AN ECONOMIC MODEL OF AGRARIAN STRUCTURE
IN LATIN AMERICA*

By

Michael R. Carter and John Kalfayan
University of Wisconsin-Madison

* Jon Jonakin and David Kaimowitz have assisted with various aspects of this paper. Their help and ideas are gratefully acknowledged. Seminar participants at the Universities of Notre Dame, California-Berkeley and Wisconsin have provided useful and thought-provoking comments. Financial support for this work provided by the U.S. Agency for International Development is gratefully acknowledged. Views expressed in this paper are not necessarily those of the funding agency.
THE STRUCTURE OF OWNERSHIP IN Latin American agriculture has long received attention on research and political agendas. The traditional latifundio-minifundio agrarian structure, exhaustively documented by Barraclough and Domike (1966), has been assailed as the culprit for a feudal sluggishness in agricultural performance and for vast income inequality. While the traditional latifundio has seemingly been displaced by capitalized and profit-oriented agriculture (Thiesenhusen 1985, Lehman 1978, de Janvry 1981), the preoccupation with the structure of agriculture continues.

This preoccupation with the distribution of land ownership would not transcend distributional considerations if agriculture exhibited "super scale neutrality" (meaning that both markets and technology are scale neutral), or if the distribution of operational units clustered around a single "efficient" operational size. In Latin America, the persistence of stylized bimodal agrarian structures, in which large farms produce for export at different factor intensities and productivities than small, food producing units, indicates that neither condition pertains. The distribution of ownership should thus influence the level of agricultural production as well as its income distribution consequences.

Building on work by Roemer (1982) and Eswaran and Kotwal (1986), the goal of this paper is to explore the economics of agrarian structure with a short run general equilibrium model which brings together the forces and interactions which shape the organization, use, and productivity of agricultural resources. The model takes as given the land ownership distribution and generates other facets of agrarian structure (organization
of production, class structure, income distribution) as the endogenous outcome of the strategy and allocative choices of individuals variously constrained by their access to resources, technology and markets. Besides providing an analysis of the short term effects of alternative ownership distributions, the model provides insights into the economic factors which create incentives for land market transactions and drive the evolution of agrarian structure over time.1/

This paper is organized as follows. Section 1 establishes the methodological starting point for a microeconomic analysis of agrarian structure. Section 2 presents the environment of imperfect and stratified markets which creates the non-neutrality of operational scale. Given those imperfections, optimally behaving individuals endogenously group themselves into distinct farming strategy classes based on their resource endowments. At this stage, potential class structure and modes of producing can be seen. A side problem in optimal capitalist relations of production is developed which offers an explanation of labor tying (inquilino or colono systems) which is modestly innovative in the context of the economics literature.

Section 3 establishes the general equilibrium model of agrarian structure by merging the specification of individual behavior with market consistency conditions and information on population and the distribution of land ownership. The model is then used to explore the productivity, income distribution and other structural consequences of alternative ownership distributions. Section 4 summarizes the model's implications about the economics of coexistence and competition between agrarian classes and modes of producing, and speculates on the various structural patterns which might
emerge over time under the pressure of agricultural intensification and growth.

SECTION 1 NEOCLASSICAL ECONOMIC ANALYSIS OF AGRARIAN STRUCTURE

In neoclassical competitive economic analysis, the distribution of property does not affect resource allocation as long as all possibilities for mutually beneficial exchange are exhausted in equilibrium (and as long as demand is homothetic, indicating that shifts in income distribution do not influence product demand). Within such analysis, questions of property rights, institutions, and economic classes are neither interesting nor particularly meaningful. The relative absence of neoclassical analysis from the debate on agrarian structure in Latin America is therefore perhaps not very surprising, despite the fact that alternative theories of structural evolution (see note 3) are fundamentally economic arguments in a narrow sense. However, this seeming irrelevance of neoclassical economics for the analysis of agrarian class and structure issues is an artifact of the peculiar informational assumptions which characterize conventional competitive analysis.

In the model developed in this paper, the distribution of endowments does affect resource allocation, and, in equilibrium, factor productivities are not equated across competing uses. Several recent theoretical contributions on economic development share these features, most notably Eswaran and Kotwal (1986), Dasgupta and Ray (1986) and Streufert and Ray (1987). These papers, as well as the present one, are rooted in a much larger literature which portrays various unconventional market equilibria and institutional arrangements (e.g., sharecropping) as (second best) competitive
solutions in imperfect market environments. What the more recent literature has done is extend the single market or partial equilibrium insights of the institutional arrangements literature to general equilibrium environments. In doing so, the impact of property and endowment distributions become clear, and it becomes meaningful to apply neoclassical analysis to questions of structure and class.

From a methodological point of view, an explicitly neoclassical approach, with its emphasis on individual rationality, brings two distinct advantages to the analysis of agrarian classes and structure. First, as will be shown below, modes of behavior which define economic classes can be modelled as the outcome of individually optimal choice. This endogenous approach to the definition of class highlights the opportunities and constraints which lead individuals to choose (or, give them no choice but to choose) particular economic strategy. The temptation to hypostatize certain modes of behavior into immutable and exogenous logics, survival strategies or production modes is thus avoided. The class position of an individual is endogenous, open to change if circumstances warrant, leaving the analysis free to evaluate a broad range of structural outcomes, such as Lehman's (1985) hypothesis that peasant producers can accumulate and become capitalist family farmers.

Second, the methodological individualism of neoclassical analysis avoids the functionalist pitfall of explaining outcomes by reference to the interest of non-behavioral entities called classes. That is, in neoclassical analysis, outcomes which are in the interests of the members of a class will emerge only if they are generated by the pursuit of individual interest.
SECTION 2 MICROECONOMICS OF AGRICULTURAL RESOURCE ALLOCATION AND CLASS STRUCTURE

This section develops the microeconomic pieces (the market environment and the specification of individual behavior) for the general equilibrium model of agrarian structure. It is assumed here that all individuals are characterized by the same goals, the same objective function. Given the specification of the market environment, differentiation of individuals into classes emerges endogenously in the model and is not the result of predetermined or exogenous behavioral types. If some individuals fail to accumulate, or produce with peasant-like hyperproductivity of land, it is not because they are born simple commodity producers who are constitutionally disinterested in accumulation. Such behavior results, according to model, because, non-accumulating, self-exploiting behavior is the best that some individuals can do given their means of production and the rules of access to markets and economic opportunity. This section will show that this simple approach can result in a rich class typology which is consistent with the stylized facts of agrarian structure.

2.1 The Market Environment

There is a burgeoning literature which deals with the nature of land, labor and capital markets in the rural economies of the third world. Drawing on insights from this literature, this subsection constructs a hopefully compelling representation of the market environment in which agricultural resource allocation and production take place. The notions of market access and equilibria presented here are the driving forces of the model. They are what make agrarian structure matter, and the quality of the analysis rises or falls with them. The discussion which follows develops Five key points about
the rural market environment:

1. Access to capital is rationed according to wealth;

2. Because hired labor must be supervised, the average and marginal cost of labor varies across family labor farms, farms which employ casual supervision and farms which employ hierarchical supervision;

3. The seasonality of demand for agricultural labor implies that not all individuals required in the peak season will be fully employed on a year round basis;

4. Because of point 3, a day wage which is sufficient to cover the marginal opportunity cost of an individual's time may not be enough to assure a stable rural labor supply. If agriculture is geographically isolated so that individuals cannot marginally allocate their time between the agricultural labor market and other activities, then an annual income constraint must be met to prevent labor outmigration. In this circumstance, capitalist producers may find it optimal to create an internal semi-proletariat through tied labor contracts;

5. Land rental and land sales market will be relatively inactive in the short run, and the operational distribution of farms will be equated to the ownership distribution, except in so far as land is transferred to internal semi-proletarians as described in point 4.

The discussion which follows develops these points in detail and offers functional specifications which embody them.

Access to Capital

Carter (1988) offers a theory of credit rationing in formal rural financial markets in which smaller farm units have little or no capital access. Figure 1 portrays a capital access rule consistent with that theory: Individuals with land endowments below some minimum level are completely rationed out of the credit market; beyond this point available credit per-hectare increases up to a ceiling value. Figure 1 also approximates agricultural development bank "package" lending rules. Typically banks offer several loan packages, with the larger per hectare loan packages offered to larger farms which are perceived to have greater need for working capital.
because of their more advanced technology and need for a wage fund.

