SIMULTANEOUSLY MODELLING THE SUPPLY OF WEEKS
AND HOURS OF WORK AMONG FEMALE HOUSEHOLD HEADS

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ABSTRACT

The labor supply of female household heads is distributed across a wide variety of hours and weeks choices. This paper explores the differential nature of the weeks per year and hours per week decisions among female heads. A model of labor supply which separates the weeks/hours decision is presented and several forms of this model are estimated, allowing for simultaneity in the weeks/hours decision, as well as for the presence of either fixed costs or minimum constraints on low levels of hours and weeks of work. The results indicate that these two decisions are separate, although not completely unrelated. Like previous researchers, I also find strong evidence of the need to separate the labor force participation decision from the weeks and hours of work decision. The paper ends with a discussion of the evidence on labor rationing among these women, either through un- or underemployment.
1. INTRODUCTION

Most analyses of labor supply focus on one variable. Typically this is annual hours of work, although occasionally one of the components of annual hours is used, either annual weeks of work or hours of work per week. Rarely have researchers attempted to deal simultaneously with both weeks per year and hours per week decisions. It is usually assumed that weeks of work and hours per week are similar decisions, and thus their aggregate, annual hours, is a meaningful and appropriate measure of labor supply. This is perhaps not an unreasonable assumption for research which looks at male labor supply decisions, since the large majority of non-elderly men are in the labor force working full time, full year. However, for females it is less clear that the assumption of a single labor supply variable is accurate. Women typically show much more variation in their labor supply, not only because many women choose not to be in the labor force, but also because many appear to choose part year and/or part time work. Given the range of choice one sees in female labor supply, it is not unreasonable to think that the number of weeks worked per year may be chosen differently (although perhaps simultaneously) from the number of hours worked in each week when work occurs. In particular, this paper explores the differential nature of weeks per year and hours per week decisions among female household heads. Treating these as separate but simultaneous decisions, I estimate the determinants of each decision. The results indicate that these decisions are quite distinct among female heads, and that both of these decisions in turn can also be distinguished from the labor force participation decision.
The only previous research to address this issue in depth is the theoretical and empirical estimations of Giora Hanoch (1980a and 1980b). Hanoch builds a model of labor supply which includes two types of leisure, distinguishing weeks and hours decisions. His theoretical work (with small modification) is the starting point for my paper. However, this paper attempts a much fuller econometric exploration of the hours/weeks relationship than Hanoch provides, allowing for simultaneity in the choice of weeks and hours of work among women workers. In addition, I allow for the discontinuities in labor supply decisions that would occur should fixed costs exist, or if firms constrain workers to work a minimum number of hours or weeks. I also discuss the problem of determining the extent to which part time or part year work can be considered a matter of labor supply choice versus labor market rationing, a crucial issue in determining which theory best explains why so many women participate in the labor force at less than full time levels.

The next section of the paper will present evidence on the range of labor market choices among female household heads. The third section presents a set of theoretical models of labor supply choice in which weeks and hours of work are distinguished. The fourth section briefly presents the data used in this research. The fifth section provides simple estimates of both separate and simultaneous models of hours and weeks. Based on these results, the sixth section presents a more complex estimation model and the seventh section analyzes the relationship between these results and reported unemployment and underemployment among female workers. The final section summarizes the paper and suggests areas where further research is needed.
2. LABOR SUPPLY AMONG FEMALE HOUSEHOLD HEADS

This paper focuses on the labor supply decisions of non-aged female household heads. This group makes labor supply choices which provide a range of observations, both in terms of weeks and hours of work, without the complexity of the joint labor market decisions which married women face. \(^3\)

Table 1 indicates the amount of variation in labor supply within my sample. (Section 4 below describes the sample in more detail. Briefly, I include all female-headed households present in the March 1979 CPS survey, whose head is between 18 and 65 years of age.) As Table 1 indicates, about 1/4 of the sample (26\%) does not work. Slightly less than 1/2 (48\%) of the sample works close to full time, full year or more. \(^4\) However, another 1/4 of the sample is working less than full time, full year, and these workers are scattered across a range of hours/weeks choices. Among all workers, 13\% work full year, but only part time. 13\% work part time, but full year. And 9\% choose to work both part time and part year. There are also a significant number of workers (12\%) choosing to work more than 40 hours per week.

Table 2 indicates how the characteristics of these workers differ. There are few surprises comparing the non-workers (column 1) to the workers (column 2). As many other studies have shown, non-workers have more and younger children, are more likely to be non-white, have less education, receive more government transfers, but have less non-labor, non-transfer income. However the last four columns distinguish workers by part time and part year work. (A part year worker works less than 47 weeks per year and a part time worker works less than 36 hours per
Columns 3 and 5 contain part year workers. Columns 3 and 4 contain part time workers. It is quickly apparent that most of the variables in Table 2 group according to weeks of work (part year/full year) status, rather than according to hours (part time/full time) status. Part time workers are distinguished by age (they are older), region (the northeast and west), and occupation (they are in sales and service jobs.) On the other hand, part year workers are characterized by lower wages, more (and younger) children, lower education, greater unemployment, more government transfers, but less total income, and are less likely to be in either professional or clerical jobs.

A simple analysis of the mean characteristics presented in Table 2 indicates that there are real differences among those who work different patterns of hours and weeks over the year. The rest of this paper discusses these differences through a variety of more sophisticated empirical techniques.

3. THEORETICAL FOUNDATIONS

(a) A Choice-Based Model

The standard model used to justify estimation of a single labor supply variable involves the maximization decision

\[
\begin{align*}
\text{(1)} \quad \text{MAX}_{L,C} \quad & U(L,C) \\
\text{(1b)} \quad L & = T - AH \\
\text{(1c)} \quad C & = Y + AH^E
\end{align*}
\]

where \( U \) is a standard utility function whose arguments are annual hours of leisure and annual consumption. \( T \) is the total available hours over the year, \( AH \) is annual hours of work, \( Y \) is nonlabor annual income, and \( E \) is a measure of hourly earnings. Maximum of this utility function
results in a Marshallian demand function for annual hours of work, 
AH(Y,E), which is the variable most labor supply studies attempt to 
estimate. This is an appropriate characterization of the labor supply 
choice only if the division of annual hours of work into periods of work 
(weeks) and intensity of work per period (hours per week) is a 
completely separable decision from the choice of annual hours of work. 
If one assumes such separability, then labor supply decisions can be 
characterized in two steps. Step one involves the maximization in (1), 
which determines annual hours of work. Step two involves a decision on 
how annual hours are divided into weeks and hours per week. This second 
step could involve a second maximization problem in which a function of 
worker's tastes for hours and weeks of work is used to optimally 
determine the best weeks/hours combination consistent with the 
predetermined level of annual leisure, T; i.e., 

\[(2) \text{MAX}_{L_w,L_h} V(L_w,L_h) \text{ subject to } L_w + L_h = T.\]

where \(L_w\) is the amount of leisure (in hours) during weeks in which no 
market work occurs and \(L_h\) is the amount of leisure (in hours) during 
weeks in which market work occurs. This will produce demand functions, 
\(L_h(T)\) and \(L_w(T)\), which are dependent upon the fixed level of annual 
leisure that was optimally chosen in step one. Alternatively, this 
second step could be determined by a set of institutional constraints 
which reflect the combinations of \(L_h\) and \(L_w\) that are possible in the 
labor market. However, as long as the weeks/hours decision is 
conditional upon a earlier choice of annual hours of work, the observed 
weeks and hours of work for an individual are irrelevant and annual 
hours of work is an appropriate variable for labor supply research.
However, if this sort of two-step procedure is inappropriate and separability in these decisions does not occur, then a more complex model of labor supply choice must be formulated, allowing for interaction between the choice of consumption level, weeks of leisure, and hours of leisure in weeks when work occurs. This implies the maximization decision,

\[
\text{(3) } \max_{L_w, L_h, C} U(L_w, L_h, C) \text{ subject to }
\]

\[
(3b) \quad L_h = (\text{Totwk} - W) \cdot \text{Tothr}
\]

\[
(3c) \quad L_w = \text{Tothr} - H
\]

\[
(3d) \quad C = Y + H \cdot W \cdot g
\]

where Totwk is the total number of weeks in a year which are feasible work weeks, and Tothr is the total number of hours in a week which are feasible hours of work. W is the weeks of work per year and H is the hours of work per week, when work occurs. E, Y, L_h, L_w, and C are defined as before. Maximizing this utility function with respect to L_w and L_h will produce demand functions for L_h and L_w which can be transposed into demand functions for H and W, H(E, Y, g), and W(Y, E, g), where g represents variables which affect the parameters of the utility function (typically demographic and household characteristics). A variant of this model is developed by Hanoch, who goes on to discuss its theoretical properties in detail, a discussion which will not be duplicated here. 7

