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HOUSEHOLD PRODUCTION, CONSUMPTION AND TIME ALLOCATION IN PERU

BY

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Abstract

Based on the neo-classical theory of time allocation, consumption and production we estimate a particular econometric model for Lima and the rural areas of Peru. This model is well suited for carrying out policy simulations on how households time allocation and the income distribution are affected from different policy measures such as increased schooling and wage rates. The econometric model is sufficiently general to account for simultaneous decisions on time allocation in large households both across sectors (wage work and selfemployment) and across adult family members.

We also report a series of policy simulation results for Lima.

CONTENTS

1. INTRODUCTION

At the outset a micro-econometric analysis of the neo-classical type may seem problematic for the Peruvian labor market. First, the country is rather complex and heterogeneous with respect to geography, cultural traditions and social and economic conditions. Second, it may be argued that the paradigm of rational behavior is not the best point of departure in order to conceptualize and describe behavior in developing countries. The impact of traditional values and customs may for example strongly influence households allocation of time between females and males.

Also severe restrictions on individuals choices may be of great importance. Even if one accepts the neo-classical framework as a reasonable description one might still be sceptical towards the possibility of undertaking a rigorous empirical analysis. This is so because this type of approach requires reasonably accurate data on a number of household economic variables as well as choice constraints. Also the extreme heterogeneity makes it hard to develop and estimate realistic econometric models.

The present study is an attempt to apply the neo-classical theory to analyze household behavior in Peru.

To summarize the main idea here consider a household consisting of husband and wife. This household is supposed to maximize a utility function with respect to male and female hours of work and consumption subject to the (static) budget constraint. This utility function depends on the age of each person and of numbers of small children. While the theoretical model is the same as those found in the literature, the econometric formulation we use is quite different. This follows from the fact that we postulate different assumptions on the stochastic error terms in the model. The labor supply functions that correspond to the utility function are not linear in the parameters. However, our assumptions imply convenient expression for the <u>probability distribution</u> of (observed) consumption and labor supply. This distribution is a function of the parameters of the utility function and it is utilized in a maximum likelihood estimation procedure. Ones the parameters of the utility function has been estimated we can use it to simulate individual household responses.

At present, empirical results for Lima and the rural areas are reported. Here the household utility framework mentioned above is extended, to include allocation of time between wage work and selfemployment in which the output is represented by a profit or a gross revenue function.

Since 1985 when the data were collected the Peruvian economy has entered a severe recession. The question is then if the results obtained under totally different economic conditions have any value under today's or future conditions. One possible attitute is the following:

It is of fundamental interest to apply empirically founded behavioral models to assess the labor supply response and the corresponding impact on economic welfare from various policy measures. Specifically, given similar conditions of the Peruvian economy as of 1985 our study suggests how, for example, different measures would affect labor supply behavior and economic inequality.

The paper is organized as follows. Section 2 contains a verbal description of the main feature and analytic approach. In Section 3 we describe at some detail the particular econometric formulation on which our study is based and in Section 4 this general framework is adapted to the rural areas of Peru. This section also contains the estimation results for the rural areas. Section 5 contains the specification and the estimation results for Lima and Section 6 yields the economic interpretation of the empirical results.

2. SUMMARY OF ANALYTIC APPROACH

The purpose of the analysis is to estimate an econometric model that is convenient for simulating certain types of policy experiments. What we consentrate on here is to study the effect on production, consumption and time allocation from changes in education and wage rates. For example, we would like to answer how many men and women would participate in wage work if education were increased. Furthermore, we are interested in how policy changes of the types mentioned above would affect the mean level and the degree of inequality in the distribution of income and welfare.

The theoretical model is based on the neo-classical model for consumption and allocation of time. Provided the data are not corrupted by measurement error it seems natural to us to apply this framework. Our justification is:

i) No one can spend more than their income. In other words, the economic budget constraint plays a crucial role.

ii) Similarly there is a time constraint; the sum of hours spent on different activities cannot exceed 24 hours per day.

iii) It is reasonable to assume that people are not indifferent with respect to different levels of leisure and consumption. Thus it makes sense to introduce the notion of preferences and to represent these by utility indexes.

In the standard models of labor supply the decision-maker is assumed to maximize utility with respect to leisure and consumption subject to the budget constraint given wages and prices. One major objection against this framework is that individuals and households in developing countries can hardly be viewed as having full freedom of choice. On the contrary, they most likely often face severe constraints related to job and production opportunities. The set of feasible opportunities a particular individual (household) faces is influenced by the individual's education, experience and training, by the structure of the economy and the general economic policy, by specific policy programs (for example health programs and development of infrastructure and transportation in rural areas) by climatic condition and ecological changes, etc. Accordingly, it seems natural that a realistic economic model of household behavior should in some sense acommodate variations in opportunities across households.

The particular econometric approach taken in the present study differs somewhat from the standard models in the labor supply literature. In our model the underlying decision variable is <u>latent</u> and is denoted <u>position</u>. By position, we mean a particular combination of market and non-market activities. Examples are work associates with certain types of agricultural production, combined with work in a particular wage earning job. A position is characterized by specific attributes like type and level of output and input factors, hours of work, wage rates related to wage earning jobs, etc. Given the position these attributes are assumed fixed. The choice problem is viewed as one in which the individuals of the household select the best "package" (maximizes utility) of attributes from a set of feasible attributes. This choice set is assumed known to the household but it is unobservable to us as econometricians. The set of household specific feasible positions is represented in the model by a distribution function which is called the <u>opportunity</u> <u>distribution</u> (density). The opportunity density represents an aggregate measure of the choice opportunities and it is defined, loosely spoken, as the fraction of positions with specific attributes that are feasible to the household. For example, if the attributes are job-specific hours and wages and profit in own farm production the opportunity density measures the amount of positions with a specific level of wages, hours and profit that are feasible. Due to unobserved heterogeneity in opportunities across households it is natural to interpret the opportunity density as a probability density. Specifically, it is the probability that a particular position-specific attribute-combination is feasible to a (randomly selected) household. This type of approach was developed and applied by Dagsvik (1988), Dagsvik and Strøm (1989), and it is related to the model developed by Ben-Akiva et al. (1985).

In the following section an outline of the econometric model is specified and the estimation procedure is described. Our final model is a simultaneous model in consumption, hours of work, wage rates, and profit conditional on family size and schooling. By "conditional" we mean that we have specified a conditional density for (optimally chosen) hours of work, consumption, wage rates and output given the optimally chosen family size and schooling. In other words (given the particular underlying assumptions of our model) the model is consistent with the notion of simultaneous choice in all the attributes mentioned above including schooling and family size.

The introduction of the opportunity distribution in addition to the specification of a household utility function is obviously appealing but it also raises new problems related to functional form and the identification of parameters related to the opportunity density and to the utility function. Even if the parameters of the utility function and of the opportunity density cannot be fully identified without strong assumptions, the present formulation has nevertheless the advantage in that it suggests a natural and convenient way of taking into account unobserved heterogeneity in opportunities and how to introduce variables that characterize individual qualifications as well as variables that characterize the community and the environment. At the present stage of the project the opportunity density is specified as a function of the individuals (belonging to the household) education. Specifically, the fraction of feasible wage work positions is specified as a function of years of schooling. Similarly the fraction of informal selfemployment positions (non-agricultural) is specified as a function of level of schooling. This enables us to simulate the effect of increased education on the allocation of time in different sectors through increased sets of market opportunities, while keeping the wage rate and the preferences fixed. Similarly, we can study the effect of schooling through increased wage rates while keeping the opportunity density fixed.

The essential postulate that ensures identification is that the opportunity density with respect to offered hours is assumed uniform which means that we assume no contraints on hours of work (given that work in the respective sectors is available). The offered wage distribution across wage work positions, conditional on education, is assumed to be log normal with mean dependent on experience and level of schooling (splines). The opportunity density of the profit conditional on the input hours is assumed log normal with mean that is consistent with a translog type specification. We do, however, not distinguish between profit from agricultural and non-agricultural selfemployment.

The preferences are represented in the model by a utility function that is additively separable in consumption and in each of the individuals leisure. The leisure terms are parameterized as a function of age and for females we have added the number of children below six years of age in interaction with hours of work in the wage sector.

The parameters of the opportunity density and of the utility function are estimated simultaneously by a modified maximum likelihood procedure. We have also estimated the wage equations and the gross revenue function by OLS. The OLS procedure may lead to biased estimates since it neglects that households do not maximize profit but the joint utility of consumption and leisure. Consequently, the conditional expectation of the error term in the profit function given the input hours is in general a function of these hours because they enter the utility function through consumption and leisure.

3. AN ECONOMETRIC FRAMEWORK FOR ANALYZING LABOR SUPPLY AND INFORMAL SELFEMPLOYMENT PRODUCTION IN THE PRESENCE OF LATENT CHOICE SETS

3.1. A discrete version

This section focuses on the essential features of our framework and its relationship to the traditional approach in the empirical analyzes of labor supply (see e.g. Killingsworth, 1983). For the sake of expository simplicity we shall take the case of a single individual. The traditional approach starts by postulating a direct (or indirect) utility function in leisure (non-market activities) and consumption from which the labor supply function is derived by maximizing utility subject to the budget constraint. (Alternatively, the labor supply function is postulated directly so as to be consistent with a well-defined utility function). In this approach it is usually assumed that the individual is free to adjust his hours of work, i.e., rarely is the notion of rationing with respect to job offers or hours of work taken into account. Another feature of most empirical models is the assumption of linear supply curves. As is wellknown, linear supply functions implies a particular and quite restrictive form of the utility function which seems unjustified a priori. For example it implies that the so called "backward bending case" is excluded a priori.

The alternative empirical approach we offer here is also within the neo-classical theory but it departs from the common econometric specifications used by others.

We assume that the essential choice variable is "job" or "position" and that hours of work and wage rate is completely determined ones the position is given. By position we understand a particular combination of market and non-market activities. For example, one position may be defined as the performance of certain amounts of specific tasks in farmwork combined with playing soccer after work. Thus hours of work and wage rates are attributes that characterize the positions. Let (H_j, W_j) be the hours-wage combination of position j. Here j is an indexation of the position. For non-market positions, $W_j=0$. The individual's choice set consists of a set of positions which is assumed known to him but unobserved by the econometrician. Only the realized hours of work and wage rates are observed i.e., the hours-wage combination that is associated with the optimally chosen position.

3.1.1. A one-sector model

To make the exposition of the main ideas of the econometrics as simple as possible we shall first assume that the set of feasible positions, B, (choice set) is finite (relative to the individual).

The individual's maximization problem can now be described formally as below.

The budget constraints are given by

(3.1) $h = H_j$

(3.2) $C = H_j W_j + I$

(3.3) $j \in B$

where I is non-labor income. Eq. (3.1) states that for a given position j, hours of work is given. The third equation states that B is the set of feasible positions. Eq.(3.2) is the standard economic budget constraint.

Let

$$U(h,C,j) = v(h,C) + \varepsilon_j$$

be the individual's utility of position, j. We assume that this utility can be decomposed in a structural term, v(h,C), (common to observationally identical individual's) and a random term, ε_j, that reflects that individuals differ in their preferences for positions with the same level of hours and consumption. Thus ε_j takes into account heterogeneity in tastes across individuals with respect to positions as well as unobserved attributes of the positions.

The individual's problem is to find the position $j \in B$ that maximizes

$$v(H_j, H_j W_j + I) + \varepsilon_j .$$

Now let B(h,w) be the set of positions for which $H_j = h$, $W_j = w$, $j \in B$ and let n(h,w) be the number of positions in B(h,w).