However, the adequacy of Figure 1 as an indicator of total access to working capital depends critically on the structure and role of the informal credit sector. Formal rationing rules of the sort displayed in Figure 1 are shown by Carter to result from the informational problems of formal lenders and weak collateral position of small farm borrowers. The ability of informal lenders to profitably lend to the small farm sector is apparently based on their better information and higher valuation of small farm collateral.

But, the very factors which give the local, informal lender an advantage over formal credit institutions also give that lender a spatial monopoly power, creating what Basu (1984) calls monopolistic isolation. Bhaduri (1982) and Basu have shown that in such environments, all risk of capital loss will in equilibrium be transferred to the borrower. Rational borrower recourse to capital available only on such terms can be expected to be rather more conservative than borrowings on formal markets.

Given then that producers are sorted between formal and informal markets according to farm size as suggested above, and that the structure of informal credit contracts discourages regular borrowing for risky working capital purposes, Figure 1 in fact adequately captures total access to working capital. Individuals thus face an external working capital constraint,

\[ K^* \leq \beta(T), \]

where \( K^* \) is the individual's desired level of borrowing, \( \beta' \geq 0 \) and \( \beta(T) \) follows the shape shown in Figure 1. Because of credit rationing, it will be assumed that this external working capital constraint always binds.

Effective Cost of Labor under Alternative Supervisory Modes
It is assumed here that informational problems inhibit the enforcement of labor contracts. The effective input of labor realized from an input of labor time (for which a wage is paid) will depend on supervisory efficiency. Supervisory modes are defined here so that the effective labor input (that is labor expressed in productivity units), \( L \), on a farm unit is given by:

\[
L = \begin{cases} 
L_h + \gamma(l_h)L_w & \text{under casual supervision} \\
L_h - \delta(L_w) + \gamma_0 L_w & \text{under hierarchical supervision}
\end{cases}
\]

where \( L_h \) is own household labor time, \( L_w \) is hired labor time and \( l_h \) is family labor per unit area cultivated. Household labor is assumed to be self-supervising so that each unit of household time produces one unit of effective labor. Hired wage labor requires supervision which can occur in either of two ways. Casual supervision occurs when family members assure hired worker effort by working next to them in the fields. Under this supervisory mode, relative hired worker productivity is \( \gamma(l_h) \) where \( \gamma < 1 \) for all \( l_h \) and \( \gamma', \gamma'' \leq 0 \) (note that \( l_h \) gives the per-hectare density of family workers/supervisors).

Hierarchical supervision, the second supervisory mode, yields a constant hired labor productivity, \( \gamma_0 < 1 \), and requires dedicated supervisory effort given by \( \delta(L_w) \) where \( \delta' > 0 \) and \( \delta'' \leq 0 \). In addition, \( \delta(0) > 0 \), indicating that there are fixed costs (in terms of lost labor input) to hierarchical supervision. Because of these fixed costs, the average cost of effective labor decreases with the amount of labor hired under the hierarchical supervisory mode. As specified here, supervisors can be hired.

Figure 2 portrays the particular specification of these supervisory modes used in the numerical analysis later in this paper (see appendix 1 for details). The first vertical line in Figure 2 indicates the farm size at
which labor would first be hired in. Because of the fixed costs of hierarchical supervision, effective labor input under this mode would initially be below one, the effective labor input which would be enjoyed by a stereotypical peasant farm which did not participate in the labor market. As farm size and hired labor increase, effective labor realized under hierarchical supervision eventually exceeds that which can be realized under casual supervision which diminishes in effectiveness with farm size. However, because of the fixed costs of hierarchical supervision, the casual supervisory mode enjoys an average cost advantage up until the farm size denoted by the second vertical line. The range over which casual supervision farms have a cost advantage over hierarchical farms has potential dynamic significance, as section 4 below discusses.

**Seasonality of Labor Demand and Unemployment**

A major assumption of this model is that employment in agriculture is probabilistic because agricultural labor demand is both seasonal and spatially disperse. An individual who supplies only a small amount of labor can choose to work in the peak season when employment is easily found. As off-farm labor supply increases, some involuntary unemployment occurs as the individual is forced to seek employment outside the peak season.

To capture this notion of seasonal unemployment in a simple way, let the number of days an individual is employed be given by $\Phi(L_m)$ where $L_m$ is labor supplied to the market, and $\Phi' > 0$, $\Phi'(0) = 1$ and $\Phi'' \leq 0$. Note that $w\Phi'(L_m)$ is the expected earning for a marginal unit of labor supplied to the market.

**Geographic Isolation of Agriculture and Non-Wage Capitalist Relations of Production**
Because agricultural labor demand is seasonal and because agriculture may be geographically isolated from other sources of employment, supply of labor to agriculture may be structured in one of two ways. First, labor may be available as long as the day wage exceeds the laborer's marginal valuation of his or her time. Alternatively, labor may only be available if the annual income or utility obtainable from full year participation in the agricultural sector is sufficient to offset opportunities in other sectors of the economy.

The first scenario should apply to individuals who have other opportunities in close proximity to agricultural employment (a semi-proletarian with an owned endowment of land), or who can move easily in and out of the agricultural sector in response to seasonal demand patterns (a seasonal migrant). The labor supply behavior of these groups could be described as a marginal labor supply decision and can be described by the following reservation wage condition:

\[ w \geq z^* \]

where \( w \) is the marginal wage and \( z^* \) is the laborer's marginal valuation of time.

The second scenario would apply to propertyless individuals in areas where seasonal outmigration is not economically feasible. Such individuals would make a binary decision whether or not to reside in the agricultural sector based on the following reservation utility condition:

\[ \pi^*(w) \geq \pi \]

where \( \pi \) is the utility the individual can attain outside agriculture and \( \pi^* \) is the total optimized utility the individual can attain in agriculture—i.e., the utility which would be associated with labor market earnings \( w(\Phi[L_m^*(w)]) \), where \( L_m^*(w) \) is the labor supply which is optimal conditional
on residence in the agricultural sector. If this reservation utility con-
straint does not bind, then the structure of labor supply under this scenario
would be identical to the first. If, however, the constraint is violated,
labor would exit agriculture until the wage rose, or a subsidy was paid, to
fulfill the constraint. The structure of labor supply could thus have a
significant impact on agrarian structure. The presence of a binding reservation utility constraint raises the
question as to the optimal response by the capitalist employer. One
response, pure wage labor production relations, is to let the wage rise under
the pressure of labor outmigration until the constraint is satisfied.
Alternatively, employers could satisfy the constraint and retain labor by
offering a package which gives access to a plot of land in conjunction with a
(lower) wage. This latter alternative, which converts landless labor into an
internal (to the capitalist farm) semi-proletariat, corresponds to the
inquilino and colono systems of production relations which have been commonly
observed across Latin America.

This view of the tied labor of the inquilino system corresponds to Kay's
(1977) contention that inquilino systems emerged as a cheap form of
remunerating labor, particularly in areas which lacked sufficient seasonal
labor migration. The internal semi-proletarianization of the inquilino
system can be expected to yield higher profits as long as the intensity of
direct capitalist cultivation is not too high and inquilinos have cheap
family labor which they can utilize to produce their own subsistence on a
relatively small plot of land. The "subsidy" to capitalist wage costs
provided by an internal semi-proletariat is exactly the same mechanism
identified by de Janvry and Garramon (1979) in their discussion of an
inactive semi-proletariat.

Inactive Land Markets

Except for the allocation of land to inquilinos, it is assumed here that the distribution of owned land corresponds to the distribution of operational farm units. That is, land market transactions are excluded.

This assumption rules out two types of transactions in the short run period of the model, sales and various forms of rentals. Inclusion of a cash (fixed) rental market in the model would not, however, have any major effects on equilibrium in the model. The capacity of capital-constrained small holders to absorb additional land, especially if it requires an expenditure of working capital is extremely limited. In addition, even without capital constraints, there are issues about transactions costs in the rental of a large farm unit to multiple small holders.