Section 2 indicated the extent to which labor supply is spread across a wide range of weeks and hours options among female household heads. A model such as (3) provides an attractive way to characterize such behavior, since it allows the variables that enter the utility
function to have diverse effects on weeks and hours choices. For instance, the presence of children, depending on their number, ages and particular needs, might make working part year more attractive if they are school-aged and free during the summer. On the other hand, the presence of preschool children and their particular demands might create a preference (and real need) for more time away from market work every day, leading to part time work. In addition to the effects of children, there may be innate taste differences among the population, with some people preferring leisure grouped together in large stretches of time (part year work), and other people preferring to take their leisure a little each week (part time work.) In addition, these needs are also affected by budget constraint factors. Poorer women earning lower wages might need to work more hours and more weeks in order to support their families, but the presence of unemployment insurance or government transfers could affect these choices. Many government transfers (such as welfare or unemployment compensation) are more readily available to the unemployed, making part year work more likely. Finally, women might also have job preferences for certain occupations (such as certain types of clerical or service work) which are predominantly available either as part time or part year positions. For example, someone who enjoys working as a salesperson to the tourist trade of the summer has necessarily made a job choice that is more likely to involve part year work.

Thus a wide variety of variables measuring demographic, occupational, and household characteristics might be expected to affect the demand functions for hours and and weeks of work in a different manner.
(b) The Effect of Fixed Costs or Labor Market Constraints

So far this discussion has assumed that weeks and hours of work are freely chosen by labor market participants, that all possible weeks/hours combinations are available, and that observed and desired labor supply are identical. I will estimate an empirical version of this simple model below and see how well it fits the data.

However, many observers of the labor market believe that there are discontinuities in the labor market options available to individuals because certain sections of the budget set are not feasible choices. In particular, three types of discontinuities might be present: fixed costs, labor market constraints requiring minimum amounts of work, or labor market rationing. I will deal with each of these in turn.

A significant literature exists on the presence of fixed costs of work (Heckman, 1974; Cogan, 1980 and 1981; Hausman 1980.) Because work involves expenses such as transportation and child care, individuals must earn at least enough income to cover these expenses before work looks attractive to them. This means individuals will not find it optimal to work only a few hours or a few weeks. Empirical estimates of this effect tend to verify the existence of such fixed costs.

With fixed costs, labor supply is derived from the utility decision

\[
\text{(4) } \max_{L_w, L_h, C} U(L_w, L_h, C) \text{ subject to }
\]

\[
\text{(4b) } C = Y - M^W + H^E(1-\eta)M^E
\]

\[
\text{(4c) } L_w = (\text{Totwk} - W)^Tothr
\]

\[
\text{(4d) } L_h = \text{Tothr} - H
\]
where \( \eta \) is the hourly fixed cost associated with each hour of work. This may reflect expenses such as the hourly cost of child care. \( M \) is the weekly fixed cost of work, which may reflect expenses such as fixed transportation costs. Maximizing (4) results in demand functions \( H(Y,E,M,\eta,g) \) and \( W(Y,E,M,\eta,g) \), where the determinants of fixed costs now directly enter the labor supply choice.

The effect of hourly fixed costs is merely to shift down the slope of the wage rate, which does not change the nature of the labor supply decision. But as a result of weekly fixed costs, a discontinuity occurs between the zero labor supply point and the point of initial labor supply. This means the labor force participation decision is no longer continuously linked with the weekly labor supply decision. An estimation procedure which allows for this discontinuity in labor supply choice should be used if fixed costs are significant.

A second possible cause of discontinuities in labor supply choice might be constraints on low levels of hours and weeks of work imposed by the demand side of the labor market. Perhaps because of the cost of hiring and training individuals, firms rarely seem to offer jobs which allow only a few hours of work a day, or a few weeks of work a year. If individuals are constrained by the structure of the labor market to work at or above minimum levels of weeks and hours, a discontinuity would result similar to that which occurs with fixed costs. (Of course, such constraints would create discontinuities in both the choice of weeks and of hours, while the fixed cost analysis above predicted discontinuities only in the weeks decision.)

The resulting utility maximization can be characterized as

\[
\text{MAX}_{L_w,L_h,C} U(L_w,L_h,C) \text{ subject to }
\]

- 9 -
(5b) $C = Y - H^W + H^W(1-t) = W^E$

(5c) $L_w = (T_{otwk} - W)^{tothr}$

(5d) $L_h = Tothr - H$

(5e) $H \geq H_{min}(LM)$

(5f) $W \geq W_{min}(LM)$

where $H_{min}$ and $W_{min}$ are the respective required minimum levels of hours and weeks of work which an individual faces. Both depend upon LM, a set of labor market characteristics specific to the individual occupation and job. The resulting hours and weeks choices also depend upon LM when the constraints from (5e) and (5f) bind. In this case, desired hours (resulting from the maximization problem in (4)) diverges from observed hours (the result of the maximization decision in (5)), and the individual is forced to supply more weeks or hours of work than she would in the absence of constraints (5e) and (5f).

As in the fixed cost situation, the presence of these constraints make segments of the budget set infeasible at low levels of hours and weeks. While it is possible to test for the presence of such discontinuities, without explicit information on fixed costs or on labor market constraints, it is impossible to distinguish model (4) from model (5). The variables that might effect fixed costs are not clearly different from those labor market characteristics that would signal the presence of low-level labor market constraints. As a result, this research will be agnostic about the relative merits of these two explanations for labor market discontinuities between the point of zero labor supply versus initial feasible labor market choices.10
Whatever the cause, it is true that few workers supply very small amounts of weeks or hours of work. Within my sample, only 53 workers (1.4%) work 10 hours a week or less. Only 111 (2.8%) work less than 12 weeks per year. Only 10 individuals work both 12 weeks or less and 10 hours per week or less. This is consistent with a theory of discontinuities at the point of zero labor supply.

A third potential limitation on weeks/hours choices in the labor market involves labor rationing at high levels of weeks and hours. Workers could be unemployed (unable to work as many weeks as they want) or underemployed (unable to work as many hours per weeks as they want), again creating a gap between desired and observed hours of work. (Of course, this type of discontinuity will not affect the labor force participation decision. It simply removes high levels of weeks and hours from the choice set.)

There is much debate about the presence or absence of such constraints in the labor market.\textsuperscript{11} Altonji (1985), for instance, has recently produced evidence that workers on a given job are limited in their labor supply choices. Dickens and Lundberg (1985) also provide evidence of hours constraints. If one believes that such labor market constraints exist, there may be differential restrictions on weeks versus hours. For instance, while slack labor demand could produce either lower hours (underemployment) or lower weeks (unemployment), the effects may differ across occupations or regions, depending on the structure of the market. Alternatively, the presence of discrimination in the market might make certain workers more likely to be "first fired", while others are simply denied full time work. This could occur
disproportionately by race, by age, or be based on stereotypes of the behavior of women with small children.