Formally, the probability that the optimal position has hours-wage combination (h,w) is expressed as

$$\varphi(h,w) = P\{\max_{j \in B(h,w)} (v(H_j, H_j W_j + I) + \varepsilon_j) = \max_{j \in B} (v(H_j, H_j W_j + I) + \varepsilon_j)\}.$$

Moreover, if we assume that the random preference terms, ε_j, are independent, extreme value distributed across positions we get immediately from the formal theory of discrete choice as developed by McFadden (1973) (see Maddala 1983)) that

$$(3.4) \quad \varphi(h,w) = \frac{n(h,w)\exp(v(h,hw+I))}{\sum_{x,y} n(x,y)\exp(v(x,xy+I))} .$$

Let

$$g(h,w) = \frac{n(h,w)}{\sum_{x,y} n(x,y)}$$

be the fraction of feasible positions with hours and wages equal to (h,w). By inserting in (3.4) we get

$$(3.5) \quad \varphi(h,w) = \frac{g(h,w)\exp(v(h,hw+I))}{\sum_{x,y} g(x,y)\exp(v(x,xy+I))} .$$

This model is analogous to the one developed by Ben-Akiva et al. (1985). The function φ expresses the labor supply density. It's observable counterpart is the fraction of individuals who work h hours at wage rate w. Instead of the usual specifications where the labor supply density is expressed as a function of the parameters of the labor supply function we realize from (3.5) that in our model the density is expressed as a function directly of the structural part of the utility function.

Moreover, this model allows the notion of rationing. Specifically, (3.5) expresses the aggregate labor supply as a simple function of the mean utility, v, and of the <u>opportunity density</u>, g(h,w).

3.1.2. Extension to two sectors

Let us next consider a particular extension to the case where the individual has the choice of participating in two sectors: One is wage work and the other is informal selfemployment. In this case the set of feasible positions consists of combinations of market activities and type of production. Thus a specific position defines type of wage work, and type of production, etc. To a position j there correspond attributes

$(\tilde{H}_j, H_j^*, W_j, T_j)$

where $\tilde{H}_j$ and H_j^* are hours of work in wage work and selfemployment, W_j is the wage rate, T_j is a variable characterizing technology (unobservable) associated with position j.

Now the budget constraints take the form

$$(3.6) \quad C = \tilde{H}_j W_j + Y_j + I$$

$$(3.7) \quad Y_j = F(H_j^*)T_j$$

where $F(H_j^*)T_j$ is the profit function conditional on hours and Y_j is profit. For expository convenience we assume the structure to be of the multiplicative form. The individual's problem is to find the position for which

$$\max_{j \in B}(v(\tilde{H}_j + H_j^*, \tilde{H}_j W_j + F(H_j^*)T_j + I) + \varepsilon_j)$$

is obtained. Analogously to $g(h,w)$ let now $g(h_1,h_2,w,t)$ be the fraction of positions with

$$(\tilde{H}_j = h_1,\ H_j^* = h_2,\ W_j = w,\ T_j = t)$$

that are feasible to the individual. From (3.7) we get

$$T_j = \frac{Y_j}{F(H_j^*)}$$

which means that we may express the fraction of feasible positions, $\tilde{g}(h_1,h_2,w,y)$, for which

$$(\tilde{H}_j = h_1,\ H_j^* = h_2,\ W_j = w,\ Y_j = y)$$

as

$$(3.8) \quad \tilde{g}(h_1,h_2,w,y) = g(h_1,h_2,w,\frac{y}{F(h_2)}).$$

Now by a straight forward extension of the above derivation of the labor supply density (3.5) we get the joint density of hours, wage and profit

$$(3.9)\qquad \varphi_1(h_1,h_2,w,y) = \frac{\tilde{g}(h_1,h_2,w,y)\exp(v(h_1+h_2,h_1w+y+I))}{\sum_{(x_1,x_2,x_3,x_4)} \tilde{g}(x_1,x_2,x_3,x_4)\exp(v(x_1+x_2,x_1x_3+x_4+I))}\ .$$

To ensure identification we shall make the following additional assumptions. The first one is expressed as

$$(3.10)\qquad g(h_1,h_2,w,t) \quad = \quad \tilde{g}_1\ g_1^*\ g_2(h_1,h_2)g_3(w)g_4(t)$$

for $h_1>0$, $h_2>0$, where $\tilde{g}_1$ and g_1^* are the fractions of wage work and self-employment positions with positive hours, $g_3(w)$ and $g_4(t)$ are the fractions of positions with $W_j=w$ and $T_j=t>0$ that are feasible, respectively. Assumption (3.10) means that there is no correlation between the attributes of the positions (apart from $\tilde{H}_j,H_j^*$). Furthermore we assume that g_2 is a bivariate uniform density on

$$\{h_1+h_2 \le N, \quad h_1 \ge 1, \quad h_2 \ge 1\}$$

which means that

$$(3.11)\qquad g_2(h_1,h_2) \quad = \frac{2}{N(N-1)}, \qquad \text{given } h_1>0,\ h_2>0\ .$$

Given $h_2=0$,

$$(3.12)\qquad g_{21}(h_1) \overset{\text{Def.}}{=} g_2(h_1,0) \quad = \quad \frac{1}{N}, \qquad 0 < h_1 \le N,$$

and given $h_1=0$,

$$(3.13)\qquad g_{22}(h_2) \overset{\text{Def.}}{=} g_2(0,h_2) \quad = \quad \frac{1}{N}, \qquad 0 < h_2 \le N,$$

where N is an upper bound on hours of work.

The assumptions (3.11)-(3.13) mean that there are no constraints on hours apart from the physical one $h_1+h_2 \le N$.

By (3.9), (3.11), (3.12) and (3.13) we obtain

$$(3.14a)\quad \varphi_1(h_1,h_2,w,y) = \frac{2\,\tilde{g}_1\; g_1^*\; g_3(w) g_4(\frac{y}{F(h_2)})\ \exp\ (v(h_1+h_2, h_1 w+y+I))}{MN(N-1)},$$

for $h_1>0$, $h_2>0$, $y>0$, $w>0$,

$$(3.14b)\quad \varphi_1(0,h_2,y) = \frac{(1-\tilde{g}_1)\; g_1^*\; g_4(\frac{y}{F(h_2)})\ \exp\ (v(h_2,\ y+I))}{MN}$$

for $h_2>0$, $y>0$,

$$(3.14c)\quad \varphi_1(h_1,0,w,0) = \frac{\tilde{g}_1(1-g_1^*)\ g_3(w)\ \exp\ (v(h_1, h_1 w+I))}{MN}$$

for $h_1>0$, $w>0$

where

$$(3.15)\quad M = \frac{2}{N(N-1)}\,\tilde{g}_1\; g_1^* \sum_{\substack{x_1>0,x_4>0\\ x_2>0,x_3>0}} g_3(x_3) g_4(\frac{x_4}{F(x_2)})\ \exp\ (v(x_1+x_2, x_1 x_3+x_4+I))$$

$$+ \frac{1}{N}\,(1-\tilde{g}_1) g_1^* \sum_{x_2>0,x_4>0} g_4(\frac{x_4}{F(x_2)})\ \exp\ (v(x_2, x_4+I))$$

$$+ \frac{1}{N}\,\tilde{g}_1(1-g_1^*) \sum_{x_1>0,x_3>0} g_3(x_3)\ \exp\ (v(x_1,\ x_3 x_1+I)).$$

The case (3.14a) corresponds to interior solutions while (3.14b) and (3.14c) correspond to corner solutions, respectively. Several conditional densities are of particular interest. For example (3.14) implies that the conditional wage density given hours, input and gross revenue is given by

$$(3.16)\quad \varphi_2(w|h_1,h_2,y) = \frac{g_3(w)\ \exp\ (v(h_1+h_2, h_1 w+y+I))}{\sum_{x_3>0} g_3(x_3)\ \exp\ (v(h_1+h_2, h_1 x_3+y+I))}$$

which illustrates the so-called selectivity bias, namely that the conditional density of the realized wage differ from the offered wage density,

$g_3(w)$, because preferences represented by $v(h,C)$ imply that the realized wage deviates from the offered ones. Similarly, the density of the realized (optimal) value, $\hat{T}$, of T given hours, wage and input is equal to

$$(3.17)\quad \varphi_3(t|h_1,h_2,w) = \frac{g_4(t)\ \exp\ (v(h_1+h_2,h_1w+tF(h_2)+I))}{\sum_y g_4(y)\ \exp\ (v(h_1+h_2,h_1w+yF(h_2)+I))}$$

which demonstrates that $\hat{T}$ is correlated with hours, wage and input through the preference term, v. The density (3.17) accounts for the fact that technology, hours and wage are choice variables so that even if the position attributes are uncorrelated ex ante the corresponding realized values are correlated with realized technology, $\hat{T}$, since their optimal values depend on the value of $\hat{T}$.

Note that it is implicit in model (3.9) and (3.14) that only capital income I is exogenous. The hours, wage and profit are endogenous. The extension to households with several adults and more general corner solutions is in principle straight forward but notationally complex. In practical empirical work the above formulations, besides their plausible behavioral interpretation, imply a considerable simplification in cases where the budget constraint is non-linear and non-convex. This is the case in most industrialized countries where the tax system implies a rather complicated budget constraint. Another example is particularly relevant, namely the analyzis of labor supply and agricultural production. In the latter case the production function (or profit function) enters the budget constraint.

Although it is possible in principle to circumferent the related econometric problems within the marginal calculus tradition this tradition has some severe drawbacks. First, it is only practical for quite restrictive functional forms. Second, it requires an instrumental variable approach to acommodate for endogenous marginal wages and shadow prices.

3.2. Extension to the continuous case

This section considers the extension of the model of the previous section to the case where the endogenous variables like hours of work and consumption take values in a continuous space. The continuous version of the labor supply model introduced above has been developed by Dagsvik

(1988) and Dagsvik and Strøm (1989) and has been estimated on micro data for Sweden and Norway. Here we shall only review some main properties. For a more thorough discussion the reader is referred to these papers.

The continuous formulation differs from the finite one in that the attributes, (H_j, W_j), and the taste shifter, ε_j, are assumed generated from a Poisson process in three dimensions. Unlike the finite formulation the Poisson process formulation is consistent with the notion of unobserved heterogeneity <u>both</u> with respect to opportunities and tastes. Recall that in the finite case above only ε_j is random. The present formulation states that $(H_j, W_j, \varepsilon_j)$ are the points of a Poisson process on $[0,\infty)x[0,\infty)x(-\infty,\infty)$ with intensity measure

$$d\lambda(h,w)e^{-\varepsilon}d\varepsilon$$

where λ is a positive bounded function.

The interpretation of the Poisson process specified here is perfectly similar to the familiar formulation on the real line. The realizations of the process are stochastically independent and the probability that a point of the process for which

$$(3.20)\quad (H_j \in (h,h+dh),\ W_j \in (w,w+dw),\ \varepsilon_j \in (\varepsilon,\varepsilon+d\varepsilon))$$

is (approximately) equal to

$$(3.21)\quad d\lambda(h,w) \cdot e^{-\varepsilon}d\varepsilon\ .$$

The behavioral interpretation is that the probability that a position for which (3.20) holds is feasible is given by (3.21). The expected number of feasible positions within a set $A \subset R_+^2 xR$ is given by

$$\Lambda(A) = \int_A d\lambda(x,y)e^{-z}dz$$

and the cumulative <u>opportunity</u> <u>distribution</u> is defined by

$$G(h,w) = \frac{\lambda(h,w)}{\lambda(\infty,\infty)}\ .$$

The supply density that follows from this formulation is analogous to (3.5) but now the sum is replaced by an integral. Specifically, the labor supply density, φ, takes the form

$$(3.22)\quad \varphi(h,w) = \frac{g_1 g_2(h,w)\exp(v(h,hw+I))}{(1-g_1)\exp(v(0,I)) + g_1 \int \exp(v(x,xy+I))g_2(x,y)dxdy}, \quad h>0$$

where $1-g_1 = G(0,0)$ and $g_2(h,w)$ is the conditional density of $G(h,w)$ given $H_j>0$. The interpretation of g_1 is as the fraction of feasible positions that are wage work positions. $g_2(h,w)$ is the density of feasible wage work positions.