For similar reasons, a land sales market is similarly unlikely to shift land to where the labor is cheap and plentiful. Indeed, sales are even less likely to work than rentals. Binswanger (n.d.) and Binswanger and Rosenzweig (1986) argue that the price of land is likely to exceed the discounted value of the agricultural income which can be produced with it. In a recent theoretical contribution, Basu (1986) argues that land sales markets could get stuck in a low level of transactions equilibrium. Independently of these arguments, the evidence on Latin American agriculture indicates a low level of land market transactions (e.g., see Brown 1972) --indeed, A.I.D. has made the activation of land markets a policy target. As an approximation to a short run equilibrium, simply excluding land sales should not be too inaccurate. Land sales should be explicitly considered in a longer run
dynamic analysis, as section 4 below discusses.

Although neither cash rental nor land sales markets are likely to shift land to the poorly endowed, share tenancy is a device which would seem to ideally suited for the task. In an outstanding addition to the sharecrop literature, Eswaran and Kotwal (1985b) portray sharecropping as the prototypical device for bringing labor and capital together when the separate factor markets for both are imperfect. However, sharecropping is no panacea because resource allocation under this tenure arrangement is burdened by moral hazard problems. As Eswaran and Kotwal demonstrate, the moral hazard costs of sharecropping may in fact outweigh the supervisory and other costs associated with direct cultivation. Viewed then as a labor incentive device, sharecropping is not qualitatively different than the modes of direct capitalist cultivation which are considered here. What is lost by ignoring sharecropping is the imperfect access to cheap family labor which sharecropping provides. Whether or not cheap family labor is sufficient incentive to radically alter the operational distribution is discussed as a dynamic issue in section 4 below.

2.2 The Individual’s Optimization Problem

As a short run model, the analysis here considers behavior over a single agricultural year. Each decisionmaking agent in the economy is endowed with a stock (perhaps zero) of means of production ("land"), denoted T, and a homogeneous quantity of labor time, denoted L0. To simplify matters, labor time is measured in years, and each individual is endowed with one year of time. Correspondingly, wages will be denominated in terms of the payment for a full year’s worth of work.
All individuals have access to the same constant returns to scale annual production technology to produce agricultural output $Q$:

$$Q(L,F,T) = T q(l,f),$$

where $L$ is effective labor as defined in equation (1), $F$ is purchased inputs (fertilizer) and lower case letters indicate per-hectare values. All inputs are necessary and $Q$ has the usual neoclassical production function properties.

Note that this production function specification does not desegregate the labor input into peak season (high productivity) and slack season components. While this substantially simplifies the model, it imposes the implicit assumption that the seasonal labor peaks on labor hiring farms do not coincide with the peaks on semi-proletarian farms which allocate labor between both home production and the labor market. That is, this specification allows semi-proletarian individuals to allocate labor to the labor market during the peak season when the marginal employment probability is high and still receive high marginal returns on their own land during the labor market slack season. This assumption is not inaccurate in the real world where the crop mixes on capitalist and semi-proletarian farms are different. However, it is not strictly compatible with the model's formal structure which assumes a single production technology.

Resources are allocated to maximize individual income which can be expressed as the sum of net farm income plus off-farm wage earnings:

$$\{Tq(l,f) - T(p_{ff} + w_{l_w}) - i\beta(T)\} + \{w\Phi(L_m)\}.$$  

Net farm income is the output valued at a numeraire price of one less fertilizer expenditures ($T_{pf}$), wage labor costs ($T_{wl_w}$), and finance costs, $i\beta(T)$ where $i$ is the interest rate and $\beta(T)$ is the amount borrowed. Off-farm
labor supply is $L_m$, and, as discussed above, the number of employed days is $\Phi(L_m)$.

Within this framework, no individual will ever hire in wage labor while he or she is supplying labor to the market. Wage labor never costs less than own labor ($wzw'_{\Phi}$ for all $L_m$), and its relative productivity is less ($\gamma_0, \gamma(l_h) < 1$), so that the efficiency wage for a unit of hired labor always exceeds that for own labor. Wage labor will be hired only by those individuals whose allocation of labor to home production is bound by the time endowment constraint, $T_h \leq L_0$.

Because production is roundabout, working capital is necessary to finance cash costs of production: wage labor, fertilizer and individual subsistence, $R_0$. Note that subsistence costs are the household production units' equivalent to the wages fund required by the capitalist producer. Their inclusion in the model recognizes that it takes a capital to engage in intensive, family labor production. As will be seen, these costs have a big impact on the behavior of some individuals and drives them into low productivity semi-proletarian strategies even though a traditional peasant behavior would seem to be more remunerative.

Production costs can be financed with labor market earnings and with external borrowing constrained by the function $\beta(T)$ discussed above. The capital constraint can thus be written as:

$$T(p_f + w_l w) + R_0 \leq w_{\Phi}(L_m) + \beta(T).$$

It is assumed that full time wage work is an economically viable option so that $R_0 \leq w_{\Phi}(L_0)$.

The general optimal choice problem for an individual with a land endowment $T$ can be written as:
(6) \[ \text{Max } \sum q(l,f) + w\Phi(L_m) - T(pf + wI_w) - i\beta(T) \]
\[ \text{s.t. } \]
\[ Tl + L_m \leq L_0 \]
\[ \begin{align*}
T_l &+ \gamma(T_l)l_w &\text{under casual supervision} \\
1 &- \delta(l_w) + \gamma_0 l_w &\text{under hierarchical supervision}
\end{align*} \]
\[ T(pf + wI_w) + R_0 \leq w\Phi(L_m) + \beta(T) \]
\[ l_h, l_m, l_w \geq 0, \]
where the choice variables are time allocation decisions \((L_m, l_h)\) and purchased inputs \((f, l_w)\). The letter \(\mu\) will be used to denote the Lagrange multiplier which corresponds to the capital constraint (5). Let \(\pi^*(w, pf, T)\) be the optimum value function defined by (7).

In addition to this general problem, large scale hierarchical capitalist producers face a production relations choice problem in certain labor market environments, as discussed on page 11 above. This choice between pure wage labor and inquilino systems can be specified as the solution to a side problem in capitalist relations of production in which the capitalist chooses \(w_r\) and \(r\) to:

(7) \[ \text{Max } \pi^6[w_r, r_T] \]
\[ \text{s.t. } \]
\[ \pi^*(r, w_r, pf) \geq \pi \]
\[ \eta = \lambda \Phi(w_r) \]
\[ T_r = T - (r\eta), \]
where \(\pi^6\) is the optimum value function which states the maximum profits which can be obtained when the wage is \(w_r\) and the area left for direct cultivation, \(T_r\), is total land stock, \(T\), less the area given out to the \(\eta\) inquilinos, each of whom receives \(r\) units of land. The number of inquilinos, \(\eta\), is some fraction, \(\lambda\), of the total number of laborers required to
voluntarily fulfill the farm's labor demand, $L_w(w)$. If all labor were provided by landless agents for whom the reservation utility constraint must hold, then $\lambda = 1$. In the more general case where there is an external semi-proletariat, $\lambda$ will be less than one and depend on the farm's labor force composition.

2.3 Typology of Potential Classes

Maximization problem (6) admits of six behaviorally distinct solutions. The solutions identify the range of classes which could emerge in an economy where resources are allocated in conformity with (6). The solution which would characterize the behavior of a particular individual depends on that individual's land endowment, prices and parameter values. For given prices and parameters, as land endowment is increased from zero, solutions or classes emerge in the following order:

Class 1: Proletariat
\[
\mu = 0 \quad \text{(Capital constraint does not bind.)}
\]
\begin{align*}
L_m &= L_0; \\
l_h &= 0 \\
l_w &= 0 \\
l &= 0 \\
f &= 0
\end{align*}

Class 2: "Garden" Semi-Proletariat
\[
\mu = 0 \\
L_m, \quad l_h > 0 \\
l_h &= 0 \\
l &= l_h \\
f &= 0
\]

Class 3: Semi-Proletariat
\[
\mu > 0 \quad \text{(Capital constraint binds.)}
\]
\begin{align*}
L_m &= l_h > 0 \\
l_h &= 0 \\
l &= l_h \\
f &= 0
\end{align*}

Class 4: Peasant
\[
\mu > 0 \\
L_m &= 0; \quad l_h = L_0/T
\]
Along the continuum of farm size there exist critical or boundary endowment levels which mark the transition from one class to another. For given parameter values, the boundaries will be functions of prices. The boundary between class j and j+1 will be denoted $T^j_0(w, p_f)$.