Specifying the the effect of labor rationing upon the individual maximizing decision is not straightforward. Ideally, one would want to jointly model both individual labor supply and firm employment decisions, interacting the labor market demand factors with labor supply choices. In a far more simple manner, I will simply assume that the aggregate demand conditions facing any individual are fixed, leading to the following maximization decision,

(6) \[ \max_{L', L_h, C} U(L_w, L_h, C) \] subject to

(6b) \[ C = Y - W^W + H^H(1-\eta)W^W \]

(6c) \[ L_w = (T_{totw} - W)^W \]

(6d) \[ L_h = T_{tothr} - H \]

(6e) \[ H \geq H_{min}(LM) \]

(6f) \[ W \geq W_{min}(LM) \]

(6g) \[ H \leq H_{max}(LM, AD) \]

(6h) \[ W \leq W_{max}(LM, AD) \]

where \( H_{max} \) and \( W_{max} \) are the maximum hours and weeks that an individual's labor services are demanded. Both \( H_{max} \) and \( W_{max} \) are functions of the labor market characteristics specific to the individual (LM), as well as overall aggregate demand (AD). If the constraints (6g) and (6h) bind, then the observed labor supply functions will be \( H(Y, E, M, \eta, LM, AD, g) \) and \( W(Y, E, M, \eta, LM, AD, g) \). However, as many previous researchers have noted, there are serious problems with interpreting coefficients on such variables as aggregate unemployment rates as evidence of labor market constraints. These problems will be discussed further in Section 7.
As a result of either labor market constraints or fixed costs, worker choice is limited. Discontinuous "kinks" in the budget set can occur between zero hours of work and the initial levels of weeks and hours at which the worker enters the labor market. In addition, observed hours or weeks of work may not reflect the desired choice of the worker, but rather reflect demand-side constraints in the labor market.

The remainder of this paper develops a set of estimating procedures which attempt to incorporate the above issues. After a brief review of the data section 5 will present simple estimates of a simultaneous model of weeks and hours of work which ignores any constraints or discontinuities. Section 6 will try to incorporate the above discussion of labor market discontinuities between the point of zero labor supply and initial weeks and hours of work in the estimation (reflecting either model (4) or (5) above). Section 7 will discuss whether the data reveals any evidence of labor market rationing, as presented in model (6).

4. DATA

This research uses the Current Population Survey (CPS) from March 1979, providing data on the year 1978. The CPS questionnaire is particularly well-suited for the questions I want to ask. Each surveyed individual is asked to report all weeks of work "either full time or part time, not counting work around the house [but] including paid vacation and paid sick leave."12 Similarly, among all who report any hours of work, each individual is asked to report the number of hours
"usually worked per week" for the weeks that they worked. From this survey I extract all female household heads between the ages of 18 and 65. This provides a sample of 3910 individuals. Table 2, discussed above, presents the mean characteristics for this sample.

Most of the variables used below to estimate hours and weeks of work are standard in labor supply research: education, age and age squared, race, nonlabor ("other") household income, number of dependents and number of children less than age 6. I also allow for regional differences and, when possible, I allow for occupational differences. (There is no occupational information available for nonworkers, which forces me to exclude these variables from the set of estimation results presented in section 5 below.) Female unemployment rates by race and state for the year 1978 are included, as is the average state replacement rate for unemployment insurance benefits. Finally, I also include a measure of state-specific welfare availability for each household, which is based on the eligibility requirements and welfare payment levels in each state.  

The unemployment and underemployment data used later in this paper is extracted from worker responses to the CPS questionnaire. An individual is counted as experiencing unemployment if she is not working and lists "could not find work" as the main reason, or if she reports working less than 50 weeks and indicates that during some of those weeks out of the labor market she was "looking for work or on layoff from a job." An individual is counted as underemployed if she reports working less than 36 hours per week and indicates the reason is either "could only find part-time jobs" or "slack work or material shortage." (The
5. A SIMPLE SIMULTANEOUS MODEL OF HOURS & WEEKS

Before dealing with the complexities of labor market discontinuities, this section will present a variety of simple "first pass" estimates of weeks and hours which will provide a basis for comparison with the more complex techniques that follow.

Labor supply equations resulting from a maximization decision similar to that in (1) typically assume a linear relationship between labor supply and its determinants. I will make a similar assumption for both hours and weeks, characterizing them as

\[ H^e = X\beta_1 + \epsilon \]
\[ W^e = Z\beta_2 + \nu \]

where \( H^e \) and \( W^e \) are the optimal level of hours and weeks derived from a utility maximization process like (3), \( X \) and \( Z \) are vectors of household income and demographic characteristics that affect labor supply choice, \( \beta_1 \) and \( \beta_2 \) are the related coefficient vectors, and \( \epsilon \) and \( \nu \) are randomly distributed error terms.

The most common approach to estimating a single labor supply equation is typically a tobit approach, where labor supply is truncated below for those who are out of the labor market. I will first estimate weeks and hours as independent tobit equations and then estimate them simultaneously using a bivariate tobit. This will provide an initial indication of the extent to which simultaneous determination of these variables affects their estimates.
Under the tobit approach, it is assumed that desired hours and weeks are observed only when they are positive. Thus, one observes hours ($H$) as

\[
H = H^* = X \beta_1 + \epsilon \quad \text{if} \quad H^* > 0
\]

and

\[
H = 0 \quad \text{if} \quad H^* \leq 0.
\]

Similarly, one observes a variable weeks ($W$), which is related to desired weeks ($W^*$) in a similar manner

\[
W = W^* = Z \beta_2 + \eta \quad \text{if} \quad W^* > 0
\]

and

\[
W = 0 \quad \text{if} \quad W^* \leq 0.
\]

Note that both of these equations are reduced form specifications with regard to wages. This will be true of all equations in this paper. This specification is reflective of the underlying choice determinants for hours and weeks, but does not allow one to separate the direct impact of the variables from their impact via the wage equation.\(^{16}\)

Columns 1 and 2 of Table 3 show the results of simple OLS estimation of hours and weeks of work, while columns 3 and 4 present the results of tobit estimation. No interactive effects between the equations are allowed. These results look familiar to anyone acquainted with standard labor supply research: Smaller hours and smaller weeks of work occur in households where the head has younger children, is nonwhite, is less educated, lives in the northeast, or has larger nonlabor income. Higher state unemployment rates, or high state welfare benefits also reduce hours and weeks of work. Being better educated or older increases both types of labor supply.

The results from these independently estimated equations reveal two very similar labor supply equations. The coefficients on almost all
variables for both hours and weeks are quite close in both sign and
magnitude. In fact, looking just at these results, one would be tempted
to conclude that the standard approach to labor supply, which does not
separate the hours and weeks decisions, is probably not inappropriate.

However, the estimates in columns 1 through 4 of Table 3 allow for
no interaction between the hours and weeks decisions. Let me now assume
that ε and v, the random error terms in equations (9) and (10), are
jointly distributed according to a bivariate normal distribution. This
creates a model which I shall refer to as a bivariate tobit. It
contains two jointly estimated equations, both of which are truncated at
the same point. It is the model of simultaneous hours and weeks
decisions which might arise from the maximization decision in model (3),
in which there are no discontinuities in labor market choices. The
weeks and hours decisions are continuous with -- and indeed the same as
-- the labor force participation decision.

