, is quite strong: a random credit recipient would use 46% more inputs (controlling for endogenous conditions and observable resource endowments), while the average self-selected credit recipient boost input use per-manzana another 43%. In total, credit is estimated to yield an 89% increase in per-manzana intermediate input use by credit recipients compared to what these same self-selected individuals would counterfactually do without credit. (The precision of this estimate is low enough that the 95% interval

estimate of -48% to 226% includes zero.) An induced increase in input use of this magnitude by the intrinsically more productive credit recipients would translate into a major output effect of credit. However, as the pseudo-profit estimates suggest, this increase may not translate into increased measured net revenues. Either these producers are allocationally irrational, or reported input and output prices vary substantially from the effective prices which guide small farm decisionmaking.

Section 4 Conclusion

The Nicaraguan agricultural credit program changed rationing rules so that small scale producers have easy access to formal credit. Descriptive statistics reveal a positive association between credit and small farm productivity. Despite difficulties empirically separating the true effects of credit from the effects of endowments and characteristics of credit recipients, a consistent interpretation of this program's impact on small farm food production emerges from the econometric analysis. Credit has its most notable effect on the use of fertilizers and other intermediate inputs. Credit itself does not seem to shift the technical efficiency of production, but those who use credit are estimated to be intrinsically more productive farmers, with or without credit. While the data give weak support to the notion that self-selected credit recipients would enjoy slightly higher net-revenues than would non-credit recipients with the same observable resources and opportunities, this differential seems to spuriously reflect the intrinsic attributes of credit recipients. The output effects of credit on production apparently have little impact on measured net-revenues.

A likely explanation for this finding is that farm net-revenues are defined at farmgate prices which understate the value of output to the small farm household production-consumption unit. Also, effective input prices may be

lower than those recorded to the extent that default penalties are weak. Credit thus seems to induce input use and production past the point which maximizes net-revenue at market prices. The credibility of this interpretation is enhanced by the fact that the analysis was restricted to the subset of subsistence-oriented food producers. For such producers, intra-household consumption and valuation of output is likely to be high, and perhaps default costs minor. As noted earlier, the behavior of this group can be expected to understate the impact of credit on the small farm sector as a whole.

These results are relevant to several debates which center around credit and small farm development strategies. First, they seem to show that credit is a constraint to small farm resource allocation and production. Given credit, production does respond. Equilibrium credit rationing which excludes small farms from the market as discussed in Carter (1985) could have high social costs and lead to serious distortions in agrarian production and structure.

The results also speak to the debate about differentiation among small scale producers. Non-redistributable, latent individual producer characteristics loom large in explaining technical efficiency differences. In addition, producers with a favorable endowment of these characteristics respond more positively to the expanded opportunities provided by credit, as revealed by the resource allocation estimates. Together these observations are consistent with a hypothesis that the extension of new opportunities into a basically egalitarian small farm sector initiates a pattern of unequalizing growth and differentiation. On the one hand, this hypothesis implies that small farm development is viable. On the other, it suggests, paraphrasing Lehman (1982), that the successful small scale family farms may rise on the graves of egalitarian peasant agriculture.

TABLE 1
Descriptive Statistics
Primera 1981 Corn and Bean Production

	Without Credit n = 284	With Credit n = 298
<u>Mean Values Per Cultivated Mz.¹</u>		
Output ²	1,143 (894)	1,410 (1008)
Intermediate Inputs ³	297 (300)	471 (1294)
Total Labor Days	43.7 (40.0)	44.9 (47.0)
Hired Labor Days	13.1 (22.3)	14.9 (28.0)
Traction ⁴	188 (223)	277 (480)
Non-Fixed Assets	1,661 (2,653)	1,704 (3,436)
Net Revenue ⁵	842 (962)	1,010 (1,110)
<u>Mean Values Per Cultivable Mz.</u>		
Net Revenue	639 (828)	793 (969)
Cultivated Mz	0.76 (0.28)	0.79 (0.25)
<u>Mean Farm Size (Cultivable Mz.)</u>		
	7.49 (9.46)	6.73 (8.81)

* Figures in parentheses are estimated standard deviations.

1 1 Mz. (manzana) = 0.68 hectares.

2 Primera '81 corn and bean production aggregated using the sample average prices of 100 per for corn and 262 per for beans.

3 Intermediate inputs is the actual and imputed deflated value of seed, fertilizer, etc. used in corn and bean production.