It should be stressed that these six classes represent the potential class structure. That is, it is possible that $T^j_0(w, p_f) - T^{j-1}_0(w, p_f)$ so that a class is squeezed out of existence. Whether any particular class actually exists will depend on the configuration of prices and parameters.

The defining characteristics of each class are straightforward and conform to conventional notions, except perhaps for class 2, "garden" semi-proletariat. This class is an artifact of the assumption that the wages generated by full time wage work are no less than subsistence costs, $w\phi(L_0) R_0$. If this inequality holds strictly, then an individual with incrementally more land than $T^j_0$ will not be capital-constrained. That is $T(p_{f}^* + wL_0^*) + R_0 < w\phi(L_0) + \beta(0)$, where the stars (*) indicate optimal input values chosen in the absence of the working capital constraint. The notion here is that even a person without access to borrowing could afford intensive
cultivation if the plot is small enough. However, unless wages are high, the capital constraint becomes binding on still quite small holdings. The distinction between class 2 and class 3 is thus substantively a rather uninteresting one between individuals with microscopic "garden" plots and other individuals with slightly larger, but still sub-family, holdings. However, the distinction is made for formal completeness. It also helps illustrate some of the model's basic mechanics.

2.4 Resource Allocation and Productivity by Class

Class 1: Proletariat

For an individual with a zero land endowment, and no possibility of renting in land in this version of the model, (6) simplifies to maximization of wage income subject to the time endowment constraint. As the model specifies no non-work use of time, optimal resource allocation for an individual with \( T = 0 \) is simply,

\[
L^{1*}(w,p_f,T) = L_0. 
\]

The labor supply function, \( L^{1*}(w,p_f,T) \), is in this instance a constant and does not vary with prices or land endowment. Note that the superscript "1" indicates that this function applies to individuals who fall into class 1.

The boundary condition marking the transition to the next class is ill-defined as any positive amount of land endowment. As will be seen momentarily, an individual with any amount of land will always choose to cultivate it.

Class 2: "Garden" Semi-Proletariat (GSP)

As discussed above, the garden semi-proletariat potentially appears as a class when \( w \Phi(L_0) > R_0 \). In this circumstance, individuals with a "small"
endowment of land are not capital constrained in that their wage income is sufficient to finance costs of production. Restricting \( \mu = 0 \) and solving (6) without the working capital constraint yields the following first order conditions for the determination of \( l \) and \( f \):

\[
q_1 = w \phi' \\
q_2 = p_f.
\]

These two equations determine the optimal per-hectare inputs of labor and fertilizer, denoted \( l^*(w, p_f, T) \) and \( f^*(w, p_f, T) \) respectively. (Recall that \( l_w \) and \( L_m \) are never both positive, as discussed in 2.3 above.) The labor supply function for members of the garden semi-proletarian class can be written as:

\[
L_m^2(w, p_f, T) = L_0 - T[l^*(w, p_f, T)].
\]

Comparative static analysis shows that as farm size expands, less labor is supplied to the market, raising expected marginal labor market earnings as \( \phi'' < 0 \). In response to the higher marginal cost of labor, \( l^* \), \( f^* \) and \( q \) (output per-hectare) all decrease with farm size \( T \). It should be noted that this inverse relationship is not driven by leisure preferences, but rather by labor market failure. The poorly endowed individual forces down the marginal productivity of labor on his holding (increasing per-hectare output) in order to match the low expected marginal earnings he faces as a nearly full time worker in an imperfect labor market. Desperation, born of relative poverty, thus drives the inverse relationship among the garden semi-proletariat.

Characterization of the behavior of class 2 was predicated on the assumptions that \( T p_f f^* + R_0 < w \phi(l_m^*) + \beta(T) \) (i.e., \( \mu^* = 0 \)) and that \( T l^* < L_0 \). Violation of either assumption as \( T \) increases (for given \( w \) and \( p_f \)) could mark the transition to the next class. For the sake of the completeness of the class typology, we will assume that the capital constraint becomes binding
before the optimal labor allocation becomes full time on farm work. (The opposite configuration could occur if wages are high enough, eliminating class three, and the transition would then be immediately from the garden semi-proletariat to full-time peasant). The endogenous class boundary can thus be defined as:

$$T^*(w,p_f) = (T| Tpf^*(w,p_f,T)+R_0 = w\Phi(I^*_m(w,p_f,T))+\beta(T)).$$

Individuals with land endowments which exceed $$T^*_2(w,p_f)$$ will optimally choose to behave in the manner of class 3.

Class 3: Semi-Proletarian

The assumptions used to characterize the behavior of this class are that the capital constraint binds and that some labor is still supplied to the market (implying that no wage labor is hired-in). Under these assumptions, Maximization of (6) yields the following first order conditions for the determination of $$l,f$$ and $$\mu$$:

$$q_1 = (1+\mu)w\Phi'$$

$$q_2 = (1+\mu)p_f$$

$$Tpf+R_0 = w\Phi(I^*_m)+\beta(T)$$

Interpretation of these conditions is straightforward. Factor inputs are used until their marginal productivities are equated to their real economic cost to the decisionmaker, defined as the direct opportunity cost "marked up" by the shadow price of working capital ($$\mu > 0$$). Thus, for example, the individual will not allocate labor as intensively to own production as he would in the absence of capital constraints because he cannot afford to. Every unit of labor allocated to home production deprives the household of the wage income needed to finance subsistence and fertilizer costs.
The shadow price of working capital ($\mu$) has two economically relevant interpretations. First, it indicates the marginal rate of return of capital to the capital-constrained producer. It can also be interpreted as the interest rate the producer would be willing to pay to informal or other lending sources which could extend credit beyond $\beta(T)$.

For class 3, the net labor supply function is defined as:

$$L_m^3(w,p_f,T) = L_0 - T[l^*(w,p_f,T)].$$

The impact of land endowment on factor intensity and land productivity is ambiguous for this class. As with the GSP class, better endowed individuals supply less labor to the market, marginal earnings increase and it no longer pays to drive own farm marginal labor productivity to the low levels characteristic of the extreme poor. In addition, if external borrowing opportunities are weak (or costly), an increasing scarcity value of capital discourages the withdrawal of labor from the labor market. Intensive cultivation may simply not be affordable. In the special case where there is no access to borrowed capital ($\beta=0$), labor and fertilizer allocated to own production are constant, regardless of farm size, creating a sharply diminishing relationship between farm size and productivity.

However, if access to capital is sufficiently robust, factor intensity and farm productivity can increase with farm size. Let $\varepsilon$ denote the elasticity of working capital ($\beta(T)+w^F(L_m)$) with respect to land endowment. A necessary condition for farm productivity to increase with farm size is

$$\varepsilon > S_f,$$

where $S_f$ is the proportion of working capital consumed by fertilizer expenditures. In this case, the increasing availability of borrowed working capital makes it financially possible (and optimal) for an individual to
devote time and fertilizer to own farm production even as the increasing withdrawal of time from the labor market raises the direct opportunity cost of labor. The credit access rules, embodied in the function $\beta(T)$ discussed above, will clearly have a major impact on the behavior and productivity of the semi-proletarian class.

The transition to the peasant class begins with the endowment level where the condition $T^*(w,p_f,T)< L_0$ no longer holds:

$$T^*_3(w,p_f) = \{T | T^*(w,p_f,T) = L_0\}.$$  

Individuals with endowments in excess of $T^*_3(w,p_f)$ will find it optimal to behave in the manner described in the next section.

**Class 4: Peasant**

In this model, "peasants" are those who neither hire in nor hire out labor. Because they supply no wage labor, the external opportunity cost of peasant labor is the full market wage ($\Phi(0) = 1$). At the class transition point, $T^*_3(w,p_f)$, the marginal product of labor will exactly equal the market wage marked up the scarcity value of capital, $q_1 = w(1+\mu)$. However, even as land endowment increases, and with it $q_1$, labor will not be immediately hired in. Because of the supervisory problems noted earlier, the productivity of hired labor is always below that of own-labor. The efficiency wage for hired labor (i.e., the wage per-unit of effective labor input) is $w/\gamma(l_h)$. The class of peasants will thus exist over the range of land endowments where the marginal product of labor is between $w$ and $w/\gamma$.

