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FIXED COSTS AND LABOR SUPPLY

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Fixed Costs and Labor Supply

ABSTRACT

This study is a theoretical and empirical analysis of the effects of time and money costs of labor market participation on married women's supply behavior. The existence of fixed costs implies that individuals are not willing to work less than some minimum number of hours, termed reservation hours. The theoretical analysis of the properties of the reservation hours function are derived. The empirical analysis develops and estimates labor supply functions when fixed costs are present, but cannot be observed in the data. The likelihood function developed to estimate the model is an extension of the statistical model of Heckman (1974) that allows the minimum number of hours supplied to be nonzero and differ randomly among individuals. The empirical results indicate that fixed costs of work are of prime importance in determining the labor supply behavior of married women. At the sample means, the minimum number of hours a woman is willing to work is about 1300 per year. The estimated fixed costs an average woman incurs upon entry into the labor market is $920 in 1966 dollars. This represents 28 percent of her yearly earnings. Finally, labor supply parameters estimated with the fixed cost model are compared to those estimated under the conventional assumption of no fixed costs. Large differences in estimated paramters are found, suggesting that the conventional model is seriously misspecified.

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FIXED COSTS AND LABOR SUPPLY

I. INTRODUCTION

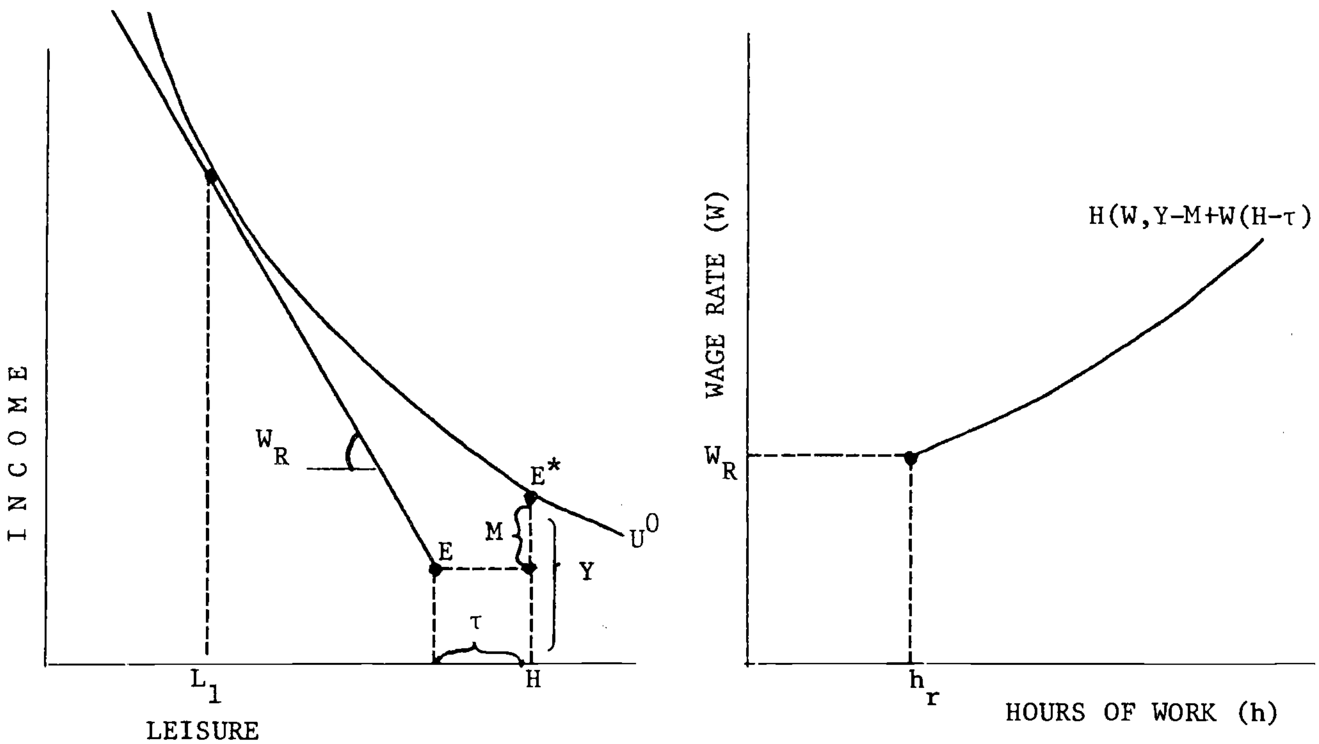
In the last seven years, labor economists have produced a considerable volume of research on the determinants of married women's labor supply behavior. During this period, several substantive methodological and empirical advancements have been made. Perhaps these advancements are best characterized by the work of Gronau (1973, 1975) on the "selectivity bias" in wage equations, Heckman (1974) on the estimation of wage, labor force participation, and labor supply functions, Hanoch (1976) on the theoretical foundations for empirical integration of alternative measures of labor supply, and Heckman (1974), Smith (1974), Heckman and Willis (1977), and MaCurdy (1980), on life-cycle models of labor supply behavior. Although these studies have greatly enhanced our knowledge of the role that economic and demographic factors play in shaping married women's labor market behavior, much remains to be done. There are several key issues that have been entirely neglected or treated only on a superficial level. One such issue is the impact of time and money costs of labor market entry on labor supply behavior. In empirical work, little if any systematic attempt to incorporate such costs into econometric models of labor supply behavior has as yet been undertaken. Most often, the existence of these costs is assumed away. This lack of empirical work stems primarily from two difficulties. First, data on actual amounts of time and/or money costs incurred upon entry into the labor market are at best scant and incomplete. Furthermore, even if entry costs could be obtained for participants in the labor force, such data are inherently not observable for nonparticipants. Second, the existence of fixed entry costs imparts a discontinuity in the individual's labor supply function. This discontinuity reflects the fact that with costs of labor market participation, individuals will not choose to work below some minimum number of hours. This minimum, or reservation hours, is not observable in the data and presumably differs among individuals.