The bivariate tobit involves rewriting (9) and (10) as a single
system of equations:

(11a) If \( H^* > 0 \) and \( W^* > 0 \) then
\[
H = H^* = X^*_1 \beta_1 + \varepsilon
\]
and
\[
W = W^* = Z^*_2 \beta_2 + v
\]

(11b) If \( H^* \leq 0 \) or \( W^* \leq 0 \) then
\[
H = 0
\]
and
\[
W = 0.
\]

The likelihood that any individual \( i \) will be observed at a certain
point of labor supply is

(12) \[
L_i = P_i \Pr( \varepsilon = H^*_i - X^*_i \beta_1, v = W^*_i - Z^*_i \beta_2 ) +
(1 - P_i) \Pr( H^*_i \leq 0 \text{ or } W^*_i \leq 0 )
\]

- 17 -
where $P_i = 1$ if individual $i$ is in the labor market and $P_i = 0$ if not. Maximizing the sum of the log of this likelihood function across all individuals produces estimates of $\beta_1$, $\beta_2$, $\sigma_\varepsilon$, the variance of $\tau$, $\sigma_\upsilon$, the variance of $\upsilon$, and $r_{\varepsilon\upsilon}$, the correlation coefficient between $\varepsilon$ and $\upsilon$.

The results of this bivariate tobit estimation are presented in columns 5 and 6 of Table 3. In contrast to columns 3 and 4, in which weeks and hours are independently estimated, columns 5 and 6 show large differences between the hours and weeks coefficients. In particular, the use of the bivariate tobit estimation process has significantly changed the coefficients of the hours equations, while the coefficients of the weeks equation are similar to those estimated independently. The primary change is smaller coefficients across almost all variables in the hours function, although significance levels on these variables have not necessarily fallen. Taking weeks of work into account, small children, race, age, regional location, state unemployment rates and welfare benefit levels, and other income have much smaller effects on hours of work. Taking weeks into account, number of dependents has a negative and significant effect on hours of work, quite different from its effect in the independent tobit estimates. Low levels of education now have a positive and significant effect on hours, another notable change.

The correlation coefficient, $r_{\varepsilon\upsilon}$, between the random errors of the weeks and hours equations is positive and significant at .42, indicating that those individuals who have positive hours residuals also tend to have positive weeks residuals. In short, this bivariate tobit estimation indicates that, accounting for simultaneity in the choice
process, weeks and hours of work appear to be distinct and differently-determined choices.

However, it is somewhat puzzling that the simultaneous estimation should so significantly affect the hours equation without affecting the weeks equation. One possible explanation lies in the limitations of the bivariate tobit model. This model forces both the weeks and the hours equations to pass through the zero labor supply point together. If the hours estimates are more sensitive to the work/no work decision than the weeks estimates, then forcing a joint truncation point in a simultaneous estimation could change the coefficients on hours more dramatically than it changes the coefficients on weeks. Essentially, the problem is that the tobit equations imbed two decisions together: They imbed the decision to work or not work (a single choice), together with the decision of how much to work (a separate, albeit simultaneous choice, for hours and weeks). This assumes that the coefficients of desired hours or weeks trace out a continuous distribution from the zero labor point. To the extent that the work/no work decision is separate from the "how much to work" decision, the bivariate tobit model can bias the coefficients on either hours or weeks. Such a bias would occur in the presence of fixed costs of work or minimum constraints on labor force participation, as outlined in either models (4) or (5) above. An obvious alternative is to free the participation decision from the weeks and hours of work decision.

6. A SIMULTANEOUS MODEL WITH LABOR MARKET DISCONTINUITIES

This section will start by developing a full estimation model of weeks and hours of work in the presence of labor market fixed costs or
constraints. Unfortunately, given the limitations in the data I have available, this complete model will not be estimable, and the second part of this section will estimate a simplified version of the full model.

Assume that either the presence of labor market constraints on low levels of weeks and hours or fixed costs to weeks and hours of work create discontinuities in the budget set. Assume that these points of discontinuity as defined in models (4) or (5) can be characterized as

\begin{align*}
(13) \quad H_{\text{min}} &= RX_1 + v_1 \\
(14) \quad W_{\text{min}} &= QX_2 + v_2
\end{align*}

where \( R \) and \( Q \) are vectors of labor market and personal variables that characterize the fixed costs of work, or, alternatively, the minimum labor market constraints facing a worker. \( X_1 \) and \( X_2 \) are the related coefficient vectors, and \( v_1 \) and \( v_2 \) are random error terms.

If an individual is observed working, it is because

\[ H^e \geq H_{\text{min}} \quad \text{and} \quad W^e \geq W_{\text{min}}. \]

Combining equations (7), (8), (13), and (14), work occurs when

\begin{align*}
(15) \quad \epsilon - v_1 &\geq RX_1 - X\beta_1 \\
(16) \quad v_2 &\geq QX_2 - Z\beta_2.
\end{align*}

Partition the \( X \) and \( Z \) vectors into \([X_0 \, X_R]\) and \([Z_0 \, Z_Q]\), where \( X_R \) and \( Z_Q \)

are the labor supply variables that are contained in \( R \) and \( Q \) respectively, while \( X_o \) and \( Z_o \) are the remaining variables in the \( X \) and \( Z \) vectors.\(^1\) Rewrite (15) and (16) as

\begin{align*}
(15') \quad \xi_1 &\geq X_o^a_1 - X_o^\beta_1 o \\
(16') \quad \xi_2 &\geq Z_o^a_2 - Z_o^\beta_2 0
\end{align*}
where $\alpha = \gamma_1 - \beta_1$, $\alpha_2 = \gamma_2 - \beta_2$, $\xi_1 = \tau - \nu_1$, and $\xi_2 = \nu - \nu_2$.

Clearly, $H^*$ and $W^*$ are observed only when $\xi_1$ and $\xi_2$ are positive.

Thus, for each worker I want to estimate the probability

\[
(17) \quad \Pr(\text{Work}) = \Pr(\xi = H^*-X\beta_1, \nu = W^*-Z\beta_2, \xi_1 \geq X\alpha_1 - X\beta_1\beta_1, \xi_2 \geq Z\alpha_2 - Z\beta_2\beta_2) = f(\xi, \nu) \int \int g'(\xi_1, \xi_2 | \xi, \nu) \, d\xi_1 \, d\xi_2
\]

where $f$ is the bivariate density function for $\xi$ and $\nu$, while $g'$ is a bivariate biconditional density function for $\xi_1$ and $\xi_2$. For a nonworker I want to estimate the bivariate probability,

\[
(18) \quad \Pr(\text{Nonwork}) = \Pr(\xi_1 < X\alpha_1 - X\beta_1\beta_1 \text{ or } \xi_2 < Z\alpha_2 - Z\beta_2\beta_2) = \int \int g(\xi_1, \xi_2) \, d\xi_1 \, d\xi_2
\]

where $g$ is the bivariate unconditional density function for $\xi_1$ and $\xi_2$.

These probabilities can be combined into a likelihood function, summed across all individuals in the sample, and maximized according to standard maximum likelihood techniques.

Unfortunately, this model is not identified for the data which I have available. In particular, I cannot identify the parameters of the two constraints separately. To see this, note first that I do not have information on whether a constraint is binding or not. I only observe $H$ and $W$, without knowing whether they are at an edge of the feasible budget set. Second, I can only differentiate situations in which both $\xi_1$ and $\xi_2$ hold with a positive inequality. If either or both $\xi_1$ or $\xi_2$ hold with a negative inequality, zero labor force participation occurs. In other words, it is impossible to work zero hours but positive weeks, and vice versa.
This model is the two-dimensional analog of the reservation hours model used by Cogan (1981) and others, in which labor force participation depends upon a comparison between desired hours and some (positive) minimum level of work. In fact, one could imagine that what I have called $H_{\text{min}}$ and $W_{\text{min}}$ is some form of "reservation hours" and "reservation weeks." However, these are rather murky concepts and of limited usefulness. Of course, the identification problems noted above do not occur when only one labor supply variable and one constraint exists.