The first order conditions which describe peasant behavior are

$$L_m = 0 \quad (T l_h = L_0)$$

$$q_f = (1+\mu)p_f$$
The net-labor supply function for the peasant household is simply:

\[ L^*_m(w, p_f) = 0. \]

With labor supply fixed, the relationship between farm size and productivity within the peasant class will be determined by the interplay between declining labor inputs per-hectare and possibly increasing intensity of fertilizer use. Buoyant capital access could permit the purchase of sufficient quantities of fertilizer to offset the productivity-depressing impact of the declining \( l^* \).

The transition to the capitalist family farm class occurs at the land endowment level where it just becomes profitable to hire in wage labor under the family supervisory mode. Formally the transitional endowment is defined as:

\[ T^*_4(w, p_f) = \{ T \mid q^1(1, l^*) = (1+\mu^*)w/\gamma(1/T) \}. \]

**Class 5: Capitalist Family Farm (CFF)**

The capitalist family farm denotes a unit of sufficient size to justify the hiring in of wage labor. The informal supervision of hired labor which defines this mode (see 2.1 above) becomes ineffective as farm size increases from \( T^*_4(w, p_f) \), leading to an increase in the efficiency wage. Unless offset by abundant working capital, the increasing real cost of labor will induce an inverse farm size-productivity relationship among the farms which define this class. As can be seen from the first order conditions corresponding to this class, labor is hired in to equate the marginal product of labor to the efficiency wage (marked up by the scarcity value of working capital):

\[ T_{l_h} = L_0 \]
These equations implicitly define the net labor supply function for class 5:

\[ l_{m}^{5*}(w,p_{f},T) = [1_{m}^{5*}(w,p_{f},T)]', \]

where the function in square brackets defines the demand for wage labor.

Transition to class 6, the hierarchical capitalist farm, will occur when the same resources produce a greater net income using hierarchical as opposed to informal family supervision. Formally the class boundary can be defined as:

\[ T_{5}^{*}(w,p_{f}) = \{T \mid \pi^{*6}(w,p_{f},T) = \pi^{*5}(w,p_{f},T)\}, \]

where the \( \pi^{*} \) are the optimum value functions defined by (6).

Class 6: Hierarchical Capitalist Farm (HCF)

Except for supervisory mode, behavior of the hierarchical capitalist farmer is identical to that of the CFF class. Under hierarchical supervision, the efficiency wage is given by \( w/(1+\mu) \). In the case where \( \delta''=0 \), the marginal efficiency wage is constant and all class 6 producers will face the same set of input prices. Choice of technique and productivity per-hectare will not vary within this class if there is no change in the scarcity value of capital.

When wage offers to landless workers are bound by the annual utility constraint (2), individuals within the HCF class must also consider the side problem in capitalist relations of production (7). Using the notation developed in this section, this problem can be rewritten as:

\[ \text{Max } \pi^{*6}(w,p_{f},T_{r}) \]
where the superscript \( j \) denotes the class of the inquilinos. The proportion \( \lambda \), which denotes what part of the capitalist's labor force behaves according to constraint (2) and must be endowed with land, is in general endogenous to the wage level. The individual capitalist can be considered to have myopic Nash expectations about \( \lambda \) -- that is, he or she assumes that a fixed amount of non-inquilino labor can be attracted. However, in the general equilibrium, this assumption can be generally violated, and \( \lambda \) must be iteratively updated until self-fulfilling expectations are achieved.

An upper boundary to this class will occur only if at some land size producers cease to be capital constrained. It will be assumed that this condition never holds so that this unconstrained class can be ignored, although its inclusion would present no particular difficulties.

### 2.5 Numerical Comparative Static Analysis of Resource Allocation and Potential Class Structure

To further illustrate the notion of endogenous class structure and the workings of the model, this section offers a numerical comparative static analysis of individual behavior. Wages and prices are exogenously fixed at arbitrary levels and no market consistency conditions are imposed. Given those prices, the analysis studies the economic behavior of individuals as a function of land endowment levels. Appendix 1 details the specific functional forms and parameter values which have been assumed for the analysis. Numerical values were chosen to approximate productivity and income levels.
characteristic of Central American agriculture. The analysis will initially
precede on the assumption that capitalists only utilize wage labor production
relations.

Farm size, measured in manzanas (1.7 manzanas equals 1 hectare) is
displayed along the horizontal axis of Figure 3. The vertical lines which
appear along that axis mark the endogenous class boundaries for two different
wage levels. Boundaries are shown for the transitions from garden semi-
proletariat to semi-proletariat, from semi-proletariat to peasant, from
peasant to capitalist family farmer, and from capitalist family farmer to
hierarchical capitalist producer. For example, at a wage level of 3000
("cordobas per year"), all individuals with land endowments between 16 and 26
manzanas will optimally follow the "capitalist family farmer" behavioral
pattern, as the dashed lines show. The pure peasant farm class exists over
the narrow range of 14 to 16 manzanas. As the wage (and other prices)
change, the class boundaries will change. For example, when the wage falls
33% to 2000 cordobas, the class boundaries shift leftwards as the solid lines
in Figure 3 show. At the lower wage, it becomes profitable to hire in labor
at smaller farm sizes, and the capital constraint binds semi-proletarian
producers more quickly.

Figure 3 also illustrates the productivity of the different sized farm
units under the low and high wage assumptions. Farm productivity (output
per-manzana) declines with farm size over the garden semi-proletarian class
and over the first part of the semi-proletarian class. (Productivity of the
GSP class cannot be seen in Figure 3 as it exceeds the bounds of the graph.)
This inverse relationship abruptly reverses itself at the endowment level of
about 9.5 manzanas, the farm size at which external credit becomes available.
Productivity eventually levels out and remains at a constant level for the large scale hierarchial capitalist farms. Productivity is higher with the lower wage for the CFF and HCF classes, and for the garden semi-proletariat. However, lower wages leads to reduced farm productivity for significant segments of the semi-proletarian class. Figures 4 and 5 display the economic forces, labor costs and access to capital, which underlay these agricultural productivity relationships.

The dashed line in Figure 4 shows the marginal opportunity cost of a unit of effective labor to the different classes of producers assuming a market wage of 2000 cordobas. For semi-proletarian households, which are net suppliers of labor, the marginal cost of labor is the reservation wage (i.e., the market opportunity cost of family labor—the market wage times the marginal employment probability). For production units which hire in labor, the marginal cost of labor represents the "efficiency wage"—the cost per unit of effective labor input. Supervisory costs, as discussed above, drive the efficiency wage above the market wage actually paid to workers.

As can be seen, marginal labor costs are inversely related to farm size until they decrease slightly at the CFF-HCF boundary. The meager land endowments of the smallest semi-proletarian producers creates a desperation (and willingness to work for low marginal returns) borne of extensive dependence on labor market earnings and high seasonal unemployment. The inverse relationship observed over the zero to 9.5 manzana range is in part a classic Chayanovian case of "overexploitation" of family labor by poor households. Yet, cheap family labor is not the only factor behind farm productivity. Despite access to extremely cheap family labor, productivity on many semi-proletarian farms (roughly over the 3 to 14 manzana range) is
below that of all other producers. As can be seen in Figures 3 and 4, beyond approximately 9.5 manzanas, productivity increases with farm size even as the marginal cost of labor increases.

Figure 5 shows the reason for this low productivity semi-proletarian sub-sector, scarcity of working capital. The shadow price of capital, \( \mu \), can be interpreted as the marginal rate of return on capital. For example, a producer for whom \( \mu = .5 \) would experience a 50% return on additional capital invested. As \( \mu \) increases, producers cannot afford to purchase fertilizer, nor even to reallocate labor away from poorly paying wage labor opportunities. The gap between marginal labor costs and marginal on-farm labor productivity in Figure 4 shows the impact of working capital scarcity on resource allocation.\(^{11/} \) As can be seen, this gap is particularly large for the lowest productivity semi-proletarian producers.

The drop off in the productivity of semi-proletarian producers when the wage declines (see Figure 3) can now be understood. As Figure 5 shows, the lower wage drives up the shadow (or scarcity) value of working capital for these households. In seemingly perverse fashion, these households supply more labor to the market, and less to their own plots, as the wage declines because they are less able to self-finance home production. Other classes of producers (GSP, CFF and HCF) cultivate more intensively and produce more per manzana when labor becomes cheaper.