4 Traction is the real and imputed value of animal and/or mechanical traction services used.

5 Net-revenue is output less the value of hired labor and intermediate inputs.

TABLE 2 NAIVE OLS ESTIMATES

Pseudo-Profit Functions

	Additive Shift		Switching Regressions	
	β	δ	β	δ
Constant	-2446	(3315)	4081	(7149)
León*	-2760	(1109)	2153	(2245)
Chontales	-2476	(857)	999	(1785)
Matagalpa	-87.1	(926)	1509	(1881)
Estelí	-493	(765)	581	(1560)
Madriz	-405	(816)	1146	(1693)
W (Wage)	396	(157)	-773	(370)
P (Fert. Price)	-30.1	(27.0)	86.0	(71.7)
L (Family Labor)	1018	(663)	-2392	(1543)
T (Cultivable Area)	581	(189)	1299	(459)
M (Non-Fixed Assets)	0.38	(0.18)	-0.13	(0.43)
W ²	-0.72	(2.3)	-3.97	(6.12)
WP	-0.68	(0.72)	4.89	(2.06)
WL	-15.2	(18.0)	34.9	(39.0)
WT	-27.7	(4.9)	-19.9	(11.9)
WM	0.0001	(0.003)	0.01	(0.009)
P ²	0.07	(0.07)	-0.57	(0.26)
PL	-1.6	(3.7)	1.41	(7.76)
PT	2.7	(1.3)	-2.99	(3.00)
PM	-0.001	(0.0008)	-0.002	(0.002)
L ²	-0.47	(16.6)	125	(78.6)
LT	3.9	(16.1)	37.3	(36.6)
LM	-0.03	(0.02)	-0.01	(0.04)
T ²	-4.2	(0.83)	-4.92	(1.84)
TM	0.005	(0.002)	0.005	(0.01)
M ²	-0.000002	(0.000001)	0.000001	(0.000004)
	$\delta_0 = 263$	(442)	$\delta' \bar{z} = 60.7$	(567)
	$R^2 = 0.21$		$R^2 = 0.26$	

Production and Resource Allocation Functions

	Production Function		Inter. Input Allocation	
	β	δ	β	δ
Constant	6.65 (0.30)	-0.84 (0.43)	Constant	4.4 (1.32)
León	-0.84 (0.24)	0.65 (0.34)	León	1.05 (0.27)
Chontales	-0.62 (0.19)	0.25 (0.27)	Chontales	-0.65 (0.21)
Matagalpa	-0.19 (0.22)	0.43 (0.29)	Matagalpa	0.20 (0.23)
Estelí	-0.39 (0.18)	0.17 (0.23)	Estelí	0.83 (0.18)
Madriz	-0.22 (0.20)	0.24 (0.26)	Madriz	-0.03 (0.20)
Labor	0.02 (0.07)	0.09 (0.09)	W	1.14 (0.26)
Inter. Inputs	0.09 (0.04)	0.11 (0.06)	P	-0.76 (0.32)
Traction	0.08 (0.02)	-0.04 (0.03)	L	0.12 (0.09)
Land	0.49 (0.10)	-0.13 (0.14)	T	0.03 (0.07)
			M	0.02 (0.02)
	$\delta' \bar{z} = 0.15$	(.07)	$\delta_0 = 0.25$	(0.11)
	$R^2 = 0.43$		$R^2 = 0.23$	

* Regional dummy variables. Nueva Segovia is the excluded region.

Figures in parentheses are estimated standard errors.

TABLE 3

Probit Estimate of Credit Self-Selection

<u>Variable</u>	<u>Estimated Coefficient</u>	<u>Mean Value</u>
Literacy	0.007 (0.11)	0.58
Tenure	-0.07 (0.13)	0.62
Pre-Revolution Credit	-0.12 (0.12)	0.43
Credit Arrears	0.18 (0.14)	0.23
Co-op Member	0.61 (0.14)	0.69

Figures in parentheses are estimated asymptotic standard errors.

TABLE 4

Two-Stage, Endogenous Credit Self-Selection Estimates

	Pseudo-Profit Functions		
	Unconditional (10')		
	Additive Shift	Switching Regressions	Conditional Specification (9)
$\underline{\delta}'\underline{z}$	-2294 (1921)	-1156 (2260)	-2094
$\sigma^c - \sigma^n$	-445 (4750)	-1665 (8575)	(1088 - 1497) = -409
$\underline{\delta}'\underline{z} + (\sigma^c - \sigma^n)\bar{\lambda}^c$	-2601 (3241)	2305 (7108)	-2376
R ²	0.22	0.30	R ² (π^c) = 0.37 R ² (π^n) = 0.16

Production and Resource Allocation*

	<u>Production Function</u>	<u>Inter. Input Allocation</u>
$\underline{\delta}'\underline{z}$	0.03 (.22)	0.46 (0.36)
$\sigma^c - \sigma^n$	-0.09 (0.57)	0.65 (0.83)
$\underline{\delta}'\underline{z} + (\sigma^c - \sigma^n)\bar{\lambda}^c$	-0.03 (0.20)	0.89 (0.79)
R ²	0.42	0.22

* A switching regressions specification was used for the production function, and an additive shift specification was used for the allocation function, as in Table 2.