In this paper, a simple model to illustrate labor supply effects of time and money costs of labor market entry is presented and a statistical procedure for estimating labor supply functions when these costs are not directly observable in the data is developed. Although the analysis is confined to married women's labor supply, the approach taken is quite general and may be applied, for example, to the estimation of demand functions for goods sold under fixed-fee plus marginal price arrangements.

Section II is devoted to a theoretical analysis of the effects of costs of labor market entry on labor supply behavior. In Section III the statistical model and estimation procedures are discussed. The model relies on two behavioral functions: an hours of work function and a reservation hours function. The hours of work function is a garden variety labor supply function. The reservation hours function indicates the minimum number of hours an individual is willing to supply to the market. With costs of labor market entry, these two functions characterize the supply side of the market. A market demand or wage function is added to complete the model. A maximum likelihood estimator is proposed to estimate the parameters of these equations. This estimator extends the statistical model of Heckman (1974) by allowing for entry hours to be nonzero and to differ randomly among individuals. Section IV presents the empirical results. These results indicate that entry costs are of prime importance in determining the labor supply behavior of married women. The estimated size of the discontinuity in the supply function is large--around 1,000 hours per year at the sample means. Again at the sample means, the estimated annual cost of labor force participation is approximately $920 in 1966 dollars, which amounts to about 28% of the average yearly earnings of working women in the sample. Also, labor supply parameter estimates of the entry cost model are compared with those obtained under the assumption of zero cost of participation. These comparisons reveal large differences between estimated parameters and suggest that the conventionally formulated empirical labor supply function is misspecified.