As discussed earlier, large scale capitalist producers face the side problem (7) in optimal production relations. This problem becomes relevant if landless labor completely withdraws from the agricultural economy when the wage which would clear the market when they maintain their rural residence yields an annual utility below some critical level. Figure 6 portrays a
graphical solution to the production relation problem on the assumption that the landless must be offered a contract, specifying a wage and a land plot size, which yields them an annual utility of 2500 cordobas. (Because of seasonal unemployment, a full time worker at an annual wage of 3000 would earn only 1800 cordobas.) As specified in (7), capitalists choose the contractual combination which maximizes their profits. For the situation portrayed in Figure 6, the optimal contract would offer a plot of about 0.8 manzanas and a wage of about 2500 cordobas, maximizing capitalist profits at about 500 cordobas per manzana owned. A 100 manzana farm which, for example, employed 10 tied laborers would thus directly cultivate only 92 manzanas and turn over the remaining 8 manzanas as partial compensation to its resident workforce. The pure wage system would appear as the corner solution to this problem, with plot size tau equal to zero.

The analysis in this section has explored the behavior of differentially endowed individuals in isolation under alternative market conditions. But what sort of equilibrium would the interaction of these individuals create, and how does the structure of endowments affect agrarian structure and productivity. Section 3 now extends the model to answer these general equilibrium directions, linking the individual behavior explored in this section to a land distribution and market consistency conditions.

SECTION 3 A SHORT RUN GENERAL EQUILIBRIUM MODEL OF AGRARIAN STRUCTURE

Imposing a small country (or big government) assumption that output and fertilizer prices are exogenous to the agrarian economy leaves only one endogenous price in the model, the wage. As specified in section 2.1, not all days of labor supplied to the market translate into employed days. This
specification was argued to partly reflect transaction costs and to partly reflect disequilibrium phenomena. The market clearing condition used here is that the wage adjusts until labor demands equals the number of days employed as determined by the interaction of labor supply and the employment function, \( \phi \). This approach to the labor market compromises between the equally undesirable assumptions of either a fixed wage or full employment.

Using the notation developed in section 2.4, the labor market clearing condition can be written as:

\[
\begin{align*}
(N_0 \Phi[L^1_m(w)] + N_1 \int_{T_1(w)}^{T_2(w)} \Phi[L^2_m(w,T)]f(t)dt + N_1 \int_{T_3(w)}^{T_4(w)} \Phi[L^3_m(w,T)]f(t)dt) + N_1 \int_{T_5(w)}^{T_6(w)} \Phi[L^4_m(w,T)]f(t)dt) - (N_1 \int_{T_4(w)}^{T_5(w)} L^5_w(w,T)f(t)dt + N_1 \int_{T_6(w)}^{T_7(w)} L^6_w(w,T)f(t)dt) & = 0.
\end{align*}
\]

where \( f(t) \) is the probability density function which describes the distribution of land, \( N_0 \) is the number of landless agents and \( N_1 \) is the number of landed agents in the economy. Note that as the wage is adjusted, the endogenous class boundaries change as well as the values of the labor supply and demand functions.

Using this market clearing condition, the remainder of this section analyzes the impact of alternative land ownership distributions and labor supply conditions on the structure and performance of a small Latin American economy endowed with 1.2 million manzanas of arable land and 126,000 rural
agents.

3.1 Numerical Analysis of Equilibrium Agrarian Structure in the Absence of Permanent Outmigration by the Landless

This section analyzes three alternative land ownership distributions: A bimodal (see note 2); A "unimodal" distribution with farm area and farm units concentrated at an intermediate holding size; and, A distribution where most small holdings have been subsumed into the large farm sector. All landless agents are assumed able to maintain themselves in the rural sector over the short run of the model. Section 3.2 below reconsiders these same distributions when there is a binding annual utility constraint which must be met to keep the landless resident in the rural sector.

Figure 7 presents a classical bimodal land ownership structure. Small holdings below 2 manzanas in size constitute 41 percent of all farm units, but control only 3 percent of agricultural area. The largest farm size class occupies 29 percent of the area, but contains only 1 percent of farm units. The situation portrayed in Figure 7 roughly corresponds to Nicaragua in 1970 as revealed by that country's agricultural census. As the aggregate census data give no information on the distribution of holdings within any size class, it is assumed here that they are simply uniformly distributed across the size class range.

Table 1 reports the equilibrium wage, class structure, income distribution and productivity for the bimodal agrarian economy depicted in Figure 7. (The appendix reports the functional forms and parametric specifications used in the calculations.) The landless, who comprises 32% of the rural population, receive annual incomes of 2183 cordobas, and suffer a 40% underemployment rate. (The wage for full time work would be 3639—the output
is the numeraire good with price equal to one.) Garden semi-proletarian families fare slightly better, with the average family earning 2711 cordobas and having 15% underemployment. It will be recalled from Figure 3 that this class of producers exhibits high productivity per-Manzana cultivated. But as these income figures make clear, their hyperproductivity reflects a poverty borne out of poor resource endowment. In total the different semi-proletarian groups comprise 61% of the population, peasants 1%, capitalist family farmers 3% and hierarchical capitalist producers 4%.

Figure 8 portrays a unimodal distribution created when all holdings greater than 35 manzanas in size are eliminated and the owners are left with 34.5 manzana reserves. Expropriated land is distributed to landless individuals in plots averaging 20.5 manzanas in size. Table 1 reports the equilibrium structure which emerges under this ownership distribution. As can be seen, the equilibrium wage declines drastically to 2664 cordobas from the bimodal benchmark value of 3639. Output is only slightly below the bimodal value, and rural income is higher, reflecting the shift to labor intensive production. This unimodal economy employs 86% of its available labor time, using 74% of its effective labor potential. Both these figures are significantly above the rates achieved under the other land ownership distributions.

Finally, expropriation of the smallest producers in the bimodal distribution (Figure 7) creates the ownership structure depicted in Figure 9. It might be thought that this proletarianization of the population (89% of which is landless following the primitive accumulation) would put extreme downward pressure on the wage relative to the bimodal case. In fact, the equilibrium wage rises between 5 and 10 percent. The higher wage level
reduces the incomes of the larger farm units which hire in labor. Income inequality does notably increase (by most measures), as cursory examination of the Lorenz curves depicted in Figure 10 show. Aggregate agricultural output falls by approximately 5%. Total agricultural income falls by almost 10% (the larger decrease in income reflects a decline in the labor intensity of production, with a proportionately greater share of output accruing to non-agricultural fertilizer producers). The incomes of the formerly landed agents falls drastically and their rate of underemployment rises to 40% with proletarianization.

This simple experiment would seem to reveal something of the cheap labor logic which has been argued by de Janvry and others to characterize the symbiotic relationship between capitalist and semi-proletarian agriculture. In this case, the semi-proletarian agriculture keeps labor cheap because it suppresses effective demand for labor. As discussed in Section 2, labor intensity on semi-proletarian holdings is kept down by capital constraints. As that land is shifted to capitalist cultivation, total labor demand increases proportionately more than labor supply.

This increase in the wage with proletarianization is perhaps a bit of an artifact of the assumed severity of capital constraints. However, were there a migration option in this model, the relative cheapness of semi-proletarian labor would become more evident and compelling. In the bimodal equilibrium, the wage is low, but annual incomes for the semi-proletarian group are relatively high. This group would be much harder to shift out of agriculture than the proletarian group under the primitive accumulation, large farm scenario, particularly if one assigns a value to the security provided even by meager self-cultivation. The next section now considers the performance
of these two economies under a binding utility constraint for landless workers.

3.2 Equilibrium Agrarian Structure under Migration Constraints

It is assumed here that landless individuals will migrate and withdraw from the agricultural economy if their annual income falls below 2500 cordobas. Under a pure wage labor system, labor outmigration occurs until the wage rises sufficiently to fulfill this constraint (given seasonal unemployment, the wage must reach 4167 cordobas to fulfill the constraint). Table 2 displays equilibrium agrarian structure for the concentrated capitalist economy (Figure 9). Under the utility constraint, when a pure wage system is maintained agricultural output and income falls in as landless labor exits agriculture. (About 10% of the landless labor migrates before the wage increases sufficiently to cease the outmigration.) Capitalist (HCF) profits per manzana owned decline to 383 cordobas, down from about 416 cordobas.