There are two types of additional data which would make the above model estimable. Most obviously, if I had actual observations on fixed costs or minimum hours requirements in firms, I could estimate the parameters of $H_{\text{min}}$ and $W_{\text{min}}$ separately. However, even in the absence of actually knowing $H_{\text{min}}$ or $W_{\text{min}}$, information on whether an individual is constrained to work more hours or weeks than they would otherwise desire, either because of firm demands or due to fixed costs, would be sufficient to identify the model. In this case, I would know whether the individual was at the discontinuous point of their labor supply. This would let me estimate a likelihood function with five parts, separating people who were unconstrained, constrained only in hours, constrained only in weeks, constrained in both hours and weeks, and not working. This would also provide separate identification of the coefficients on the two constraints.\footnote{17}

However, lacking such data I must choose an alternative estimation route. While there are two possible constraints in the budget set (on weeks or on hours), there is still only one labor force participation
decision. Essentially, the worker makes the maximization decision
described in models (4) or (5). If the resulting desired weeks and
hours of work are within the feasible labor supply set, those levels are
chosen. If not, the utility at the various discontinuities is compared
with the zero labor supply point, and the location with the highest
utility level is chosen. Thus, labor force participation occurs if
utility at some attainable point inside or along the feasible budget set
is greater than utility at zero hours of work.18

Denote the highest attainable level of utility on the budget set
as $U_1(H_o, W_o, C)$. (Note we are replacing $L_h$ and $L_w$ with $H$ and $W$ here,
changing the sign of the marginal effect of the first two arguments.)
This utility level may be achieved at $H_o = H^*$ and $W_o = W^*$, or somewhere
along any constraint. Denote the utility attainable without working as
$U_2(0,0,Y)$. Labor market participation occurs if
\begin{equation}
(19) \quad P^* = U_1(H_o, W_o, C) - U_2(0,0,Y) > 0.
\end{equation}
Nonparticipation occurs when
\begin{equation}
(20) \quad P^* \leq 0.
\end{equation}
If I can parameterize this utility comparison, then I can estimate
observed hours and weeks among workers, conditional upon (19).

Given the convenience of assuming linear weeks and hours demand
functions, one would like to find a utility function that imbeds a two-
way labor supply decision and is also theoretically consistent with
linear weeks and hours. Hausman (1980) does this in the context of a
single labor supply decision. With two labor supply variables, this
task is much more complex. I do not attempt it, but rather make a
simplifying -- and clearly theoretically inconsistent -- assumption that
this utility choice can also be characterized in a linear manner. Thus
I assume that the labor force participation decision, based on the
utility choice of the individual between maximum utility available when
working and when not working, is determined by the underlying latent
variable $P^*$ (defined in equations (19) and (20)), which can be specified
as

$$(21) \quad P^* = S \delta + \mu$$

where $S$ is a vector of variables characterizing the participation
decision, $\delta$ is its related coefficient vector, and $\mu$ is a random error
term. Since $P^*$ is nonobservable, we can only estimate a dichotomous
system, characterized by the discrete variable $P$, where

$$(22) \quad P = 1 \text{ if } P^* > 0$$

and

$$P = 0 \text{ if } P^* \leq 0.$$  

This is a standard probit specification.

If I ignore the simultaneous nature of the choice of weeks and
hours, I can now estimate the standard selectivity-corrected models of
labor supply, in which labor supply is conditional upon the
participation decision. For the hours decision, this model can be
written as

$$(23) \quad \text{If } P = 1 \quad H = X_{i1} \beta_1 + \epsilon \quad \text{and } \mu > -S \delta$$

$$\text{If } P = 0 \quad \mu \leq -S \delta.$$  

The likelihood function for any individual $i$ is

$$(24) \quad L_i = (1 - P_i) \Pr(\mu \leq -S_i \delta) +$$

$$P_i \Pr(\mu > -S_i \delta, \epsilon = H_i - X_{i1} \beta_1)$$

Summed across all individuals, the log of this likelihood function can
be maximized by standard maximum likelihood techniques, providing an
estimate of $\beta_1$, $\delta$, $\sigma_\mu$, and $r_{x\mu}$. A similar estimating model of weeks of work can also be constructed, providing estimates of $\beta_2$, $\sigma_\nu$, and $r_{y\nu}$, and a second estimate of $\delta$.

The resulting coefficients from these two independent models are presented in Table 4. Columns 1 and 3 provide estimates of the parameters of hours, with and without occupational dummies in the equation, while columns 2 and 4 provide estimates of the parameters of weeks. The estimates of $\delta$, which determine the labor force participation decision, are not shown here. Table 4 indicates the effect of separating the weeks and hours decisions from the labor force participation decision, without allowing any simultaneity between weeks and hours. The results in Table 4 should be compared to columns 3 and 4 of Table 3, containing independent tobit estimates of weeks and hours. If there were no discontinuities in labor supply between zero hours of work and the initial hours/weeks choices, these estimates would be similar. Comparing the two, it is clear that separating the labor force participation decision makes a significant difference to the estimates for both weeks and hours, although the hours coefficients show more significant changes than the weeks coefficients.\(^{19}\) Once the participation decision is accounted for, number of children and low educational levels now have significant and positive effects on hours of work. Not surprisingly, standard errors are smaller, as are many of the coefficients.

In short, the data appear to provide clear evidence of either the presence of fixed costs of minimum labor supply constraints. However, the independence of the hours and weeks equations in Table 4 do not
reflect our full model of labor supply choice. Using the characterization of the labor force participation decision in equation (22), I now present a joint estimation model, where weeks, hours and participation are all chosen simultaneously.

A fully simultaneous model can be written as

\begin{equation}
\text{If } P = 1, \; P^* > 0
\end{equation}

\[ H = X\beta_1 + \epsilon \]

and

\[ W = Z\beta_2 + u. \]

while if \( P = 0, \; P^* \leq 0, \)

where all variables are defined above. Thus, \( H \) and \( W \) are estimated only when the labor supply decision is positive. In order to estimate this model, I assume that \( \epsilon, u, \) and \( \mu \) are jointly distributed as a trivariate normal.

The likelihood that any individual \( i \) is observed at a certain point of labor supply is

\begin{equation}
L_i = (1-P_i)^* \Pr(\mu \leq -S_i\delta) +
\end{equation}

\[ P_i^* \Pr(\mu > -S_i\delta, \epsilon = H_{i1} - X_{i1}\beta_1, u = W_{i1} - Z_{i1}\beta_2) \]

Maximization of this likelihood function is done by rewriting the trivariate term as the product of a bivariate density function in \( \epsilon \) and \( u \) and a univariate distribution function in \( \mu \), conditional upon the values of \( \epsilon \) and \( u \), i.e.,

\begin{equation}
L_i = (1-P_i)^* \int_{-\infty}^{-S_i\delta} g(\mu) d\mu +
\end{equation}

\[ P_i^* f(\epsilon, u) \int_{-\infty}^{\infty} g'(\mu / \epsilon, u) d\mu \]

where \( f \) is the bivariate density function for \( \epsilon \) and \( u \), \( g \) is the unconditional density function for \( \mu \), and \( g' \) is the biconditional
density function for \( \mu \). This biconditional density can be written as a simple unconditional normal density with a mean of

\[-S_i \delta - \text{COND}\]

where \( \text{COND} = \left( (r_{\mu \epsilon} - r_{\mu u} r_{\epsilon u})(H - X\beta_1) + (r_{\mu u} - r_{\mu \epsilon} r_{\epsilon u})(W - Z\beta_2) \right) / (1 - r_{\epsilon \mu}^2) \).

and a variance of

\[\text{VAR} = \sqrt{1 - (r_{\epsilon \mu}^2 + r_{\mu u}^2 - 2r_{\epsilon \mu} r_{\mu u} r_{\epsilon u}) / (1 - r_{\epsilon \mu}^2)}\].