II. SOME THEORETICAL CONSIDERATIONS

Most of the important implications of cost to labor market entry are easily summarized by the familiar income-leisure and corresponding labor supply diagram:



(a) (b)

Figure 1

In Figure 1(a) Y and H are the individual's endowment of nonwage income and time, respectively. The variables M and τ denote the level of money and time lost upon entry into the labor market. The reservation wage, the minimum wage offer just necessary to induce the individual to work, is depicted as W_R. As Figure 1 illustrates, an implication of fixed working cost is that individuals will not be willing to work below some minimum number of hours, termed reservation hours. The reservation hours is given in Figure 1(a) by $H-\tau-L_1$ and is described by the discontinuity of the labor supply function at the reservation wage in Figure 1(b). The size of the discontinuity depends on the individual's preference function as well as the levels of Y, M, and τ.[1]

A second immediate consequence of fixed cost of labor market entry is that their existence severs the identity between the reservation wage and the shadow price (value) nonworkers assign to their time. The value a nonworker assigns to his or her time is given in Figure 1(a) by the slope of the indifference curve at E^*. Previous attempts to estimate nonworkers' values of time have relied on its equality with the reservation wage. Two approaches have been used. One is to use labor force participation data (Gronau, 1973, 1974). The other is to use the height of an estimated labor supply function at zero hours of work (Heckman, 1974). As Figure 1(a) suggests, the former approach, which correctly estimates reservation wages, will tend to overestimate values nonworkers assign to their time. The latter approach, which estimates the slope of the indifference curve net of the time and money cost (pt E in Figure 1(a)), will underestimate the value of time at zero hours of work if only money costs of entry exist, and overestimate this value if only time costs exist.

The effects of variations in fixed costs on hours of work among workers are obvious and can be stated without derivation. Increases in money cost of entry act as reductions in money wealth and, if leisure is a normal good, will increase hours of work among workers. Increases in the time cost of working, on the other hand, will reduce hours of work among workers.[2]

The effects of money and time costs of entry on the minimum number of hours the individual is willing to work are less obvious, but easily established by using the individual's expenditure function. The expenditure

[1] The properties of the reservation wage function are derived later in this section.

[2] Strictly speaking, these results follow only if leisure is a normal good in the case of money costs and the composite commodity (income) is a normal good in the case of time costs.

function is written as

(1) $$Y = G(W,\ U) + M - W(H - \tau)$$

where $(\partial Y/\partial W) \equiv G_1$ equals the equilibrium quantity of leisure demand and $(\partial Y/\partial U) \equiv G_2$ is the reciprocal of the marginal utility of income. Furthermore, $(\partial^2 G/\partial W^2) \equiv G_{11}$ is the Hicks-Slutsky substitution effect of a rise in the wage rate on the quantity of leisure demanded, and $(\partial^2 G/\partial W \partial U) \equiv G_{12} > 0$ if leisure is a normal good.

The reservation hours of work function may be derived by differentiating equation (1) with respect to the wage and evaluating the derivative at the reservation wage (W_R).

(2) $$h_R = -G_1(W_R,\ U^0) + H - \tau$$

where U^0 is the level of utility achieved if the individual does not work.

To obtain the effect of a change in the money cost of work on reservation hours, differentiate equation (2) with respect to M holding utility constant at U^0. This differentiation yields

(3) $$\frac{dh_R}{dM} = -\ G_{11}\ \frac{dW_R}{dM}\ .$$

The term, $\frac{dW_R}{dM}$, is the change in the reservation wage for a given change in the money cost of labor market entry. As should be intuitively obvious, an increase in the cost of entry will raise the reservation wage; that is, $\frac{\partial W_R}{\partial M} > 0$.[1] The remaining term, $-\ G_{11}$, is the substitution effect of a wage

[1]Formally, this result may be derived by differentiating the expenditure function simultaneously with respect to W and M, and solving for $\frac{dW_R}{dM}$ at $(W_R,\ U^0)$.

change on the quantity of labor supplied. It is also necessarily greater than zero. Reservation hours, therefore, rise with increases in the money costs of work.[1]