4. A HOUSEHOLD MODEL FOR RURAL AREAS

4.1. The econometric formulation

This section specifies the decision model for time allocation, consumption and household production in rural areas. The household here is assumed to consist of at least two adults (more than 15 years of age). We assume that there are no internal conflicts within the family so that any household member act so as to maximize a household utility function, which depends on household consumption and of the respective leisures of the household members (adults). The household's decision variables are schooling, hours of work in different sectors, household size and consumption. As discussed in section 3 the households choice problem is viewed as one in which the most preferred position is selected from the (household specific) set of feasible positions. Recall that given the position then the attributes follow. This means that the basic choice variable is the position. Before proceeding with the formal econometric model let us introduce the necessary symbols.

Y_j = Profit of position j (farm and non-farm)

$\tilde{W}_{jM}$ = $(W_{j1M}, W_{j2M}, \ldots)$ = vector of market wage rates associated with position j where W_{jkM} is the wage offered to male no. k in the household.

$\underset{\sim}{W}_{jF}$ = $(W_{j1F}, W_{j2F}, ..)$ = vector of market wage rates offered to the females of the household.

$\underset{\sim}{\bar{H}}_{jM}$ = $(\bar{H}_{j1M}, \bar{H}_{j2M}, ..)$ = vector of male hours of work in the wage sector associated with position j.

$\underset{\sim}{\bar{H}}_{jF}$ = $(\bar{H}_{j1F}, \bar{H}_{j2F}, ..)$ = vector of female hours of work in the wage sector.

$\underset{\sim}{H}^{*}_{jF}$ = $(H^{*}_{j1F}, H^{*}_{j2F}, ...)$ = vector of female hours of work in position j in non-agricultural selfemployment.

$\underset{\sim}{H}^{*}_{jM}$ = $(H^{*}_{j1M}, H^{*}_{j2M}, ..)$ = vector of male hours of work of position j in non-agricultural selfemployment.

$\underset{\sim}{H}^{**}_{jM}$ = $(H^{**}_{j1M}, H^{**}_{j2M}, ..)$ = vector of male hours of work of position j in agricultural selfemployment.

$\underset{\sim}{H}^{**}_{jF}$ = $(H^{**}_{j1M}, H^{**}_{j2M}, ..)$ = vector of female hours of work of position j in agricultural selfemployment.

$H^{*}_{jC} + H^{**}_{jC}$ = Household child hours of work in selfemployment, position j.

S_j = level and type of education associated with position j

F_j = Family size and composition associated with position j

Q_j = vector of all the above attributes of position j.

C = Per capita household consumption.

T_j = Technology of position j

The household preferences is represented by a utility function

$$U(\underset{\sim}{\bar{H}}_{jF},\ \underset{\sim}{H}^{*}_{jF} + \underset{\sim}{H}^{**}_{jF},\ \underset{\sim}{\bar{H}}_{jM},\ \underset{\sim}{H}^{*}_{jM} + \underset{\sim}{H}^{**}_{jM},\ C_j,\ S_j,\ F_j,\ j).$$

The variables s, f and j represents schooling, family size and the index of the position. The budget constraints are:

i) Given the position j, the respective hours of work and the profit are fixed. The position vector Q_j belongs to a household specific set of feasible attributes.

ii) The economic constraint is given by

$$(4.1) \quad N_jC_j = \sum_k W_{jkM}\tilde{H}_{jkM} + \sum_k W_{jkF}\tilde{H}_{jkF} + Y_j + I$$

$$(4.2) \quad Y_j = F(\underset{\sim}{H}^{*}_{jM} + \underset{\sim}{H}^{**}_{jM}, \underset{\sim}{H}^{*}_{jF} + \underset{\sim}{H}^{**}_{jF}, H^{*}_{jkC} + H^{**}_{jkC})T_j$$

where N_jC_j is the total net income associated with position j, I is other income, $F()T_j$ is the profit function and N_j is a household equivalence scale. The household maximize utility subject to (i) and (ii); i.e., it selects the optimal position from the set of feasible ones. The utility function conditional on the position attributes is assumed to have the form

$$(4.3) \quad U_j = v\,(\underset{\sim}{\tilde{H}}_{jF}, \underset{\sim}{H}^{*}_{jF} + \underset{\sim}{H}^{**}_{jF}, \underset{\sim}{\tilde{H}}_{jM}, \underset{\sim}{H}^{*}_{jM} + \underset{\sim}{H}^{**}_{jM}, C_j, S_j, F_j) + \varepsilon_j$$

where v is a systematic term and ε_j is a random term that captures the effect of unobserved heterogeneity across households and across positions. The set of feasible position attributes is not observed. Here, this set is perceived as random due to heterogeneity in opportunities. We represent this set by the opportunity distribution function, G(q). Specifically G(q) is, loosely spoken, the fraction of positions with attributes, $Q_j \leq q$, that is feasible to the household. Let $\Phi(q)$ be the distribution of the <u>realized</u> attribute vector, i.e. of the attribute vector of the optimal position. Formally Φ is defined by

$$\Phi(q) = P\left\{\max_{Q_j \leq q} U_j = \max_j U_j\right\}.$$

Let M be the dimension of the position vectors, i.e., $Q_j \in R^m_+$. The dimension depends evidently on the household size. Under specific assumptions analogous to the ones presented in section 3.1 and 3.2 it follows that

$$(4.4) \qquad \Phi(q) = \frac{\int_{y \le q} e^{v^*(y)} dG(y)}{\int_{R_+^m} e^{v^*(y)} dG(y)}$$

where

$$(y \le q) \Leftrightarrow (y_1 \le q_1,\ y_2 \le q_2, \ldots,\ y_m \le q_m).$$

and

$$v^*(Q_j) = v(\tilde{\bar{H}}_{jF},\ \tilde{H}^*_{jF} + \tilde{H}^{**}_{jF},\ \tilde{\bar{H}}_{jM},\ \tilde{H}^*_{jM} + \tilde{H}^{**}_{jM},\ C_j,\ S_j,\ F_j).$$

4.2. Estimation

The estimation is based on a quasi-maximum likelihood procedure suggested by McFadden (1978). This method has been applied in Dagsvik and Strøm (1989) and has proven to be efficient. An exact full maximum likelihood procedure based on (4.4) is computationally very costly since it involves the computation of multidimensional integrals. McFadden's procedure consists in replacing the alternative space, which here is R_+^m by a set of finite points in R_+^m drawn from a specified probability distribution (see McFadden, 1978). McFadden has proven that this method yields consistent estimates. Our application of the method consists in drawing 80 vectors $Q_i = (\log Y_i, \log \tilde{W}_{iF}, \log \tilde{W}_{iM}, \tilde{\bar{H}}_{iF}, \tilde{\bar{H}}_{iM}, \tilde{H}_{iF}-\tilde{\bar{H}}_{iF}, \tilde{H}_{iM}-\tilde{\bar{H}}_{iM})$ where the components are drawn independently, $\log Y_i$ and the hours of work variables are drawn from uniform distributions and $\log W_{iF}$ and $\log W_{iM}$ are drawn from normal distributions. The resulting modified density which enter the likelihood function takes the form

$$\varphi(Q_k) = \frac{e^{v^*(Q_k)} g(Q_k) \pi_j}{\pi_j e^{v^*(Q_k)} g(Q_k) + \sum_{i \ne k}^{80} e^{v^*(Q_i)} g(Q_i) \pi_i}$$

where π_i are <u>known</u> weights and Q_k denotes the observed attribute vector for household k.

4.3. Specification of the opportunity density

The offered hours and wage distributions are assumed independent across household members. As in (3.10)-(3.14) we assume no constraints on hours given that hours are positive, which mean that for individual k, $(H^{*}_{jk}, H^{**}_{jk}+\tilde{H}_{jk})$ are uniformly distributed on $H^{**}_{jk}+H^{*}_{jk}>0$, $\tilde{H}_{jk}>0$, $H^{**}_{jk}+H^{*}_{jk}+\tilde{H}_{jk}\leq N$. The offered wage density conditional on $\tilde{H}_{jk}>0$ is log normal with expectation.

$$(4.5)\quad E\log W_{jk} = \beta_{0k} + (SPLYRSC1+SPLYRSC2)\beta_{1k} + SPLYRSC3\cdot\beta_{2k}$$

where

$$(SPLYRSC1,\ SPLYRSC2,\ SPLYRSC3) = \begin{cases} (x,0,0) & \text{if } x\leq 5 \\ (5,x-5,0) & \text{if } 5<x\leq 10 \\ (5,5,x-10) & \text{if } x>10. \end{cases}$$

The opportunity mass that corresponds to the corner solutions is

$$g^{*}_{Fk} = P\{H^{*}_{jkF} > 0\},\quad g^{*}_{Mk} = P\{H^{*}_{jkM} > 0\},$$
$$g^{**}_{Fk} = P\{H^{**}_{jkF} > 0\},\quad g^{**}_{Fk} = P\{H^{**}_{jkM} > 0\},$$
$$\tilde{g}_{Fk} = P\{\tilde{H}_{jkF} > 0\},\quad \tilde{g}_{Mk} = P\{\tilde{H}_{jkM} > 0\}.$$

The interpretation is that $\tilde{g}_{Fk}$ is the fraction of wage work positions that are feasible for woman k of the household. The other terms are interpreted analogously. It is implicit in the definitions above that the respective amounts of feasible positions are independent across family members. This assumption could be relaxed at the cost of econometric simplicity.

The probabilities $\tilde{g}_F$, $\tilde{g}_M$, g^{*}_F and g^{*}_M are specified as logit functions of the respective individual levels of education.

We assume conditional profit function

$$(4.6) \quad \log Y_j = \alpha_0 + \alpha_1 \log(1 + \sum_k (H^*_{jkM} + H^{**}_{jkM}))$$

$$+ \alpha_2 \log(1 + \sum_k (H^*_{jkF} + H^{**}_{jkF})) + \alpha_3 \log(1 + \sum_k (H^*_{jkC} + H^{**}_{jkC}))$$

$$+ \alpha_4 \log(1 + \sum_k (H^*_{jkF} + H^{**}_{jkF}))\log(1 + \sum_k (H^*_{jkM} + H^{**}_{jkM}))$$

$$+ \alpha_5 \log(1 + \text{TOTWET}) + \alpha_6 \log(1 + \text{TOTDRIED})$$

$$+ \alpha_7 \text{MAXED} + T_j$$

where

TOTWET	is total area of watered land worked by household
TOTDRIED	is total area of dry land worked by household
MAXED	is years of schooling of most educated household member older than 15 years.

and T_j are supposed to account for unobserved choice variables that affect the production technology. The distribution of the technology attribute, T_j, is assumed to be normal $N(0,\tau)$, and it is assumed to be independent of other input factors. In other words the fractions of T-attributes with values less than or equal to t equals the cumulative normal distribution function with zero mean and variance τ^2.

By (4.6) and the assumption about T_j we are able to express the conditional opportunity density for Y_j given the observable input attribute.