The inquilino system offers a potentially profitable alternative to the pure wage labor system. In general equilibrium, the inquilino system can generate two possible outcomes. The first is that when HCF capitalists behave optimally according to (7), the number of inquilino positions offered is less than or equal to the number of rural landless. The second case occurs when HCF capitalists demand more inquilinos than there is rural labor. Rather than permit labor immigration from outside the rural economy to resolve this second situation, it will be assumed that competitive capitalists bid up the reservation utility level until demand for inquilinos equals the available pool of landless. In all cases, HCF capitalist grant
the optimally sized land plot to their inquilinos and then pay a single wage to all workers (whether inquilinos or genuine external semi-proletarians) which is determined by the labor market clearing condition.

Table 2 reports economic performance under the inquilino system for the concentrated land ownership distribution. In equilibrium, all landless laborers are retained in the rural sector with the offer of small inquilino plots. With the increased labor supply made possible by the inquilino system, the equilibrium wage declines, and aggregate output and income increase. Capitalist profits per manzana owned increase notably over what they were in the pure wage labor system.

SECTION 4 MECHANIZATION, ACCUMULATION AND LAND MARKETS--TOWARDS THE ECONOMICS OF STRUCTURAL EVOLUTION

The model developed in this paper displays the impact of alternative ownership distributions on agrarian structure and productivity. In its display of the differential productivity and profitability of different classes of producers, it also reveals the economic incentives and pressures for dynamic structural evolution. Serious analysis of structural evolution must not only consider these pressures and whether or not they are resolved over time under a system of imperfect markets. It also must consider the simultaneous impact of technological change, mechanization, population growth and migration, market expansion and capital accumulation. None the less, it is possible at this stage to use the current static model to speculate on alternative structural trajectories.

The fundamental pressure for structural evolution in the model results because of market structures which isolate relatively cheap labor in the small farm sector, and relatively cheap capital in the large farm sector.
Logically, there are two basic structural trajectories which could occur to eliminate this pressure. The first is an expansion of the small holder sector. The second is an expansion of the large scale sector. These two paths roughly correspond to what Kay (1977) calls expansion of the "peripheral" (or peasant) enterprise and expansion of the "core" enterprise, respectively. It should be noted that rising labor costs associated with the proletarianization of both inquilinos and small holders could choke off the latter path before all land was transformed to the large farm sector. This stunted version of the core enterprise expansion path would generate a long term structural equilibrium similar to what de Janvry (1981) calls functional dualism.

Which of these evolutionary paths is most likely? Absent an overhaul of capital markets, expansion of the small farm sector seems unlikely, except through sharecropping arrangements. However, incentives to reallocate land through that device could be radically altered by mechanization, particularly as sharecropping is an imperfect device to access cheap labor.

Abijhat Sen (1981) gives clear statement to the notion that mechanization (or, more generally, non-labor intensive production technologies, including ranching) is one way to circumvent the labor access problems of large holdings. Indeed, some argue that mechanization has displaced earlier modes of large scale labor intensive cultivation, including inquilino systems.

Mechanization would thus seem to give a push to the large farm expansion path. However, the scale at which mechanization would seem to be feasible is likely to be rather small, at least compared to the large capitalist farms which occupy hundreds of manzanas in this model. A key question then becomes
whether mechanized production can be adopted by the capitalist family farm sector. As noted, average labor costs may be lower under this organization of production than under hierarchical supervision giving them a potential competitive advantage. If the wage were to increase over time (either because of developments outside the rural economy, or because of proletarianization) the class boundary between family and hierarchical capitalist farms shifts out, meaning capital mechanization becomes more likely. Under this scenario, competitive land reallocation in a land market could lead to an agrarian structure dominated by capitalist family farms. Otherwise, a large farm path seems most likely.
Fig 1  Rationed Access to Capital

Fig 2  Supervisory Modes

Dashed Line, Hierarchical Supervision
Solid Line, Casual Supervision
Farm Prod. & Class

Dashed Line, Wage=3000
Solid Line, Wage=2000

Output per Mz

Manzanas
Inquiline System

Inq. Wge, Dashed Line
Kist \( \pi/mz \), Solid Line
Utility Constraint = 2500

Inq Plot Size, \( \tau \), (Mzs)
Shadow Price of Capital

Dashed Line, Wage=3000
Solid Line, Wage=2000
Marg. Prod. Labor & Eff. Wage

Dashed Line, Eff. Wage
Solid Line, MPL
Wage = 2000

MPL, Eff. Wage
5000
4000
3000
2000
1000
0

Manzanas
0.  5.  10.  15.  20.  25.  30.
Farm Size Distribution

Average Farm Size is 14.4 Mzs
32% of Households are Landless

First Bar is % Units. Second is % Area.

Farm Size Distribution

Average Farm Size is 10.2 Mzs. 44% of Households are Landless

First Bar is % Units. Second is % Area.
**Fig 9** Farm Size Distribution

Average Farm Size is 96 Mzs, 90% of Households are Landless

First Bar is % Units, Second is % Area
Figure Lorenz Curve for Income Dist.

- Cum. % Income vs Cum. % Population

- Bimodal Economy
- Proletarianized Economy
### TABLE 1
**EQUILIBRIUM AGRARIAN STRUCTURE**

<table>
<thead>
<tr>
<th>Class Structure</th>
<th>Bimodal Economy</th>
<th>Prole. Economy</th>
<th>Egal. Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proletariat</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Population</td>
<td>0 Mzs</td>
<td>0 Mzs</td>
<td>0 Mzs</td>
</tr>
<tr>
<td>Avg. Income</td>
<td>2183</td>
<td>2326</td>
<td>1598</td>
</tr>
<tr>
<td>Underemployment Rate</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Garden Semi-Proletariat</strong></td>
<td>0.6 Mzs</td>
<td>---</td>
<td>0.2 Mzs</td>
</tr>
<tr>
<td>% Population</td>
<td>9%</td>
<td>9%</td>
<td>3%</td>
</tr>
<tr>
<td>Avg. Household:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzs Owned</td>
<td>0.3</td>
<td>---</td>
<td>0.1</td>
</tr>
<tr>
<td>HH Income</td>
<td>2703</td>
<td>---</td>
<td>1858</td>
</tr>
<tr>
<td>Income/Mz</td>
<td>9012</td>
<td>---</td>
<td>18,584</td>
</tr>
<tr>
<td>Underemployment Rate</td>
<td>15.3%</td>
<td>---</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Semi-Proletariat</strong></td>
<td>0.6-15 Mzs</td>
<td>7-15.5 Mzs</td>
<td>0.2-14 Mzs</td>
</tr>
<tr>
<td>% Population</td>
<td>52%</td>
<td>3%</td>
<td>64%</td>
</tr>
<tr>
<td>Avg. Household:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzs Owned</td>
<td>3.6</td>
<td>11.2</td>
<td>4.2</td>
</tr>
<tr>
<td>HH Income</td>
<td>4773</td>
<td>8294</td>
<td>3898</td>
</tr>
<tr>
<td>Income/Mz</td>
<td>1326</td>
<td>741</td>
<td>928</td>
</tr>
<tr>
<td>Underemployment Rate</td>
<td>9.5%</td>
<td>5.2%</td>
<td>13.9%</td>
</tr>
<tr>
<td><strong>Peasants</strong></td>
<td>15-17 Mzs</td>
<td>15.5-18 Mzs</td>
<td>14-15 Mzs</td>
</tr>
<tr>
<td>% Population</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Avg. Household:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzs Owned</td>
<td>16.3</td>
<td>16.8</td>
<td>14.5</td>
</tr>
<tr>
<td>HH Income</td>
<td>11,261</td>
<td>11,469</td>
<td>10,349</td>
</tr>
<tr>
<td>Income/Mz</td>
<td>691</td>
<td>683</td>
<td>713</td>
</tr>
<tr>
<td><strong>Capitalist Family Farms</strong></td>
<td>17-28 Mzs</td>
<td>18-28 Mzs</td>
<td>15-24 Mzs</td>
</tr>
<tr>
<td>% Population</td>
<td>3%</td>
<td>3%</td>
<td>12%</td>
</tr>
<tr>
<td>Avg. Household:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzs Owned</td>
<td>22.5</td>
<td>23.0</td>
<td>19.5</td>
</tr>
<tr>
<td>HH Income</td>
<td>13,330</td>
<td>13,397</td>
<td>12,749</td>
</tr>
<tr>
<td>Income/Mz</td>
<td>593</td>
<td>583</td>
<td>654</td>
</tr>
<tr>
<td><strong>Hierarchical Capitalists</strong></td>
<td>28-600 Mzs</td>
<td>28-600 Mzs</td>
<td>24-35 Mzs</td>
</tr>
<tr>
<td>% Population</td>
<td>4%</td>
<td>5%</td>
<td>16%</td>
</tr>
<tr>
<td>Avg. Producer:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mzs Owned</td>
<td>166</td>
<td>190</td>
<td>29.9</td>
</tr>
<tr>
<td>Total Income</td>
<td>69,217</td>
<td>75,208</td>
<td>17,345</td>
</tr>
<tr>
<td>Income/Mz</td>
<td>417</td>
<td>396</td>
<td>580</td>
</tr>
<tr>
<td>Aggregate Indicators</td>
<td>1st Year</td>
<td>2nd Year</td>
<td>3rd Year</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Wage (x10^6)</td>
<td>3639</td>
<td>3876</td>
<td>2664</td>
</tr>
<tr>
<td>Output (x10^6)</td>
<td>1188</td>
<td>1127</td>
<td>1168</td>
</tr>
<tr>
<td>Rural Income (x10^6)</td>
<td>851</td>
<td>779</td>
<td>880</td>
</tr>
<tr>
<td>Fertilizer Use (x10^6 kilos)</td>
<td>3.12</td>
<td>3.18</td>
<td>2.69</td>
</tr>
<tr>
<td>Labor Utilization Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor Time</td>
<td>77.5%</td>
<td>63.9%</td>
<td>86%</td>
</tr>
<tr>
<td>Labor Power</td>
<td>66.8%</td>
<td>51.7%</td>
<td>74%</td>
</tr>
<tr>
<td>Credit Disbursed (x10^6)</td>
<td>490</td>
<td>593</td>
<td>398</td>
</tr>
</tbody>
</table>
Table 2
Equilibrium Agrarian Structure under Labor Migration Constraints
(Using Proletarianzed Land Distribution)