The effect of an increase in time cost of market entry on reservation hours is, on the other hand, theroetically ambiguous in sign. To see this, differentiate equation (2) with respect to τ holding utility constant at U^0 to obtain

$$(4)\qquad \frac{dh_R}{d\tau} = - G_{11} \frac{dW_R}{d\tau} - 1.$$

The product of the first two terms is the change in the quantity of leisure demanded at the reservation wage. As with money costs, an increase in time costs increases the reservation wage. The higher reservation wage reduces the quantity of leisure demanded at the reservation wage. However, the total quantity of time available for work or leisure declines by an amount equal to the increase in time cost of market entry. The change in reservation hours depends upon the relative strengths of these two opposing effects.[2]

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[1]An interesting implication of equation (3) is that if one had data on money costs and could estimate reservation hours of work, one could use this information to estimate the parameters of the compensated labor supply function.

[2]Further expansion of equation (4) yields an interesting though, perhaps, less intuitive expression. Using the expenditure function, the effect of time cost on the reservation wage can be solved for as $\frac{W_R}{h_R}$. Substituting this result into equation (4) yields

$$(5)\qquad \frac{dh_R}{d\tau} = \frac{\partial h^c}{\partial W} \frac{W_R}{h_R} - 1.$$

The product of the first two terms is the elasticity of the compensated labor supply function evaluated at the reservation wage-hours combination. Thus, the effect of time costs on reservation hours may be said to depend on whether the compensated labor supply function evaluated at the reservation wage is greater or less than unity.

Finally, to obtain the effect of nonwage income on reservation hours differentiate equation (3) with respect to Y, allowing utility to vary. Differentiation yields

$$\text{(5)} \qquad \frac{dh_R}{dY} = - \left[G_{11} \frac{dW_R}{dY} + G_{12} \frac{dU^0}{dY} \right] .$$

Assuming leisure is a normal good, an increase in nonwage income will raise the reservation wage; hence $\frac{dW_R}{dY}$ is positive. Obviously since an income in nonwage income raises the utility achieved by not working, $\frac{dU^0}{dY}$ is also positive. However, under the assumption that leisure is a normal good G_{11} and G_{12} are opposite in sign. Thus, in general, the effect of nonwage income on reservation hours is ambiguous.

This effect, however, can be signed in at least one interesting case; when the uncompensated labor supply function is backward bending in the neighborhood of the reservation wage. If it is, an increase in nonwage income will raise reservation hours. To derive this result, differentiate the expenditure function with respect to Y holding utility constant to obtain an expression for the change in the reservation wage for a given change in nonwage income. Differentiation yields

$$\text{(6)} \qquad \frac{dW_R}{dY} = \frac{1}{h_R} \left[\frac{dU^0}{dY} G_2 - 1 \right] .$$ 1/

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[1] As stated earlier, this expression is positive if leisure is a normal good. Note that the product of the first two terms inside the bracket is actually a ratio of marginal utilities evaluated at two points along an indifference curve in income-leisure space. If leisure is a normal good then the ratio is greater than unity. This proposition is easily proven by evaluating the utility compensated effect of a wage change on the marginal utility of income.

Substituting equation (6) into (5) and rearranging terms yields

$$(7) \qquad \frac{dh_R}{dY} = - \left[G_{11} + h_R G_{12} + G_2 G_{11}\right] \frac{\partial U^0}{\partial Y} \frac{1}{h_R} = \left[\frac{\partial h^c}{\partial W} + h_R \frac{\partial h}{\partial Y} - G_2 \frac{\partial h^c}{\partial W}\right] \frac{\partial U^0}{\partial Y} \frac{1}{h_R}$$

The sum of the first two terms inside the brackets is the slope of the uncompensated labor supply function evaluated at the reservation wage. All other terms have been defined earlier and are positive in sign.