4.4. Specification of the preferences

The systematic term, v, of the utility function is assumed to have the form:

$$(4.7) \quad v(\underset{\sim}{h},\underset{\sim}{\tilde{h}}_F,C,f,S) = \alpha_2 \frac{((1+\frac{C}{1000})^{\alpha_1}-1)}{\alpha_1}$$

$$+ \sum_j (\alpha_4 + \alpha_5 \log A_{jM} + \alpha_6 (\log A_{jM})^2) \frac{(L_{jM}^{\alpha_3}-1)}{\alpha_3}$$

$$+ \sum_j (\alpha_8 + \alpha_9 \log A_{jF} + \alpha_{10} (\log A_{jF})^2) \frac{(L_{jF}^{\alpha_7}-1)}{\alpha_7}$$

$$+ \alpha_{11} \sum_j \tilde{h}_{jF} f_j + \alpha_{12} \sum_j D_{jM} + \hat{v}(S)$$

where L_{jr} is defined by

$$L_{jr} = 1 - \frac{h_{jr}}{8760}, \quad r = F,M,$$

C = households per capita household consumption,

f_j = number of children less than six years,

A_{jr} = Age of household member j, sex r = F,M,

h_{jr} = total annual hours of work for household member j, sex r

$\tilde{h}_{jF}$ = annual hours of wage work, female j,

and

$$D_{jM} = \begin{cases} 1 \text{ if male j has annual hours of work in (2475, 2525)} \\ 0 \text{ otherwise} \end{cases}$$

$\hat{v}(S)$ = utility component of schooling. (This component will not be estimated)

Except for the term $\alpha_{11}\sum_j \tilde{h}_{jF} f_j$, utility is assumed additively separable in consumption and leisure. Note that the utility of consumption is concave and increasing when $\alpha_1 < 1$, $\alpha_3 < 1$, $\alpha_7 < 1$ when

$$\alpha_4 + \alpha_5 \log A_{jM} + \alpha_6 (\log A_{jM})^2 > 0$$

and

$$\alpha_8 + \alpha_9 \log A_{jF} + \alpha_{10} (\log A_{jF})^2 > 0.$$

The dummy variable, D_{jM}, allows males to have a particular preference for total hours of work in the interval (2575, 2525). The motivation for introducing this dummy is that the data show a marked consentration of hours in this interval both for males that are engaged in wage work as well as in farm and non-farm selfemployment. This can only occur if

i) The males have a particular preference for "full-time" hours,

ii) If there are constraints on hours i.e., that there are more full-time work positions relative to other positions

iii) If the data are corrupted by measurement errors.

The reason why we have specified number of children solely in interaction with wage work hours is because selfemployment activities often can be combined with childcare.

The estimated model is consistent with all these explanations but we are not able to identify which is the true one.

4.5. Estimation results

This section resports the estimates of the model parameters. As mentioned above a simultaneous maximum likelihood procedure is applied. Despite the complexity of the model this is possible through the application of McFadden's method (1978). First we report summary statistics in table 1.

Table 1. Household and individual sample statistics, rural Peru

Variables	Mean	Standard deviation of mean
HOUSEHOLD STATISTICS		
Number of households		
Consumption per capita	2578	86
Female hours of work in wage work	101	13
Female hours of work in selfemployment	2232	49
Male hours of work in wage work	594	29
Male hours of work in selfemployment	2724	51
Childrens hours of work in selfemployment	4	0.1
Total gross revenue from selfemployment	9056	385
Total profit from selfemployment	7183	311
Number of children below 7	1.34	0.03
Number of children 7-14	1.39	0.03
Number of females 15-70	1.52	0.02
Number of males 15-70	1.54	0.02
Number of people above 70	0.08	0.01
Equivalence scale	3.7	0.04
INDIVIDUAL STATISTICS		
Number of females 15-70, 2087		
Number of males 15-70, 2057		
Participation rates in		
wage work for females	0.07	0.01
selfemployment for females	0.85	0.01
wage work for males	0.34	0.01
selfemployment for males	0.89	0.01
Hours of work in		
wage work for females	67	7
selfemployment for females	1477	25
wage work for males	387	17
selfemployment for males	1777	25
Wage rate, females	7.38	2.45
Wage rate, males	2.98	0.30

Table 2. Parameter estimates of the utility function for rural areas

Variables	Coefficients	Estimates	t-values
Consumption	α_1	-12.941	4.0
	α_2	35.891	2.0
Leisure, males	α_3	-7.680	14.9
	α_4	3.189	3.3
	α_5	-1.704	3.3
	α_6	0.231	3.3
Leisure, females	α_7	-5.380	12.6
	α_8	5.057	2.8
	α_9	-2.475	2.5
	α_{10}	0.320	2.3
$10^{-3} \sum_j \tilde{h}_{jF} f_j$	α_{11}	-0.152	2.2
$\sum_j D_{jM}$	α_{12}	2.231	19.7

Table 3. Parameter estimates of the conditional profit function for the rural areas.*) The simultaneous estimation procedure and OLS

Variables	OLS		Simultaneous ML estimates	
Intercept	4.246	(7.1)	2.181	(2.5)
Male labor	0.329	(4.3)	0.543	(4.9)
Female labor	0.222	(2.7)	0.393	(3.4)
Interaction between male and female labor	-0.031	(3.0)	-0.053	(3.5)
Child labor	-0.0004	(0.4)	-0.010	(0.7)
Watered land	0.419	(7.5)	0.443	(5.2)
Dry land	0.264	(7.6)	0.249	(4.8)
Maxed	0.578	(9.7)	0.734	(7.3)
Standard error	1.303		1.445	(31.3)
R^2	0.18			

*) t-values in parenthesis.

The estimates of the parameters of the utility function imply that the systematic term of the utility function is strictly concave and increasing in consumption.

The parameters associated with the conditional profit function given in the third column of table 3 differ partly from the estimates obtained by OLS. Recall that the OLS estimates may be biased (simultaneous equation bias) while the ML estimates are obtained by a procedure that takes into account that the input factors are endogenous. Observe that these estimates all have the correct sign. The effect of male and female labor seem to be underestimated by the OLS estimation procedure. The coefficient of Maxed also seems to be underestimated by OLS.

Table 4. Wage equations. Simultaneous ML estimation procedure*) versus OLS

	Males		Females	
	OLS	Simultaneous ML	OLS	Simultaneous ML
Intercept	0.352 (6.2)	0.395 (5.4)	0.473 (4.0)	0.451 (3.2)
SPLYRSC1+SPLYRSC2	0.040 (3.5)	0.034 (2.3)	-	-
SPLYRSC3	0.284 (6.1)	0.306 (4.8)	0.303 (3.0)	0.540 (3.4)
Standard error	0.888	0.933 (34.4)	1.856	1.316 (17.7)
R^2	0.09		0.06	

*) t-values in parenthesis.

The ML parameter estimates of the wage functions seem to be close to the corresponding OLS estimate apart from the coefficient of SPLYRSC3 for females which seems to be underestimated by OLS.

Table 5. Estimates*) of the opportunity probabilities for Rural areas

SECTOR			
Agricultural selfemployment males	$\log\left(\frac{g_{1M}^{**}}{1-g_{1M}^{**}}\right)$	=	1.932 (24.0)
Non-agricultural selfemployment, males	$\log\left(\frac{g_{1M}^{*}}{1-g_{1M}^{*}}\right)$	=	-1.501 + 0.027S (13.0) (1.5)
Wage work, males	$\log\left(\frac{\tilde{g}_{1M}}{1-\tilde{g}_{1M}}\right)$	=	-0.545 + 0.042S (5.5) (1.9)
Agricultural selfemployment, females	$\log\left(\frac{g_{1F}^{**}}{1-g_{1F}^{**}}\right)$	=	1.656 (24.0)
Non-agricultural selfemployment, females	$\log\left(\frac{g_{1F}^{*}}{1-g_{1F}^{*}}\right)$	=	-0.516 (9.4)
Wage work, females	$\log\left(\frac{\tilde{g}_{1F}}{1-\tilde{g}_{1F}}\right)$	=	-2.656 + 0.162S (15.2) (4.7)

S = Length of schooling.
*) t-values in parenthesis.

Table 5 shows that schooling (as measured here) only has significant effect on wage work opportunities.

Figure 1. Observed and simulated distributions of annual hours of work for females living in rural areas.

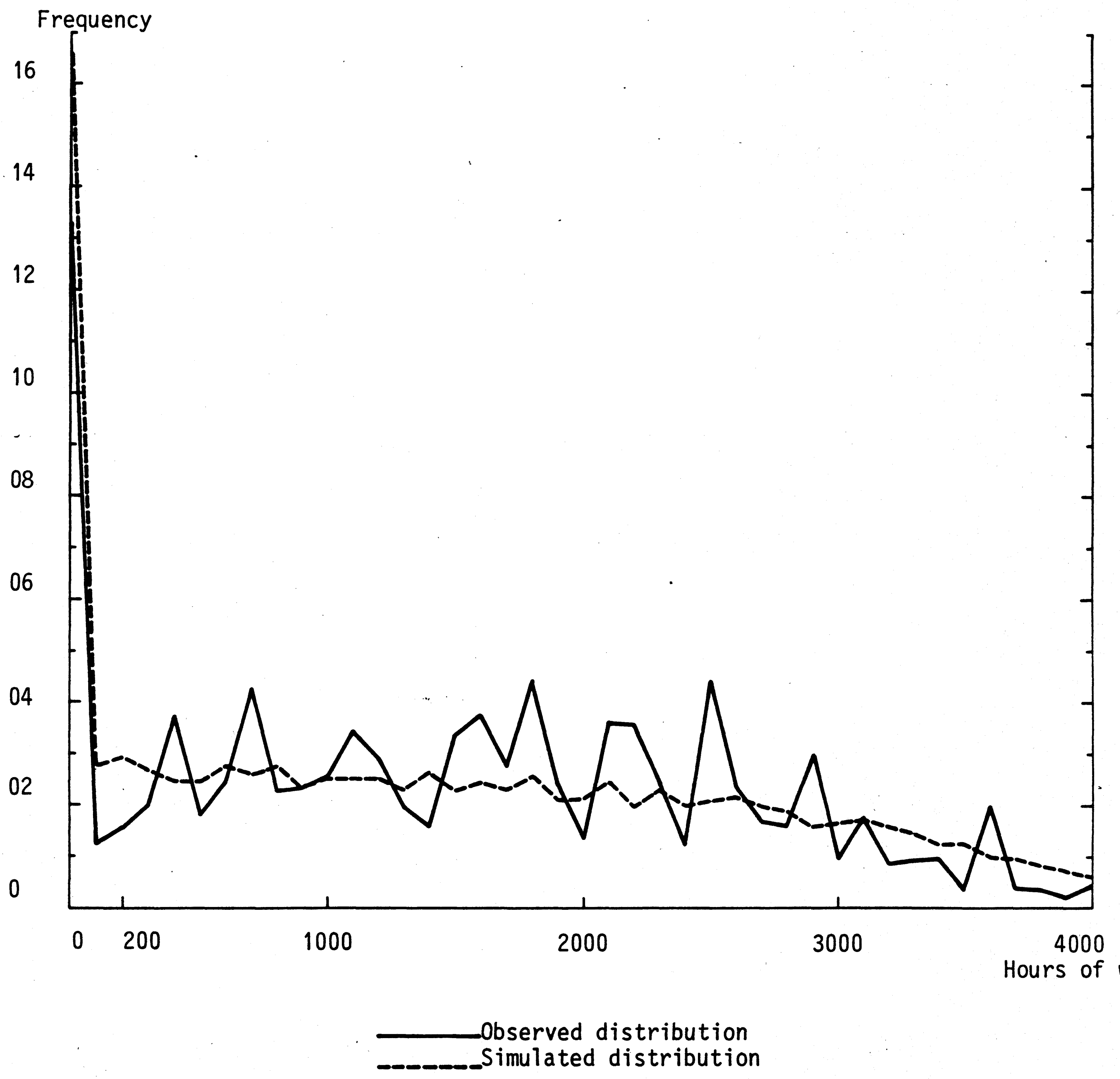


Figure 2. Observed and simulated distributions of annual hours of work for males living in rural areas.