Figures in parentheses are estimated standard errors calculated using uncorrected second stage OLS results.

Notes

- 1/ The 1971 agricultural census figures (cited in FIDA 1980) show that 60% of the area devoted to food crops was concentrated in the small farm strata which contains 76% of the units, but only 13% of the cultivated area. The complementary large farm strata produced 80% to 90% of the major export crops.
- 2/ FIDA (1980) presents the view that Nicaragua's agricultural growth was seriously distorted under the agro-export model. To rigorously call that growth pattern "distorted", however, requires a counterfactual about alternative growth patterns which could occur in the same, constrained environment. Carter (1985) offers a theory of credit rationing which is at least capable of providing such an alternative. Whether agro-export growth is in fact a social distortion has been a major debate in Nicaragua. One point of view basically argues that the market was socially correct in leaving out the backward, peasant sector from the growth process.
- 3/ Feder (1985) derives theoretical implications of this specification of family labor on resource allocation and farm productivity.
- 4/ Work in progress by the author formally models class and agrarian structure as the endogenous outcome of individual choice constrained by resource and market access rules. This approach is in the spirit of Roemer (1982) and Eswaran and Kotwal (1985) who show that class structure emerges from individual choice constrained by access to means of production.
- 5/ The typical first order condition specification for optimum input use need to be expanded to include the constraints which shape small farm production strategy. Unobservable individual attributes could also be hypothesized to directly influence allocation behavior.
- 6/ This qualitative definition is dictated by the lack of reliable quantitative information on credit in the data set to be analyzed below. The relevance of per-hectare lending rules in formal credit institutions may seem to lessen the stringency of this definition. However, in Nicaragua credit approved per-hectara varied with the designated technology level of the particular applicant. Further variation among credit recipients was likely induced by individual variation in the percentage of approved credit which was actually disbursed.
- 7/ Included here are such items as transaction costs, expected default costs and the consumption value of (diverted) credit.
- 8/ Productivity attributes which are likely to enhance the probability of credit self-selection can also be hypothesized to be correlated with latent attributes which influence technical efficiency and resource allocation behavior. A formal demonstration of the impact of endogenous self-selection on estimation of production and resource allocation parameters would proceed exactly like the analysis of the pseudo-profit function.

- 9/ While the data are not representative of the small farm population as a whole, they represent a fairly large group, thanks in large part to the "piñata" credit program from mid-1979 to mid-1980. Over half the sampled farmers had never had formal credit prior to 1979. In addition, many of those who had received credit prior to the revolution received it under the INVIERNO program which was an effort from 1976-78 to extend credit to the small farm sector (see Bathrick 1980 and Stanfield 1982).
- 10/ A farm was excluded from the study if more than 1/3 of its gross revenues generated by primera 1981 crops came from crops other than the food staples of corn and beans, or if more than 1/3 of its cultivated area in the primera 1981 season was devoted to crops other than corn and beans. This procedure eliminated 260 observations. Another 336 observations were excluded because they produced no food crops in primera 1981 (or had incomplete data). Finally, 49 observations were dropped because of irreconcilable data problems, leaving a final sample of 582 observations.
- 11/ For those observations not reporting price data, the mean value of the price in its respective municipality was used.
- 12/ The results also demonstrate a great deal of imprecision in the effort to identify the credit effect. The estimates also proved to be sensitive to specification changes. With a different definition of the machinery stock variable, the endogenous switching regressions estimate of $\delta' \bar{z}$ was still negative, but the estimate of $(\sigma^c - \sigma^n)$ recorded large positive increases to latent skills when credit is used. These results would seem to support a strong peasant differentiation story. But like the results reported in the text, these point estimates were extremely imprecise.
- 13/ First order conditions for profit maximization subject to a Cobb-Douglas production function imply that the value share of an input in the value of output equals the partial elasticity for the input. This Cobb-Douglas formulation, augmented by the exogenous constraints which shape small farm allocational logic (see note 6), was also estimated. It gave similar point estimates of credit effects, but yielded an R^2 markedly worse than the specification reported in the text.

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