The likelihood function then becomes

\[(26') L_i = (1 - P_i)^{\alpha}\mathbb{G}(\mu \leq -S_i \delta) + (1 - P_i)^{\alpha}\mathbb{G}(\mu > -S_i \delta - \text{COND}) / \text{VAR}.\]

where \( \mathbb{G} \) is the distribution function for \( \mu \). Summing the log of this likelihood function across all individuals, we can use standard maximum likelihood techniques to estimate the three coefficient vectors \( \delta, \beta_1 \) and \( \beta_2 \), along with the variances of \( \epsilon \) and \( u \), \( \sigma_\epsilon \) and \( \sigma_u \). We also can estimate the three correlation coefficients, \( r_{\epsilon \mu} \), the correlation coefficient between the weeks and hours equations, \( r_{\mu u} \), the correlation coefficient between the hours and labor supply equations, and \( r_{\epsilon u} \), the correlation coefficient between the weeks and labor supply equations.\(^{20}\)

Note that this set of equations would be estimable even if the \( X \), \( Z \), and \( S \) vectors all contained an identical set of variables, although identification would then come solely through the functional form of the joint distribution of \( \epsilon, u \) and \( \mu \). In reality, we are able to specify several differences between these vectors. State unemployment insurance replacement rates are included only in the weeks equations. They would not be expected to affect hours, and since few people are eligible for unemployment benefits beyond 26 weeks, they should not influence labor force participation over an entire year.
The welfare benefits variable also varies between the participation equation and the hours and weeks equations. In the participation equation, the relevant welfare effect is taken to be the expected welfare benefits available to a household if they choose not to work. Once having chosen to work, the effect of welfare on hours and weeks is measured by a dummy variable indicating whether a household is still eligible for welfare at their given level of labor income.

Finally, since weeks and hours are estimated only for nonworkers (unlike the tobit estimates), I can include occupational dummies in these equations. I provide estimates of all equations both with and without the occupational dummies. Not surprisingly, the inclusion of occupational information has strong effects on other coefficients, especially education. For comparison with the estimates in Table 3, the equation without occupations should be used.

Table 5 presents the results of estimating the simultaneous system described in (25). The results in Table 5 are quite different from those in Table 3 and Table 4, indicating that both allowing for simultaneity in the weeks/hours decision and separating the labor force participation decision affects the estimates.

The coefficients of the participation equations require little discussion, since they are similar to the participation results from probit equations reported in elsewhere in the literature. Nonwhite women with younger children, less education, higher "other" income, along with higher state welfare benefits and higher state unemployment rates, are less likely to be in the labor market.
The major result in Table 5 is the dramatically different hours and weeks coefficients which are estimated, once one makes these decisions simultaneous and separates the labor force participation decision. I will discuss the results in columns 3 and 4, which include occupational information in the weeks and hours equations. Race and low education negatively influence the probability that an individual will work, but once a work decision is made, these variables now have positive effects on both the number of hours and the weeks of work that occur. In other words, poorly educated black women who work, work longer hours and more weeks. Unemployment rates and welfare benefits have consistently negative effects on participation and on weeks and hours, while age has consistently positive effects on all three variables. All occupations, relative to the omitted sales occupation, increase both hours and weeks of work. Most surprising, having children under the age of six makes a woman less likely to work and likely to work fewer weeks, but increases the hours she works. (Perhaps these women are choosing to work for shorter, more intense periods of time, in exchange for periods of out of the labor market entirely.) A large number of dependents increases the probability of work, but has little effect on weeks or hours. As usual, education levels are directly correlated with the probability of labor force participation; but once this effect is accounted for, education loses all significance in the hours equation and low levels of education have strong positive effects on weeks, quite the opposite of the tobit results.

The correlation coefficient between hours and weeks, $r_{xy}$, falls to .16 (from .42 in the bivariate tobit), indicating that the unexplained
residuals from the two decisions are only mildly positively correlated once the work decision is accounted for. This further confirms that these two decisions are quite distinct from each other. The correlation coefficients between the participation decision and hours and weeks of work, \( r_{xh} \) and \( r_{w} \), are both small, positive, and insignificant, indicating that there is little remaining correlation between the labor force participation decision and the labor supply choices once the variables in these regressions have been accounted for.

Jointly estimating these equations and accounting for labor market discontinuities by separating the participation decision significantly changes the parameters of both the weeks and hours equations, although the hours parameters appear to be more sensitive to both the simultaneous estimation and to the separate nature of the work/no work decision. This seems to indicate that accounting for the simultaneity in hours and weeks choice is more crucial if one is interested in measuring hours of work per week rather than weeks of work per year.

Unfortunately, because of the reduced form nature of this model, I cannot separate the independent effects of these variables on fixed costs or labor market constraints, from their effects on the underlying labor supply choices of individuals. Clearly, regional location, aggregate unemployment rates and institutional variables are important in these equations. But the exact nature of these effects cannot be determined here. The next section asks whether these results provide any support for the presence of more aggregate demand constraints on labor supply.

6. IS THERE LABOR MARKET RATIONING?
I have found that significant differences in labor market choice occur among female heads with different demographic and household characteristics, and these differences also vary by occupation and by state levels of unemployment and welfare. Can we conclude anything from these results about the existence of labor market constraints that would help determine whether model (6) is appropriate?

The only conclusive way of settling this issue is to demonstrate that a variable which is clearly uncorrelated with labor market choices, and which can only reflect labor market constraints, is significant in the estimation. The estimates in Table 5 show significant and negative effects of state-specific female unemployment rates by race on both weeks and hours of work. This evidence is consistent with the rationing hypothesis and might be considered proof that labor market constraints exist among female household heads.

However, there are other possible explanations of this result which are consistent with a non-rationed model of the labor market. First, unemployment rates could affect wage rates. Since I estimate a reduced form model, the negative effect of unemployment could be occurring through the influence of the wage. I investigate this possibility by estimating wage equations for my sample (conditioning them on positive labor market participation.) The unemployment rate is insignificant in these estimates, indicating that the negative effect of unemployment rates in my model is probably not due to wage effects.

Second, one could claim that those individuals with a stronger preference for leisure might locate in areas with higher unemployment rates. Should this occur, then the negative effects of unemployment in
my estimates are not indicative of labor market rationing but of choices. Third, one could claim that the true wage variable in this model is not observed wages, but shadow wages, which cannot be estimated. It is possible that unemployment rates affect shadow wages, although they do not affect observed wages.

Thus, the presence of significant unemployment coefficients in these results, although consistent with the constraints hypothesis, is not conclusive proof of labor market constraints. Further evidence and research on this issue would be of significant interest.

An alternative approach to this issue is to look at the effects of under- and unemployment on weeks and hours of work. If observed weeks and hours are the result of a choice process, then reported unemployment or underemployment are not meaningful concepts. Low hours or weeks should be explainable by variables which represent underlying household's tastes and needs, and reported under- or unemployment should not add new information. In the context of the model, this implies that self-reported under- or unemployment should have no significant effect in explaining weeks or hours once all other variables are included in the model.