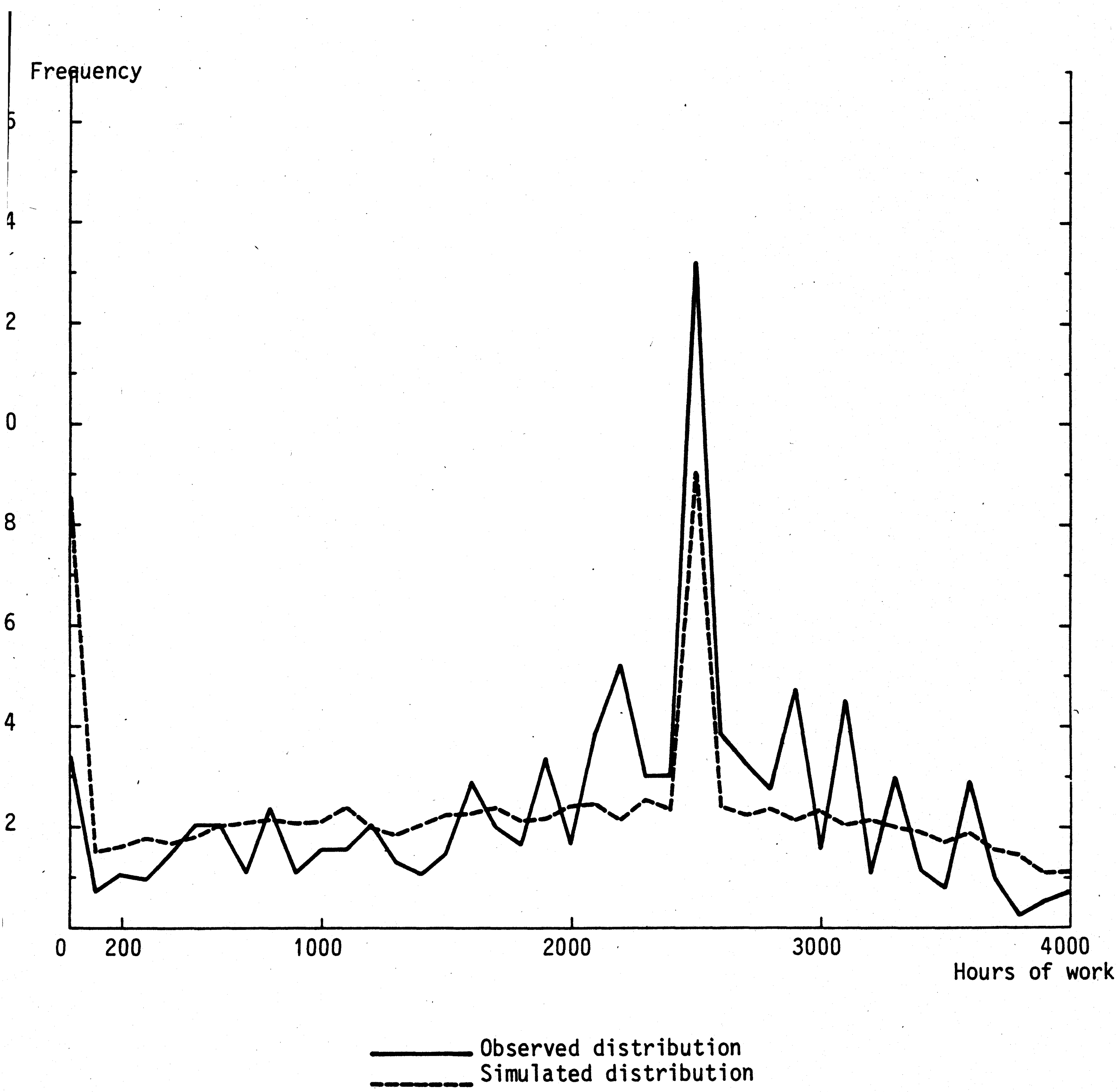
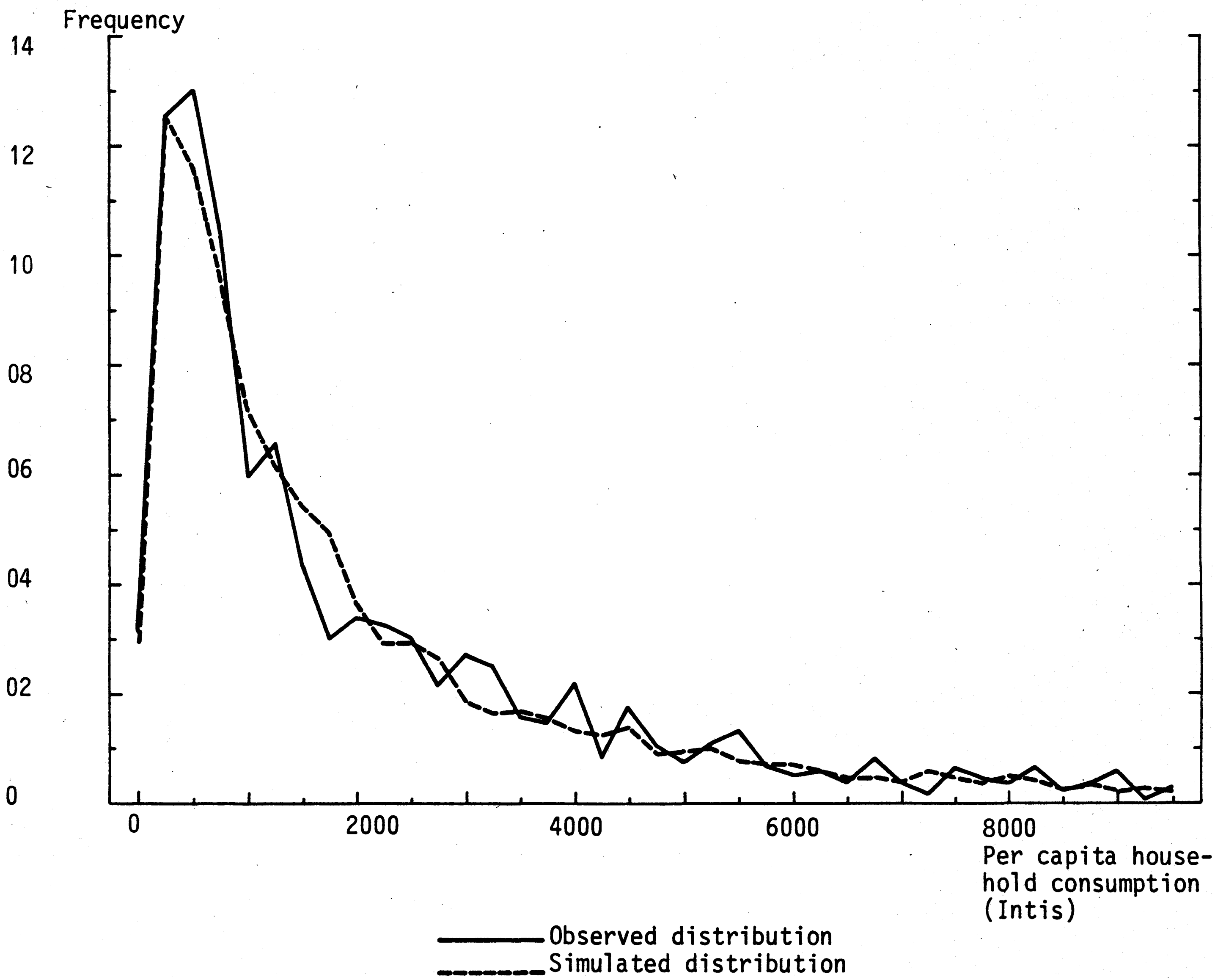


Figure 3. Observed and simulated distributions of per capita consumption among households living in rural areas.



Figures 1, 2 and 3 give the observed and the simulated distributions of consumption and hours of work for males and females for the rural areas. The figures show that the model reproduces the observed distributions quite well.

5. A HOUSEHOLD MODEL FOR LIMA

5.1. Specification of the model

The specification of the structural part of the utility function is the same as the one for the rural areas given by (4.7).

We have specified a profit function conditional on labor input. Specifically, we assume for $Y_j>0$

$$\text{(5.1)} \quad \log Y_j = \alpha_0+\alpha_1\log(1+\sum_k(H^*_{jkM}+H^{**}_{jkM}))+\alpha_2\log(1+\sum_k(H^*_{jkF}+H^{**}_{jkF}+ H^*_{jkC}+H^{**}_{jkC}))$$

$$+\alpha_3\log(1+\sum_k(H^*_{jkM}+H^{**}_{jkM}))\log(1+\sum_k(H^*_{jkF}+H^{**}_{jkF}+H^*_{jkC}+H^{**}_{jkC}))$$

$$+\alpha_4 \text{MAXED}+T_j$$

where T_j is normal $N(0,\tau)$. T_j is as above supposed to account for unobserved variables that characterize the production technology and the environment.

Furthermore, the probability of positive profit is introduced by

$$g_s \quad = \quad P\{Y_j>0\}.$$

The rationale behind g_s is that in addition to a limited set of feasible selfemployment positions is the fact that a successful business does not necessarily yield positive profit through every period. In fact the data demonstrates that profit is negative for some households during the period of the data collection. We may interpret g_s alternatively as the (average) fraction of the year the business is likely to operate with positive profit. A rigorous treatment of the choice of selfemployment activity would of course require a model for decision under uncertainty.

Finally, let g_y be the fraction of all feasible positions that are selfemployment positions for the household. Let g^*_r be the fraction of feasible positions for an individual of sex r, r=F,M, that are non-farm selfemployment positions. Let g_r^{**} and $\tilde{g}_r$ be defined analogously as the corresponding opportunity probabilities for farm selfemployment and wage work, respectively.

A convenient parametrization of g_y is

$$1 - g_y = \frac{\beta}{a+\beta(1-a)} ,$$

where

$$\beta = \prod_{r=F,M} [(1-g_r^{*})(1-g_r^{**})]^{m_r}$$

and m_F, m_M are the numbers of females and males in the household and a>0 is a parameter. The case a=1 corresponds to the case in which all selfemployment opportunity sets are independent across household members.

5.2. Estimation results

Here we report the estimation results for Lima. The first table displays household and individual sample statistics.

Table 6. Household and individual sample statistics, Lima

Variables	Mean	Standard deviation of mean
HOUSEHOLD STATISTICS		
Number of households 898		
Consumption per capita	6900	150
Female hours of work in wage work	832	44
Female hours of work in selfemployment	638	44
Male hours of work in wage work	2171	61
Male hours of work in selfemployment	907	50
Childrens hours of work in selfemployment	53	10
Total gross revenue from selfemployment	10700	600
Total profit from selfemployment	6300	400
Number of children below 7	0.84	0.03
Number of children 7-14	1.08	0.04
Number of females 15-70	1.79	0.04
Number of males 15-70	1.71	0.03
Number of people above 70	0.09	0.01
Equivalence scale	4	0.10
INDIVIDUAL STATISTICS		
Number of females 15-70, 1611		
Number of males 15-70, 1539		
Participation rates in		
wage work for females	0.32	0.01
selfemployment for females	0.35	0.01
wage work for males	0.63	0.01
selfemployment for males	0.35	0.01
Hours of work in		
wage work for females	463	21
selfemployment for females	356	20
wage work for males	1267	32
selfemployment for males	529	27
Wage rate, females	5.25	0.40
Wage rate, males	6.41	0.20

Table 7. Parameter estimates for the utility function. Lima

Variables	Coefficients	Estimates	t-values
Consumption	α_1	-0.776	7.9
	α_2	4.832	7.3
Leisure, males	α_3	-3.605	9.5
	α_4	43.258	5.4
	α_5	-23.194	5.3
	α_6	3.134	4.1
Leisure, females	α_7	-1.454	5.7
	α_8	86.655	5.5
	α_9	-46.354	5.3
	α_{10}	6.369	3.2
$10^{-3} \Sigma \tilde{h}_{jF} f_j$	α_{11}	-0.149	2.3
ΣD_{jM}	α_{12}	2.234	18.8

Table 8. Wage equations for Lima. Simultaneous ML estimation procedure*) versus OLS

	Males		Females	
	OLS	Simul-taneous ML	OLS	Simul-taneous ML
Intercept	0.049	-0.105	-0.596	-0.674
	(0.4)	(0.8)	(3.5)	(3.8)
SPLYRSC1+SPLYRSC2	0.092	0.100	0.126	0.125
	(8.4)	(8.2)	(8.2)	(7.9)
SPLYRSC3	0.117	0.136	0.126	0.150
	(10.1)	(9.9)	(6.2)	(6.5)
Experience	0.050	0.038	0.056	0.050
	(8.8)	(5.7)	(5.7)	(5.0)
$(\text{Experience})^2/100$	-0.060	-0.039	-0.073	-0.063
	(5.3)	(3.1)	(3.5)	(3.1)
Standard error	0.659	0.660	0.780	0.753
		(40.4)		(32.9)
R^2	0.27		0.25	

*) t-values in parenthesis.