<table>
<thead>
<tr>
<th></th>
<th>Pure Wage System</th>
<th>Inquilino System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage</td>
<td>4167</td>
<td>3975</td>
</tr>
<tr>
<td>Inquilino Plot Size (mz)</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>Inquilino Utility</td>
<td>2500</td>
<td>2500</td>
</tr>
<tr>
<td>Average HCF Profits per Owned Manzana</td>
<td>382</td>
<td>405</td>
</tr>
<tr>
<td>Aggregate Indicators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1105</td>
<td>1145</td>
</tr>
<tr>
<td>Rural Income</td>
<td>735</td>
<td>788</td>
</tr>
</tbody>
</table>
Appendix: Model 1 Specification

Numerical analysis of the model requires that the general functional forms be explicitly and numerically specified. A farm level data set from Nicaragua (discussed in Carter 1987b) was used to crudely calibrate parameters presented here. Any Parameter for which there is no empirical justification is marked with a "*".

Production

\[ Q(L, F, T) = D(L)^\alpha (F)^\alpha (T)^\alpha, \quad D=1780; \quad \alpha=1/3. \]

Prices

Output price = 1;
\[ P_F = 100; \]
Wage, endogenous or as indicated.

Subsistence Requirement

\[ R_0 = 1000*. \]

Credit Rationing Function

\[ \beta(T) = k_1T - k_0/T, \quad k_1=900, \quad k_0=45,000*. \]

Labor Market Employment Function

\[ \Phi(L_m) = L_m - cL_m^2, \quad c=0.4*. \]

Effective Labor under Casual (Family) Supervision Function

\[ L_h + \gamma(L_h/T)L_w = 1 + (g_1/g_1+T^2)L_w, \quad g_1=750* \]

Effective Labor under Hierarchial Supervision

\[ L_h - \delta(L_w) + \gamma_0L_w = 1 - (a + bL_w) + \gamma_0L_w, \quad a=.25*, \quad b=.1*, \quad \gamma_0=0.9*. \]
Figure 7 portrays what has come to be known as a "bimodal" farm size distribution—bimodal in the sense that the mode of the distribution of farm units is at a small farm size class, while the mode of the farm area distribution is at a large size class.

Bimodalism probably exists in the ownership distribution of industrial assets in market economies, with many people owning a small proportion of the asset stock and a few people owning a large share. But as small holders of industrial assets typically do not operate their own firms, bimodalism in the distribution of operating firms would be rather more surprising. In agriculture, the significance of the bimodalism in the operational distribution of farms displayed in Figure 6 would not transcend distributional considerations if operational scale exhibited what might be called "super neutrality".

While there seems to be general agreement that capitalism has taken firmly taken root in Latin American agriculture, there is significant disagreement over the form of emergent agrarian structure. Competing theories can be lumped into three groups based on their expectations of what will happen to bimodal land ownership distributions such as that displayed in Figure 7. The first theory hypothesizes an increasing concentration of land ownership which will squeeze out the small farm sector along a Leninist "junker road" (e.g. see Kay 1930). A second hypothesizes that the bimodal distribution will be squeezed into the middle from both sides, yielding a unimodal distribution of capitalized family farmers (see Scott and Lehman). The third point of view asserts that the bimodal distribution is basically stable, held in place by an economic symbiosis between the minifundio and large farm sectors (de Janvry 1981).

An example of this hypostatization in a formal economic model is the paper by Dutt (1984) which assigns exogenous behavioral attributes to agents. Lehman (1985) presents a more general critique of this phenomena in the peasant studies literature.

This does not rule out the formation of political groups capable of pursuing common class interest. A good example of this is the recent work by de Janvry, Sadoulet and Fafchamps (1987). But as this work indicates, the formation of such coalitions is not trivial. More generally, concern is with situations where there are incentives for some individuals to deviate from the class interest, so that there is not incentive compatibility between class and individual interest.

Examples of collateral which have greater value to local informal than formal lenders include geographically isolated productive assets (which would be costly for a formal lender to sell, but remunerative for a local lender to directly exploit) and standing crops (which can be hidden from distant formal institutions, but not from local lenders).
Feder (1985) suggests a similar supervisory specification.

In an analysis of the slow rate of mechanization in southern U.S. cotton agriculture, Whatley (1985) illustrates the significance of what has here been called a binding reservation utility constraint. His argument is that the presence of such a constraint inhibited partial mechanization because it would not have reduced total labor costs which were bound by a constraint such as (2) above. Mechanization was much more rapid, he argues, in Texas cotton where a migrant labor force structured labor supply in conformity with a reservation wage constraint.

Eswaran and Kotwal (1985a) put forward an alternative explanation of labor tying based on the need to "overpay" a segment of the labor force so that workers in this segment can be entrusted with hard to supervise tasks. Their theory could be used to provide an alternative rationale for utility constraint (2). The analysis here will show the internal semi-proletarianization can be a cheap way for the capitalist to meet such a constraint, regardless of why it exists.

The changing intensity of capitalist production, and hence the cost of land foregone to the inquilino system, can be expected to change with capital accumulation, mechanization and technological change in agriculture. As section 4 of this paper discusses, these factors will be incorporated in a complementary dynamic analysis which should be able to address the issue of inquilino displacement, or internal proletarianization, as Kay (1977) calls it.

The gap also indirectly shows the impact of credit rationing and differential credit constraints on production. Could efficiency labor be reallocated from holdings where the MPL is low to holdings where it is high, total agricultural production would increase. However, imperfections in the labor market block this reallocation. Note that the reallocation of land, in the opposite direction, could also apparently increase total production. However the ability of small holders to productively absorb land is tightly constrained by their access to capital as the next paragraphs discuss (also see Jonakin and Carter 1987).

Eswaran and Kotwal (1986) specify the endowment distribution in their model in terms of a single parameter cumulative density function. While analytically neat, their approach suppresses a number of interesting land distribution variants, in exactly the same way that a gini coefficient cannot fully describe the attributes of an income distribution. The analysis here uses the complete pdf for the land distribution, making it possible, for example, to distinguish between bimodal and non-bimodal land ownership distributions which may have similar concentration measures, but which are economically distinct.

Discuss agricultural ladder and Lehman's rediscovery of same in Ecuador.
REFERENCES


Binswanger (n.d.)--Appendix B to a Brazil report