Table 6 shows the coefficients that result from including reported underemployment in the hours equation and reported unemployment in the weeks equation of the model estimated in Table 5. Table 6 indicates that even controlling for all variables in the model, unemployment is still associated with a significant drop in weeks of work and underemployment is still significantly associated with lower hours of work.
Unfortunately, as before, this test is again consistent with the constraints hypothesis, but is not conclusive. Proponents of a choice-based theory could argue that there are omitted variables affecting the labor supply choice that I have not included which are correlated with reported under- and unemployment. These two variables then proxy for the underlying tastes for leisure that have not been adequately measured.

The conclusion is a weak one. I have several pieces of empirical evidence that are consistent with the occurrence of labor market rationing for this population, both for hours of work and weeks of work. However, there are alternative explanations for these results which do not require rationing, and which cannot be ruled out. Any final statement must be left to future research.

7. SUMMARY

The results of this research have revealed a variety of facts about the labor market for female household heads:

1. The labor supply of female household heads is distributed across a wide variety of hours and weeks choices. This research indicates that these two variables are not identical proxies for each other, but that weeks of work over the year are chosen in a different manner from hours of work during the period in which work occurs. My estimates indicate that these are separate (although not completely unrelated) decisions. Aggregate analysis that focuses only on annual hours of work inaccurately describes labor supply for this population.

2. This research provides further evidence on either the presence of significant fixed costs for female heads, or the presence of
structural barriers to low levels of weeks or hours of work. An estimation system that separates the labor force participation decision from the weeks and hours of work decisions is shown to perform well. With labor force participation accounted for, the determinants of weeks and hours are quite different from those estimated by independent or bivariate tobits. A variety of variables such as race or poor education, which decrease the probability of labor force participation, actually increase both weeks and hours of work, once the work/no work decision is made.

3. Not only are weeks and hours decisions distinguishable from the labor participation decision, but they are distinguishable from each other and appear to be jointly determined. Hours of work per week appears to be more sensitive to both the simultaneous estimation and to the work/no work decision.

4. Even after all other characteristics of the household and the labor market are taken into account, unemployment and underemployment explain a significant proportion of the remaining negative residuals in the equations for weeks and hours of work. This result, along with the significant negative effect of unemployment rates on both weeks and hours, is consistent with stories of labor market rationing. However, since alternative explanations are possible which do not require rationing, this evidence cannot be taken as conclusive proof of labor market constraints.

In attempting to answer one set of questions, this paper has raised a variety of new ones. Among issues that might be of significant interest to a future researcher are exploration of the hours and weeks
choices among married women as opposed to household heads. It would also be interesting to explore further the reasons why labor force participation effects differ from hours and weeks effects, detailing the extent and type of fixed costs or minimum level constraints. A data set that would allow estimation of the full model in equations (17) and (18) would be very interesting. Also, this research has been conducted completely via reduced-form equations. A fuller exploration of the relationship between labor supply responses on weeks and hours and related wage equations would be of significant interest. Finally, further exploration of the existence of labor market rationing continues to be needed.
FOOTNOTES

1. Of course, unemployment is the major exception to this. The exact meaning of unemployment continues to be analyzed and debated. See the most recent contribution by Ham (forthcoming).

2. The emphasis in this work on weeks per year and hours per week is of course heavily influenced by the type of data collected. One could just as easily imagine considering months of work per year, and hours of work per month. The distinction is between intensity of employment during any period in which one chooses to work, and the number of periods in which work is chosen.

3. Of course, many of these female-headed households contain teenage or older parental earners. But these earnings are rarely large, and far from the magnitude of husband’s earnings. We ignore their influence on the labor supply decision, except as they affect the lump-sum variable ‘all other household income.’

4. Throughout this paper, I use 'full time' or 'part time' to refer to hours of work per week and 'full year' or 'part year' to refer to weeks of work per year.

5. I use leisure here to indicate non-market time. Of course, for many in my sample, this time is filled with nonmarket work.

6. Totwk is typically assumed to be 52. Assuming 10 hours/day for "maintenance" activities, Toth is often assumed to be approximately 98 hours.

7. Hanoch’s model is arranged so that the two unique labor supply variables which emerge are weeks per year and annual hours of work. However, in my arrangement of the model, the two unique variables are weeks per year and hours per week. The model can be set up either way--the third variable is always a nonlinear combination of the other two. Killingsworth (1983) also makes this point.

8. Note that hourly fixed costs affect this decision in the same way as tax rates. They decrease the return to each hour of work, which does not create a discontinuity, but changes the slope of the budget line.

9. Cogan (1980, 1981) deals with both fixed costs of money and time. In contrast, this analysis adjusts only for fixed monetary costs of work. As Cogan points out, time costs can often be transformed into to monetary costs. (I.e., an individual can take a taxi to work, rather than waiting for a bus.)

10. There is some evidence that minimum constraints do not affect many workers. The PSID study asks individuals if they are working more hours than they desire. No more than 7% of male household heads claim to be experiencing "overemployment" in any year from 1968 to 1974—not a large number, however enough that this hypothesis cannot be entirely discounted. And one might expect that more
women than men would be concerned with "overemployment." See Ham (1977) for further discussion of this issue.

11. For a fuller discussion of the evidence and arguments in this debate see Ham (forthcoming).


13. This calculation varies widely between states. The methodology used here was developed in Blank (forthcoming) and varies with household characteristics, state maximum payment levels, state allowable deductions, and differential state payment plans.

14. Including wages explicitly in the equations creates difficulties since wages are also censored and observed only with positive labor supply.

15. Note that the truncation for the bivariate tobit is not where both \( H^* \leq 0 \) and \( W^* \leq 0 \), but rather occurs whenever either \( H^* \leq 0 \) or \( W^* \leq 0 \). Thus, it is possible in this specification that desired hours could be positive, but no labor supply is observed because desired weeks are negative.

16. While it is possible that there are variables in R and Q that do not appear in X and Z, it is hard to name a variable that would affect labor market minimums but not effect labor supply.

17. The primary issue with respect to identification of this model is the need to observe one constraint in the absence of the other, in order to separately estimate them.

18. In the case of a single labor supply variable, this is often depicted nicely with a graph. However, in my model, the indifference curves become "indifference bowls", scooping out indifference points between \( C, L_h, \) and \( L_c \). Similarly, the maximum feasible budget set is no longer a straight line, but a nonlinear two-dimensional relationship between \( H, W, \) and \( C \), which creates a "curved plane" around the three axes. This picture of utility maximization is hard to draw clearly, and not useful to persons (like myself) who have difficulty interpreting three-dimensional pictures.

19. In the theoretical model (4), it was noted that hourly fixed costs would not create discontinuities, but only change the slope of the wage equation. The significant differences in the hours coefficients in Tables 3 versus 4 indicate that there are labor market discontinuities in the choice of hours, which is consistent with the theory of minimum constraints on hours imposed by firms.

20. Note that this equation is similar to that used by Cogan (1981), although his variables were labor supply and wages, conditional upon reservation wages. However, rather than estimating this equation with a full maximum likelihood procedure, he used a two-step process, estimating the wage separately. My technique should
be more efficient.

21. Of course, one really wants to include occupational information in all three equations, but the impossibility of estimating occupations for nonworkers prevents this.
BIBLIOGRAPHY


- 39 -
Table 1

LABOR SUPPLY AMONG FEMALE HOUSEHOLD HEADS

Each cell contains: Number of observations
Percent of total sample
Percent of all workers

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Non Workers = 1026 (26%)
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(1) Sample: CPS, March 1979. All female household heads, ages 18 to 65.
(2) Part time work is less than 36 hours/week. Part year work is less than 46 weeks/year.
(3) Reported unemployment during the last year.
(4) Reported working fewer hours than desired.
(5) Nonlabor income. Includes all government and private transfers, plus investment income.
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<th>Tobit Estimate of Hours</th>
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** Significant at 1% level
* Significant at 5% level
Standard errors in parentheses

(1) For each household this is the appropriate state female unemployment rate by race.