Table 9. Parameter estimates of the conditional profit function given positive profit. The simultaneous estimation procedure*) and OLS

Variable	OLS		Simultaneous ML estimates	
Intercept	2.681	(5.9)	3.078	(7.1)
Male labor	0.756	(13.3)	0.572	(10.5)
Female labor	0.656	(11.0)	0.487	(8.7)
Interaction, female-male labor	-0.085	(9.8)	-0.061	(7.6)
Maxed	0.047	(2.4)	0.072	(4.0)
Standard error	1.356		1.257	(31.9)
R^2	0.33			

*) t-values in parenthesis.

Table 10. Estimates*) of the opportunity probabilities for Lima

SECTOR		
Agricultural selfemployment males	$\log\left(\frac{g_{1M}^{**}}{1-g_{1M}^{**}}\right)$	= -2.804 (19.3)
Non-agricultural selfemployment, males	$\log\left(\frac{g_{1M}^{*}}{1-g_{1M}^{*}}\right)$	= -0.197 (2.5)
Wage work, males	$\log\left(\frac{\tilde{g}_{1M}}{1-\tilde{g}_{1M}}\right)$	= -0.488 + 0.103S (2.6) (5.4)
Agricultural selfemployment, females	$\log\left(\frac{g_{1F}^{**}}{1-g_{1F}^{**}}\right)$	= -1.198 (12.5)
Non-agricultural selfemployment, females	$\log\left(\frac{g_{1F}^{*}}{1-g_{1F}^{*}}\right)$	= 0.007 (0.1)
Wage work, females	$\log\left(\frac{\tilde{g}_{1F}}{1-\tilde{g}_{1F}}\right)$	= -1.236 + 0.152S (7.0) (8.1)
Household profit from selfemployment	$\log a$	= -0.550 (4.4)
Positive profit from selfemployment	$\log\left(\frac{g_s}{1-g_s}\right)$	= 1.884 (12.2)

S = Length of schooling.
*) t-values in parenthesis.

Table 7 demonstrates that the parameters of the utility function all have the correct sign according to economic theory and they are in general determined with high precision.

The results of Table 8 demonstrate that education and experience are very important determinants for the wage rate in the wage work sector. It also shows that the so-called selectivity bias is negligible. This is not the case for the profit function estimates given in Table 9. Here we see that the direct effect of both male and female labor is overestimated by OLS.

The profit-function estimates also imply that the Cobb-Douglas structure is rejected since there is a strong negative interaction between male and female hours of work. In contrast to the result for the rural areas Maxed (the length of schooling of the highest educated member of the family) seems to be of little importance for the level of the profit.

The estimates of the opportunity probabilities given in Table 10 show that length of schooling has a substantial effect on the opportunities for wage work, particularly for females. The last line of Table 10 also shows that the probability of positive profit given that selfemployment activity takes place is 0.87.

The Figures 4, 5 and 6 yield the observed and the simulated distributions of consumption and hours of work for females and males in Lima. These figures demonstrate that the model reproduces data quite well on the aggregate level.

Figure 4. Observed and simulated distributions of hours of work for females living in Lima

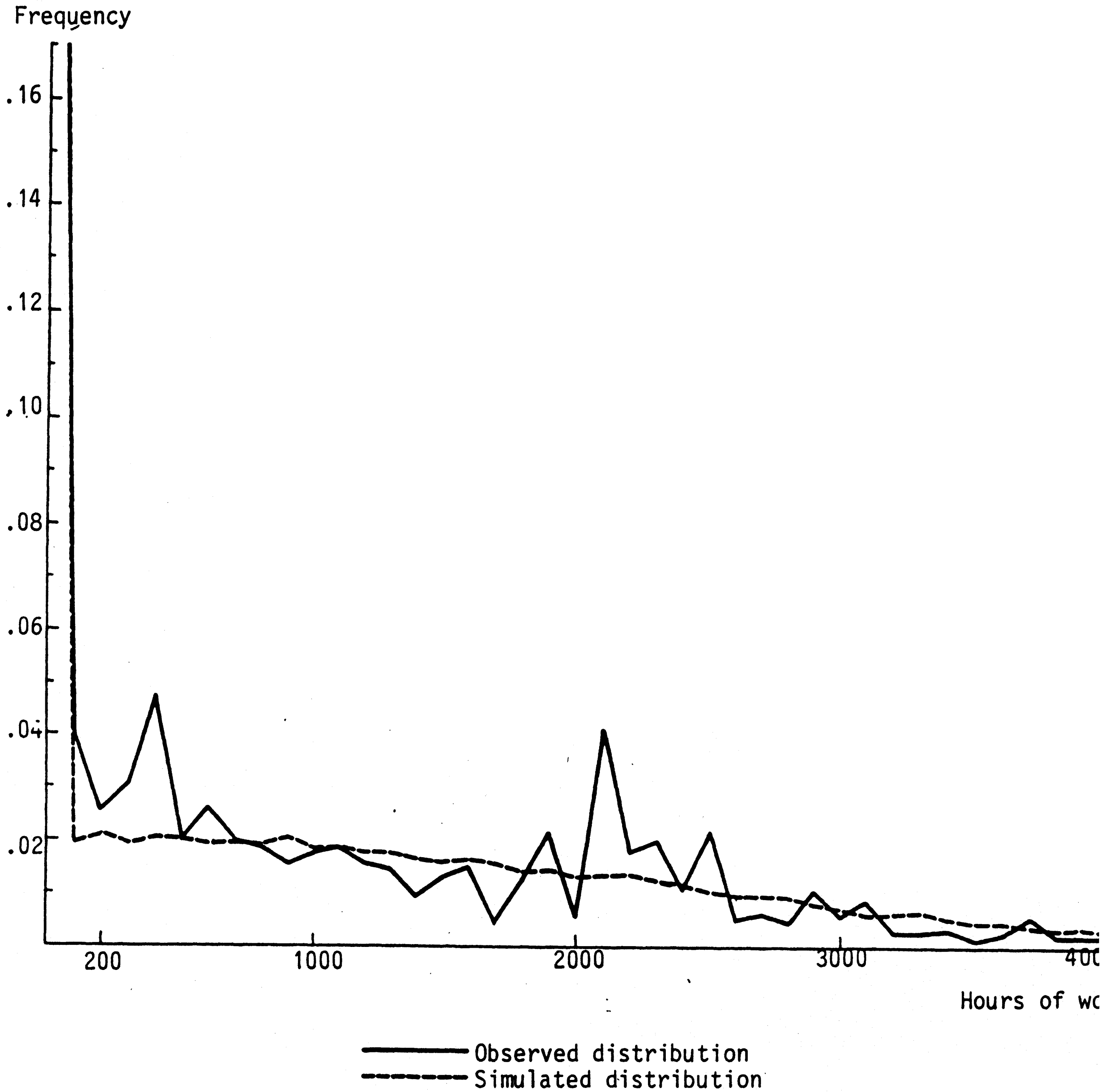


Figure 5. Observed and simulated distributions of hours of work for males living in Lima

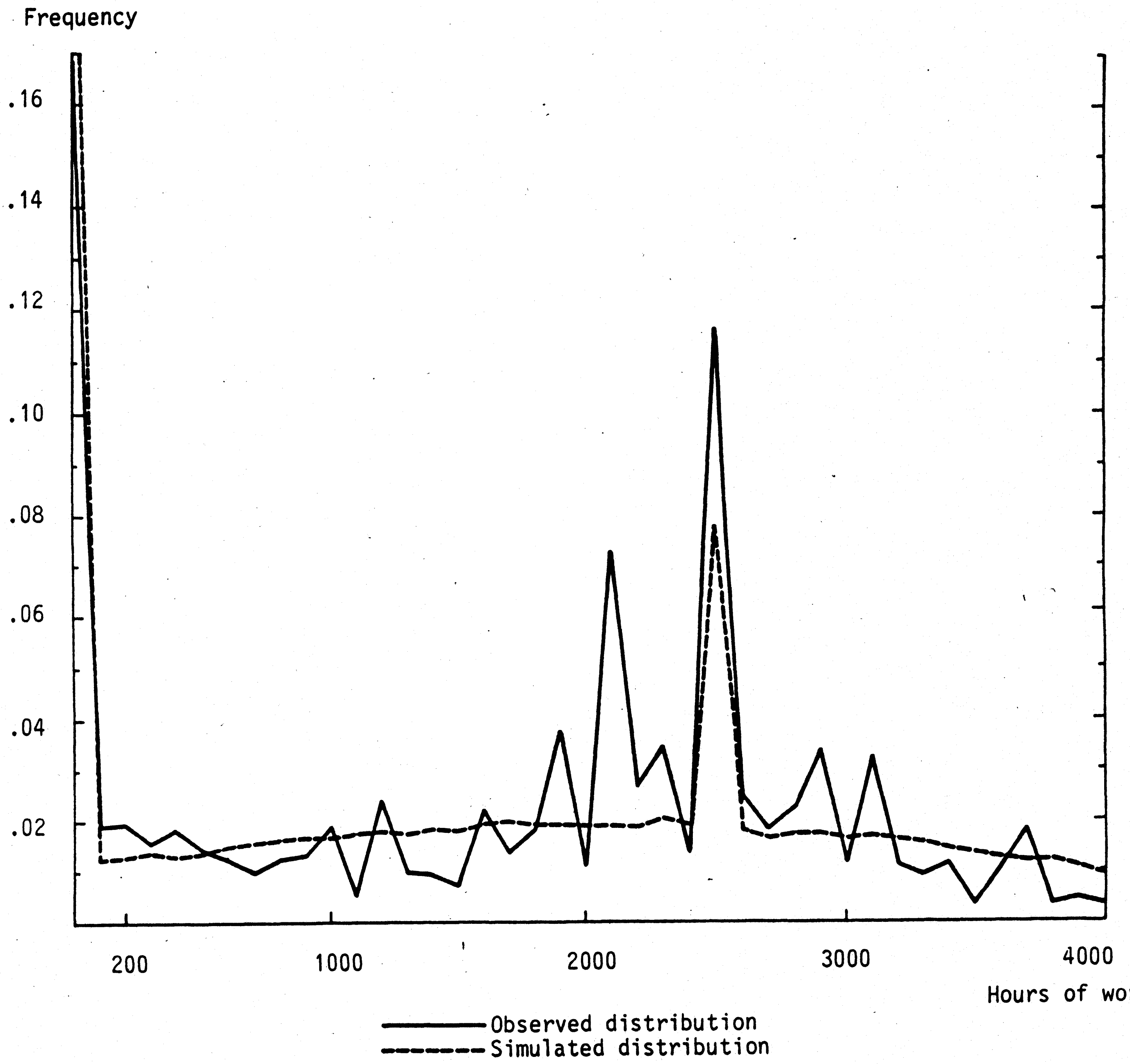
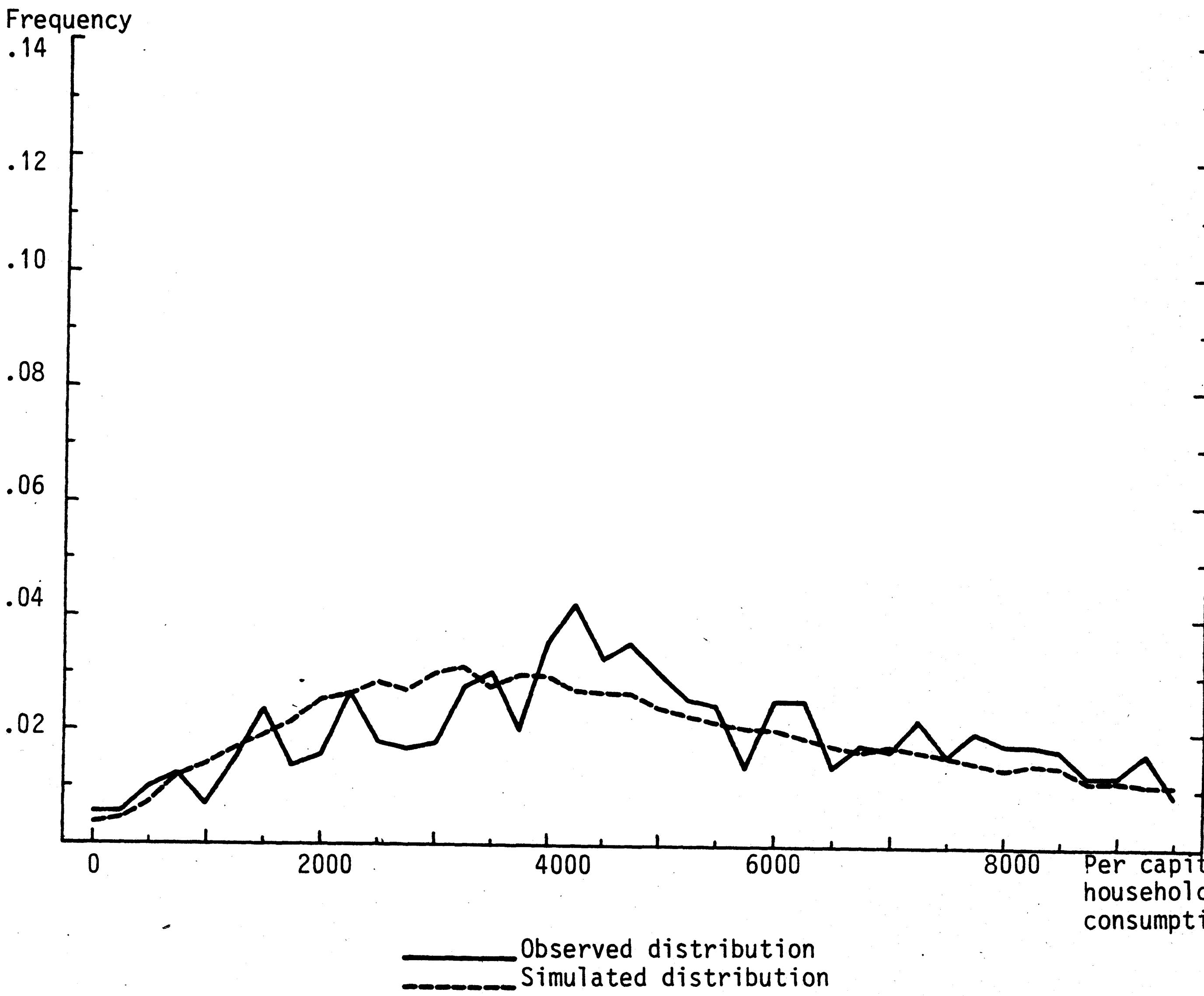