Assuming an upward rising labor supply function, the analysis suggests a rather convenient characterization of the hours of work and labor force participation decisions. Define an augmented labor supply function as the actual labor supply function extrapolated back to the wage axis. This augmented labor supply function can be written as

$$(8) \qquad h^* = H\big(W, Y - M + W(H - \tau)\big)$$

The reservation hours function is

$$(9) \qquad h_R = F(M, \tau, Y)$$

Using equations (8) and (9) and assuming an upward rising labor supply function, the labor force participation decision may be cast in terms of a comparison between h^* and h_R. If h^* exceeds h_R the individual will choose to work and her observed hours of work (h) will equal h^*. If h_R exceeds h^* the individual will choose not to work and observed hours of work will equal zero.[1]

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[1] This formulation of the participation decision is obviously equivalent to using the more conventional market wage-reservation wage characterization. The above formulation is used because it leads naturally to a specification of the econometric model that facilitates comparisons with early work.

III. ESTIMATION

To estimate labor supply functions when there are costs of labor force participation, one of two empirical strategies may be followed. If information on the time and money costs of labor market entry incurred by participants is available, then these costs can be used to estimate the structural parameters of not only the labor supply function but also of costs of work functions. On the other hand, if information on the time and money costs of work is not available, then one can only obtain estimates of a quasi-reduced form labor supply function. The quasi-reduced form estimates will reflect not only the parameters of the individual's utility function but also the effects of variations in the cost of work. In this section, I discuss estimation when time and money costs cannot be directly observed on the data.[1]

In order to estimate the parameters of the model, it is necessary to specify the relevant equations and the underlying stochastic structure. Following the analysis of Section II, two functions characterize the labor supply decision: an augmented hours of work function and a reservation hours function.

The augmented hours equation is assumed to take the following form for the ith individual:

$$(10)\qquad h_i^* = \gamma_0 + \gamma_1 N(W_i) + \gamma_2 Y_{H_i} + \gamma_3 C_i + \gamma_4 E_i + \gamma_5 A_i + \varepsilon_{0_i} \equiv \gamma_1 N(W_i) + \gamma' Z_1 + \varepsilon_{0_i}$$

[1]Estimation of the complete set of structural parameters when the costs of work are available is discussed in Cogan (1977).

where $N(W_i)$ is the natural logarithm of the wife's hourly wage, E is her years of education, C is the number of preschool children (age 0-5) in the home, Y_{H_i} is the husband's income, and A_i is the wife's age. The theoretical and empirical relevance of each of these variables, in the absence of costs of work, is well known.

The reservation hours equation assumes the form

$$(11)\quad h_{R_i} = \beta_0 + \beta_1 Y_{H_i} + \beta_2 C_i + \beta_3 E_i + \beta_4 A_i + \varepsilon_{1_i} \equiv \beta' Z_{1_i} + \varepsilon_{1_i}$$

Although one may have intuitive feelings about the effects of each of these variables on reservation hours, the theory developed in the preceding section offers little insight into their expected effects.

The dependent variable is annual hours of work in 1966. This choice requires some discussion. Ideally, we would like to use a measure of labor supply whose dimension is the same as the period of time over which the fixed costs are incurred. That is, if daily fixed costs, such as transportation costs to and from work, are important, then the appropriate measure of labor supply would be hours of work per day. Unfortunately, existing micro data files do not contain information on daily hours of work.

Together equations (10) and (11) imply a reservation wage equation of the form

$$(12)\qquad W_{R_i} = \delta_0 + \delta_1 Y_{H_i} + \delta_2 C_i + \delta_3 E_i + \delta_4 A_i + u_{2_i}$$

where

$$\delta_0 = \frac{\beta_0 - \gamma_0}{\gamma_1} \text{ and } \delta_j = \frac{1}{\gamma_1}(\beta_j - \gamma_{j+1}) \quad \text{for } j = 1, 4$$

The specification of the wage offer equation is

$$(13) \qquad N(W_i) = \alpha_0 + \alpha_1 E_i + \alpha_2 X_i + \alpha_3 U_i + \alpha_4 N_i + \alpha_5 WE_i + \alpha_6 A_i + \varepsilon_{2_i} \equiv \alpha' Z_{0_i} + \varepsilon_{2_i}$$

where E is the level of education completed by the wife, X is her prior labor market experience,[1] U is a dummy variable which assumes a value of one if the woman resides in an urban area, and N and WE are two regions of the country dummies, north and west, respectively.