(2) For each household this is the appropriate state average replacement ratio for UI.

(3) For each household, this is the maximum AFDC benefits available to a household of this size, with this amount of nonlabor, nongovernment income, in this state.

(4) Nonlabor income. Includes all government and private transfers, plus investment income.
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**Significant at 1% level.
*Significant at 5% level.
Standard errors in parentheses.

(1) Full regression results available from author upon request.
Coefficients shown are all from hours or weeks equations, estimated jointly with a separate participation equation.

(2) See footnotes, Table 3.

(3) Dummy Variable. (1 = Eligible for AFDC benefits; 0 = Not eligible.) People who are employed do not receive maximum benefits. This provides a better measure of welfare effects on the employed.
<table>
<thead>
<tr>
<th></th>
<th>Without Occupation</th>
<th></th>
<th>With Occupation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours</td>
<td>Weeks</td>
<td>Participation</td>
<td>Hours</td>
</tr>
<tr>
<td>Number of Children 6</td>
<td>.818*</td>
<td>-.3919**</td>
<td>-.462**</td>
<td>.609*</td>
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<tr>
<td></td>
<td>(.488)</td>
<td>(.626)</td>
<td>(.064)</td>
<td>(.467)</td>
</tr>
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<td>Number of Dependents</td>
<td>.143</td>
<td>-.199</td>
<td>.054*</td>
<td>.057</td>
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<td></td>
<td>(.151)</td>
<td>(.177)</td>
<td>(.034)</td>
<td>(.148)</td>
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<tr>
<td>Race</td>
<td>-.134</td>
<td>.208</td>
<td>-.094</td>
<td>.335</td>
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<tr>
<td>(1=Non White)</td>
<td>(.624)</td>
<td>(.871)</td>
<td>(.103)</td>
<td>(.592)</td>
</tr>
<tr>
<td>Age</td>
<td>.704**</td>
<td>.413**</td>
<td>.042**</td>
<td>.622**</td>
</tr>
<tr>
<td></td>
<td>(.097)</td>
<td>(.145)</td>
<td>(.016)</td>
<td>(.093)</td>
</tr>
<tr>
<td>Age Squared</td>
<td>-.009**</td>
<td>-.005**</td>
<td>-.0008**</td>
<td>-.008**</td>
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<tr>
<td></td>
<td>(.001)</td>
<td>(.002)</td>
<td>(.0002)</td>
<td>(.001)</td>
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<tr>
<td>Education</td>
<td>-.199</td>
<td>-2.598**</td>
<td>-.714**</td>
<td>.062</td>
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<tr>
<td>(High School)</td>
<td>(.678)</td>
<td>(.929)</td>
<td>(.058)</td>
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<tr>
<td>Education</td>
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<td>1.108*</td>
<td>.345**</td>
<td>-.472</td>
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<tr>
<td>(High School)</td>
<td>(.405)</td>
<td>(.639)</td>
<td>(.071)</td>
<td>(.390)</td>
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<tr>
<td>Unemployment Rate (1)</td>
<td>-.177**</td>
<td>-.107</td>
<td>-.021*</td>
<td>-.171**</td>
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<tr>
<td></td>
<td>(.077)</td>
<td>(.104)</td>
<td>(.013)</td>
<td>(.074)</td>
</tr>
<tr>
<td>UI Replacement Rate (1)</td>
<td>-.056*</td>
<td>-</td>
<td>-</td>
<td>-.038</td>
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<tr>
<td></td>
<td>(.044)</td>
<td>-</td>
<td>-</td>
<td>(.045)</td>
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<tr>
<td>AFDC Benefit Max. (1)</td>
<td>-</td>
<td>-</td>
<td>-.001**</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(.0003)</td>
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<td>AFDC Eligibility</td>
<td>-5.985**</td>
<td>-7.811**</td>
<td>-</td>
<td>-4.935**</td>
</tr>
<tr>
<td>(1=Eligible) (2)</td>
<td>(.475)</td>
<td>(.574)</td>
<td>-</td>
<td>(.452)</td>
</tr>
<tr>
<td>'Other' Income</td>
<td>-.0004**</td>
<td>-.0009**</td>
<td>-.0001**</td>
<td>-.0004**</td>
</tr>
<tr>
<td>(1)</td>
<td>(.0001)</td>
<td>(.0001)</td>
<td>(.00001)</td>
<td>(.0001)</td>
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<tr>
<td>Without Occupation</td>
<td>With Occupation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Hours</td>
<td>Weeks</td>
<td>Participation</td>
<td>Hours</td>
</tr>
<tr>
<td><strong>Northeast Region</strong></td>
<td>-1.146** (.475)</td>
<td>.549</td>
<td>-.261** (.075)</td>
<td>-1.268** (.448)</td>
</tr>
<tr>
<td><strong>No. Central Region</strong></td>
<td>.173 (.427)</td>
<td>1.008* (.632)</td>
<td>-.046 (.077)</td>
<td>.263 (.411)</td>
</tr>
<tr>
<td><strong>Southern Region</strong></td>
<td>-.306 (.431)</td>
<td>.306</td>
<td>-.064 (.078)</td>
<td>-.270 (.406)</td>
</tr>
<tr>
<td><strong>Occupation Prof, Tech, or Admin.</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.955** (.456)</td>
</tr>
<tr>
<td>Sales</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.394 (.548)</td>
</tr>
<tr>
<td>Clerical</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.458** (.407)</td>
</tr>
<tr>
<td>Oper, Craft, or Labor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.848** (.548)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>28.865** (1.864)</td>
<td>44.074** (3.182)</td>
<td>1.524** (.358)</td>
<td>26.675** (1.816)</td>
</tr>
<tr>
<td><strong>Standard Errors</strong></td>
<td>7.836** (.080)</td>
<td>11.056** (.164)</td>
<td>-</td>
<td>7.488** (.076)</td>
</tr>
<tr>
<td>Correlation Coefficients &amp; $\hat{\rho}$</td>
<td>$r_{\hat{\omega}} = .176** (.014)$</td>
<td>$r_{\hat{\psi}} = .067 (.178)$</td>
<td>$r_{\hat{\mu}} = .033 (.196)$</td>
<td>$r_{\hat{\omega}} = .157** (.014)$</td>
</tr>
<tr>
<td>Likelihood Value</td>
<td>-22,714</td>
<td></td>
<td></td>
<td>-22,559</td>
</tr>
</tbody>
</table>

**Significant at 1% level.
*Significant at 5% level.
Standard errors in parentheses.
1 See footnotes, Table 3.
2 See footnotes, Table 4.
**Table 6**

**COEFFICIENTS ON UNEMPLOYMENT & UNDEREMPLOYMENT, WHEN HOURS, WEEKS & LABOR FORCE PARTICIPATION ARE ESTIMATED SIMULTANEOUSLY.**

(The model is identical to that shown in Table 5, except for the inclusion of the 2 variables presented below.)

<table>
<thead>
<tr>
<th></th>
<th>HOURS</th>
<th>WEEKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underemployment</td>
<td>-2.442**</td>
<td>--</td>
</tr>
<tr>
<td>Reported During Year</td>
<td>(.399)</td>
<td></td>
</tr>
<tr>
<td>Unemployment</td>
<td>--</td>
<td>-1.497**</td>
</tr>
<tr>
<td>Reported During Year</td>
<td></td>
<td>(.501)</td>
</tr>
<tr>
<td>(l=Yes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Value</td>
<td>-22280</td>
<td></td>
</tr>
</tbody>
</table>

**Significant at 1% level.**