Figure 6. Observed and simulated distributions of per capita consumption among households living in Lima



6. POLICY SIMULATION RESULTS FOR LIMA

The econometric framework outlined in Section 3 allows us to perform rather complex simulation experiments where we take into account observed heterogeneity that stem from age, schooling, household size and composition. In addition, we account for unobserved heterogeneity that is represented in the model by random error terms associated with the wage, the conditional profit and the utility function. After the model has been estimated it is possible to perform simulations since we then "know" the parameters of the structural part of the utility, the wage and the profit function, and the probability distributions of the related random terms.

In practical policy simulation experiments we proceed as follows. For each household the respective random terms are drawn from the corresponding probability distributions. Now the maximization of the utility function is a pure numerical problem given the observed household characteristics. The resulting hours that maximize utility are the females and the males labor supply in each sector. This procedure is performed for each household in the sample from which we obtain the participation rates, the population distribution of the labor supply in each sector, the consumption and the profit from selfemployment. Note that this procedure implies <u>exact aggregation</u>. Unfortunately, since the model is so rich it turned out to be quite costly to perform exact simulations. We have therefore only carried out approximate simulations in which the approximation error is of moderate size. These approximate simulations are still quite good as seen from the figures 1-6.

In this section we confine the analysis to households with at least one female and one male adult where the households consumption per capita does not exceed 20 000 Intis.

The simulation experiments that are undertaken here relate to the effect of changes in wage rates and education on labor supply, wage earnings, profit from selfemployment. The welfare implications are reported in Aaberge and Dagsvik (1989).

6.1. Wage effects

In Table 11 we report the effect of wage changes on participation probabilities and on mean hours worked in each sector. The table shows that a 20 per cent increase has only a small effect on labor supply. A 20 per cent wage increase for the females implies that their mean hours of work and participation rate in the wage sector increase by 5.8 and 3.2 per cent, respectively. The effect on females mean hours and participation rate in selfemployment is almost negligible. Also the cross effect on males participation rates and mean hours of work in each sector is negligible.

Recall that the sum of the participation rates across sectors may be greater than one because many individuals work in both sectors. When the males wage rates are increased by 20 per cent, participation and mean hours of work for males in the wage sector increase by 1.6 and 2.7 per cent, respectively. For the selfemployment sector, male participation and mean hours of work decrease by 1.2 and 2 per cent, respectively. Female participation and mean hours of work are reduced by 2.0 and 2.4 per cent in the selfemployment sectors. The reason why female labor supply decreases is due to the income effect that stem from the increase in male wage earnings. When both male and female wage rates are increased by 20 per cent, the impact is similar but weaker.

The largest effect is obtained when the females wage rates are increased by 20 per cent of the mean wage rate. Then participation and mean hours in wage work increase by 3.8 and 8.0 per cent, respectively. By using the results of Table 11 we obtain that the mean hours, given participation in the wage work sector, increases by 4.0 per cent. However, the decrease in participation and mean hours in the selfemployment sector is small. So is also the change in male labor supply from this policy.

When males wage rates are increased by 20 per cent of the mean wage rate then males participation and hours of work in the wage sector increase by 2.1 and 3.8 per cent, respectively. In the selfemployment sector male participation and mean hours decrease by 2.3 and 3.5 per cent. The corresponding income effect implies that female participation and mean hours in the wage sector decrease by 2.9 and 3.6 per cent, respectively, while there is almost no change in female participation and mean hours in the selfemployment sector.

Table 11. Changes in participation rates, annual hours of work, earnings and consumption as a result of wage increments. Percentage changes from base case

	Sectorspecific participation rates				Sectorspecific annual hours of work (unconditional)*)				Wage earnings (unconditional)		Wage earnings	Consumption
	Wage work		Selfemployment		Wage work		Selfemployment					
	F	M	F	M	F	M	F	M	F	M	Households	
Base case	0.32	0.62	0.34	0.35	414	1165	414	492	2300	8100	17900	27800
20 per cent increase in females wages	3.2	-0.6	-0.9	-1.2	5.8	-0.7	-0.5	-0.4	30.0	-1.2	6.3	5.0
20 per cent increase in males wages	-1.9	1.6	-2.0	-1.2	-2.2	2.7	-2.4	-2.0	-4.6	22.3	17.1	11.9
20 per cent increase in both females and males wages	0.6	0.6	-1.8	-1.4	1.9	1.9	-1.5	-2.4	19.8	20.5	21.2	11.5
Female wage rates increased by 20 per cent of the mean wage	3.8	-1.4	-0.9	0	8.0	-1.4	-1.5	0	25.0	-0.8	5.0	4.7
Male wage rates increased by 20 per cent of the mean wage	-2.9	2.1	-0.9	-2.3	-3.6	3.8	-0.5	-3.5	-4.5	17.6	14.0	7.0
Female and male wage rates increased by 20 per cent of the mean wage	1.6	1.0	-2.3	-2.9	3.4	2.0	-2.7	-4.3	19.7	15.1	16.2	8.6

*) Recall that conditional hours in the respective sectors can be obtained by dividing the unconditional hours by the corresponding participation rates.

Table 12. Simulation of the model without random elements in the model and without restrictions on the choice set of positions. Base case, Lima

Wage rates in Intis		Hours in wage work		Hours in selfemployment	
Male	Female	Male	Female	Male	Female
1	1	790	0	861	118
1	3	114	808	991	58
1	5	0	1113	762	40
1	7	0	1192	574	31
3	1	2027	0	193	87
3	3	2027	0	193	87
3	5	1707	536	198	56
3	7	1327	857	201	37
5	1	2140	0	93	49
5	3	2140	0	93	49
5	5	2140	0	93	49
5	7	1963	307	92	38
7	1	2130	0	54	29
7	3	2130	0	54	29
7	5	2130	0	54	29
7	7	2130	0	54	29
9	1	2091	0	33	18
9	3	2091	0	33	18
9	5	2091	0	33	18
9	7	2091	0	33	18
9	9	2091	0	33	18
9	11	2087	7	33	18
11	1	2046	0	22	11
11	3	2046	0	22	11
11	5	2046	0	22	11
11	7	2046	0	22	11
11	9	2046	0	22	11
11	11	2046	0	22	11

Transfers = 2400 inits, Maxed is equal to mean level of years of schooling
Female age = male age = 30 years
Number og children = 0

Table 13. Wage elasticities for the model without random elements and without restrictions on the choice set positions. Lima

Base level of wage rate in Intis		Male wage increase				Female wage increase			
		Wage work sector		Self-employment sector		Wage work sector		Self-employment sector	
M	F	M	F	M	F	M	F	M	F
1	1	2.8	0	-1.5	0.8	0	0	0	0
1	3	28.0	-0.5	-1.7	1.7	-12.3	1.2	0.2	-1.7
1	5	0	0	0	0	0	0.3	-0.7	-2.5
1	7	0	0	0	0	0	0.2	-0.9	0
3	1	0.2	0	-1.6	-1.1	0	0	0	0
3	3	0.2	0	-1.6	-1.1	0	0	0	0
3	5	0.7	-2	-1.5	0	-0.8	2.2	0	0
3	7	1.1	-0.8	-1.5	2.7	-1.0	0.9	0	0
5	1	0.05	0	-2.2	-2.0	0	0	0	0
5	3	0.05	0	-2.2	-2.0	0	0	0	0
5	5	0.05	0	-2.2	-2.0	0	0	0	0
5	7	0.50	-4.6	-1.0	0	-0.5	4.2	0	-2.6
7	1	-0.05	0	-1.9	0	0	0	0	0
7	3	-0.05	0	-1.9	0	0	0	0	0
7	5	-0.05	0	-1.9	0	0	0	0	0
7	7	-0.05	0	-1.9	0	0	0	0	0
9	1	-0.1	0	-2.1	-2.2	0	0	0	0
9	3	-0.1	0	-2.1	-2.2	0	0	0	0
9	5	-0.1	0	-2.1	-2.2	0	0	0	0
9	7	-0.1	0	-2.1	-2.2	0	0	0	0
9	9	-0.1	0	-2.1	-2.2	0	0	0	0
9	11	-0.1	100	-2.0	-1.7	-0.4	221.2	-0.3	-1.7
11	1	-0.13	0	-2.3	-2.6	0	0	0	0
11	3	-0.13	0	-2.3	-2.6	0	0	0	0
11	5	-0.13	0	-2.3	-2.6	0	0	0	0
11	7	-0.13	0	-2.3	-2.6	0	0	0	0
11	9	-0.13	0	-2.3	-2.6	0	0	0	0
11	11	-0.13	0	-2.3	-2.6	0	0	0	0

Note that above we only reported aggregate effects. In Tables 12 and 13 we report labor supply and wage elasticities, respectively, based on simulations for a two-person family for the particular case in which all the random terms are equal to zero and without any choice constraints. These simulations demonstrate that the elasticities of hours are highly dependent on wage rate levels. The reason why the corresponding aggregate effects are much smaller may be the large heterogeneity in wage rates and the fact that in many families one or several persons are "stuck" in corner solutions i.e., they participate at most in one sector. Such families are therefore less responsive to wage changes compared to families where all members work in both sectors. Table 13 shows that when male and female wage rates are equal to 1 and 3, 9 and 11 intis, respectively, the elasticities are very high. In the latter case wage work hours for females increases from 7 to 23 hours. In addition, as we shall see below, the restrictions on choice opportunities are very important for the occurence of a large number of corner solutions.

6.2. Education effects

In Table 14 we report the impact of schooling through the opportunity probabilities. Here the wage rates and the education variable (Maxed) in the conditional profit function are kept unchanged. Thus we study the pure "opportunity" effect. Contrary to the wage simulations above we obtain a large effect from increased education. If female education is increased by one year, female participation increases by 9.2 per cent in the wage sector. The change in the participation rate for the selfemployment sector is however within the simulation error margin. If male education is increased by one year participation in wage work increases by 3.4 per cent and remains almost unchanged for the selfemployment sector. If the minimum education for females is increased to 9 years, female participation increases by 19 per cent. When the males level of schooling is increased analogously male participation in the wage sector increases by 3.9 per cent. The cross effects appear to be negligible.

Table 14. Changes in sectorspecific participation rates as a result of additional schooling when the wage rates are kept fixed. Percentage changes from base case

	Sectorspecific participation rates			
	Wage work		Selfemployment	
	F	M	F	M
Base case	0.32	0.62	0.34	0.35
One year of additional schooling for females	9.2	-1.4	0	0
One year of additional schooling for males	-1.3	3.4	0	-0.6
One year of additional schooling for both females and males	7.6	2.4	0	-0.9
Nine years of schooling as a lower limit for females	19.0	-1.0	0	-0.3
Nine years of schooling as a lower limit for males	-1.3	3.9	0	-0.9
Nine years of schooling as a lower limit for both females and males	18.0	3.5	0	-1.2

In Table 15 we also report the impact on labor supply from increased education. Here only maxed is kept unchanged. In other words, the increase in schooling has an effect both through increased wage levels as well as through expanded choice sets of wage work positions. The first line demonstrates that the wage effect seems to be small compared to the impact through the opportunity probabilities. In Table 14 we found that the corresponding female participation rate increased by 19 per cent which is only 2.5 percentage points less than what we obtained by increasing minimum level of schooling up to nine years for the females without keeping the wage rate fixed. The subsequent effect on mean hours of work in the wage sector is a 25.6 per cent increase for the females and a 2.7 per cent decrease for the males. The corresponding increase in the conditional mean hours given participation in the wage work sector for females is 3.3 per cent. The other income and cross effects on hours are small. The mean wage earnings for females increases dramatically, up to 42.6 per cent.

Table 15. Changes in participation rates, annual hours of work, earnings and consumption as a result of additional schooling and subsequent increase in wage rates. Percentage changes from base case

	Sectorspecific participation rates				Sectorspecific annual hours of work (unconditional)				Wage earnings (unconditional)		Wage earnings	Consumption
	Wage work		Selfemployment		Wage work		Selfemployment					
	F	M	F	M	F	M	F	M	F	M	Households	
Base case	0.32	0.62	0.34	0.35	414	1165	414	492	2300	8100	17900	27800
Nine years of schooling as lower limit for females	21.5	-1.8	1.2	-0.6	25.6	-2.7	-1.5	0	42.6	-2.0	8.4	6.5
Nine years of schooling as lower limit for males	-3.5	5.6	0	-1.7	-4.4	6.7	0	-3.5	-5.0	14.8	11.2	7.6
Nine years of schooling as lower limit for both females and males	19.0	3.7	0.9	-1.4	20.5	3.0	-1.2	-2.4	33.9	11.1	17.3	11.2

If the minimum level of schooling for males is increased up to 9 years the impact on labor supply is much less. In this case participation in the wage work sector increases by 5.6 per cent for males and reduces by 3.5 per cent for females. Mean hours of work in the wage work sector increases by 6.7 per cent for the males and reduces by 4.4 per cent for the females. Other income and cross effects on labor supply are small. Concerning wage earnings, they increase in this case by 14.8 per cent for males and decrease by 5.0 per cent for females. However, the total effect on household income is larger in this case than in the former case where minimum education for females was 9 years.

The last line reports the effect from letting both males and females have minimum education equal to 9 years. The results show that female participation and mean hours in wage work increase by almost the same amount as in the "marginal" case reported in the first line. Male participation and mean hours in the wage work sector increase by 3.7 and 3 per cent, respectively, which is much less than the response in the "marginal" case of the second line.

We have also carried out simulations in which Maxed is increased. The results from these simulations (not reported here) show very small impact on the profit.

7. CONCLUSION

This paper departs from the assumption that the members of a household behave so as to maximize a household utility function given the available resources, work and production opportunities. The corresponding econometric model we propose here differ from the traditional labor supply models found in the literature. Our particular approach has the advantage of being well suited for taking into account latent opportunity constraints, the interdependence between each persons activities in different sectors and the interdependence between household members. Since quite a few households consist of more than two adults this is a major challenge.

As mentioned in the introduction it may not be obvious that a neoclassical type of model which we have used here is appropriate for analysing the Peruvian labor market. However, we have not discussed the limitation of the micro-economic neo-classical modeling approach to this end. Our analysis rests however critically on the presumption that the heterogeneity with respect to preferences and opportunities is to a "large" extent reflected in the data. For example, it may be questionable if essential background information about the heterogeneity in customs and value systems across social classes, ethnic groups and "professions" is reflected in the data. It is of course also essential that the data on participation, hours and economic variables are not corrupted by measurement errors. Measurement errors in the economic variables may occur if, for instance, household members are engaged in black market activities or if a substantial part of the goods and labor markets operate by trading services and goods without explicit prices. This is particularly relevant if the inflation is high like in Peru. Note, however, that consumption of home-grown food and other in-kind income is given a monetary value so that profit include consumption of these items. Specifically, the assumption underlying our model is that profit, hours and wage rates are reasonably accurately measured. Also we assume that the number of feasible wage work positions with low (offered) hours is, on average, the same as the number of feasible wage work positions with high offered hours. Under the assumption that there are no restrictions on hours of work in the selfemployment sector it is in fact possible to test this assumption.

If, however, we are willing to accept the neo-classical point of departure the estimation results at least for Lima demonstrate that the parameters are determined with remarkably precision and have the expected signs according to economic theory. The model is also able to reproduce quite well the aggregate distributions of hours and consumption.

In order to examine the possibility of constraints on hours in the wage work sector we have also carried out a rough test of this assumption. This test suggests that the wage work hours are not severely constrained.

As regards the empirical results it may be the case that the model for the rural areas is less able to capture the corresponding economic reality and behavioral patterns than the version for Lima. This may be so because it seems questionable if the data on key economic variables are sufficiently accurate. Also the large heterogeneity makes it hard to model the activities in the rural areas. This may be the reason why simulation experiments (not reported here) show that wage changes have no effect on behavior in the rural areas.

The simulation results for Lima demonstrate that proportional wage changes have only a small effect on behavior (indirect effect), see Aaberge and Dagsvik (1989), which also report the effects of changes in wage rates and education on the distribution of welfare.

APPENDIX 1

Definitions of main variables

The Peruvian Living Standards Survey records information on the two most important jobs held by each individual in the last 7 days and in the last 12 months prior to the survey, respectively. Accordingly, this survey provides information about cases where the individual held one main job in the last 7 days and another main job in the last 12 months and similar information for second jobs. Therefore annual hours of work and wage earnings is defined by (A.1) and (A.2).

Table A1. Measures of annual hours of work and wage earnings

	Last 7 days			Last 12 months		
	Weekly hours of work	Weekly wage earnings	Number of weeks	Weekly hours of work	Weekly wage earnings	Number of weeks
Main job	h_1	k_1	r_1	h_2	k_2	r_2
Second job	h_3	k_3	r_3	h_4	k_4	r_4

(A.1) Annual hours of work $= \sum_{i=1}^{4} r_i h_i$

and

(A.2) annual wage earnings $= \sum_{i=1}^{4} r_i k_i$.

As an illustration we give examples of three possible outcomes of h_1, h_2, r_1 and r_2 in Table A2.

Table A2. Three examples of observations of main job activities in the course of 12 months

Outcome	Last 7 days		Last 12 months	
	Weekly hours of work	Number of weeks	Weekly hours of work	Number of weeks
1	40	50	0	0
2	0	0	40	50
3	40	28	30	24

Based on the measurements of wage earnings and annual hours of work the wage rate is given by

$$\text{wage rate} = \frac{\text{Annual earnings}}{\text{Annual hours of work in wage sector}} .$$

Table A3 gives details of how profits from farm and non-farm production are measured.

Table A3. Measure of profits from farm and non-farm production

	F A R M	N O N - F A R M
Revenue	TOTREV	REVCONS
Expenses	EXPFARM = (TOTINP+ TOTLIVST)	EXPENSES = (TOTAL MTHLY EXPENSES*NO. MTHS ENTERPRISE OPER IN LAST YEAR)
Value added	PROFARM = TOTREV - EXPFARM	PROFITS = REVCONS - EXPENSES

APPENDIX 2

Sample selection criteria

Rural areas:

1) Only households with at least two adults, one of each sex, (between 15-70 years of age are considered.

2) Households with zero or negative profit from selfemployment are removed.

3) Households for which any adult works more than 5000 hours are removed.

4) Households for which any adult has wage rate above 375 intis are removed

5) Households with gross revenue above 100000 intis are removed

6) Household with consumption per capita above 20000 and below 30 intis are removed.

Lima:

1), 3), 4), and 5) hold.

7) Households with positive profit and zero hours in selfemployment are removed.

8) Households with negative profit are removed

9) Households with consumption per capita above 20000 intis are removed

REFERENCES

Aaberge, R. and J.K. Dagsvik (1989): "Inequality in Distributions of Hours of Work and Consumption in Peru", Mimeo, The World Bank.

Dagsvik, J.K. (1988): "The Generalized Extreme Value Random Utility Model for Continuous Choice", Mimeo Central Bureau of Statistics, Oslo.

Dagsvik, J.K. and S. Strøm (1989): "A Labor Supply Model for Married Couples with nonconvex Budget Sets and Latent Rationing", Discussion Paper, Central Bureau of Statistic, Oslo.

Ben-Akiva, M., N. Litinas and K. Tsunokawa (1985): "Spatial Choice: The Continuous Logit-Model and Distribution of Trips and Urban Densities", Transpn. Res. 19A, 119-154.

Killingsworth, M. (1983): Labor Supply, Cambridge University Press.

Jacoby, H. (1988): "The Returns to Education in the Agriculture of the Peruvian Sierra", Mimeo, The World Bank.

Maddala, G.S. (1983): Limited-Dependent and Qualitative Variables in Econometrics, Cambridge University Press.

McFadden, D. (1973): "Conditional Logit Analysis of Qualitative Choice Behavior ". In Zarembka (Eds), Frontiers in Econometrics, Academic Press.

McFadden, D. (1978): "Modelling the Choice of Residential Location". In A. Karlquist et al. (Eds), Spatial Interaction Theory and Planning Models, North-Holland.

Schafgans, M. (1988): "Labor Market Activity of Women in Peru: A Descriptive Analysis", Mimeo, The World Bank.

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