The vector of disturbances $(\varepsilon_0, \varepsilon_1, \varepsilon_2)$ is assumed to be normally distributed with mean vector zero and constant covariance matrix Ω.

Clearly, if the endogenous variables, h^*, h_R, and W, could be observed for all individuals, then the parameters of equations (10)-(13) could be estimated with two- or three-stage least squares. Unfortunately, these variables are not observed for all individuals. Reservation hours cannot be observed for <u>any</u> individual in the data, and h* and wage offers cannot be observed for nonworkers. Without these data, an alternative statistical approach, such as maximum likelihood is required to estimate the parameters.

To form the likelihood function it is necessary to relate the values of the hypothetical dependent variables to their empirical counterparts, and describe the process by which these observable counterparts are generated in terms of the underlying stochastic elements. Assuming an upward rising supply function, a woman will be observed to be working if

$$(14) \qquad h_i^* > h_{R_i}$$

[1]Work by Heckman and Willis (1977) casts serious doubt on whether it is appropriate to regard prior labor market experience as exogenous to the current wage offer. Also, more recent work by Heckman (1980) suggests that prior experience may also belong in the structural labor supply function.

Substituting the market wage offer equation into the hours of work function, the participation decision may be written as

(15) $$\gamma_1\alpha'Z_0 + (\gamma' - \beta_0')Z_1 > \varepsilon_1 - (\varepsilon_0 + \gamma_1\varepsilon_2)$$

or more compactly, as

(16) $$I > u$$

where

$$u \sim N(0,\ \sigma_1^2 + \sigma_0^2 + \gamma^2\sigma_2^2 - 2\sigma_{10} - 2\gamma_1\sigma_{12} + 2\gamma_1\sigma_{02})$$

The likelihood of observing a nonparticipant is simply

(17) $$\mathrm{Prob}[I < u] = \int_{\frac{I}{\sigma_u}}^{\infty} \frac{1}{\sqrt{2\pi}}\, e^{-1/2(\tau)^2}\, d\tau = 1 - P\left(\frac{I}{\sigma_u}\right)$$

For observations on workers we know that reservation hours are less than the solution to the augmented hours, that is,

(18) $$h^* - \beta_0'Z_1 > \varepsilon_1$$

Hence, the appropriate density measure for observations hours and wages among the workers is

(19) $$\int_{-\infty}^{h^* - \beta_0'Z_1} f(h - \gamma_1\alpha'Z_0 - \gamma'Z_1,\ W - \alpha'Z_0,\ \varepsilon_1)\,d\varepsilon_1$$

where f(·) is the trivariate normal density function. Using equations (17) and (19), the likelihood of the data consisting (say) of T observations, S of them on nonworking women, is .

$$(20)\quad L = \prod_{i=1}^{S}\left(1 - P\left(\frac{I_i}{\sigma_u}\right)\right)\prod_{i=S+1}^{T}\int_{-\infty}^{h_i - \beta_0 Z_{1_i}} f(h_i - \gamma_1\alpha' Z_{0_i} - \gamma' Z_{1_i}, W_i - \alpha' Z_{0_i}, \varepsilon_{1_i})\, d\varepsilon_1$$

The computational burden of optimizing the likelihood function may be reduced by replacing the trivariate normal density function with the product of the bivariate conditional normal and unit normal marginal densities. This permits factoring the right-most term in equation 20 into a simple univariate probit and bivariate normal density.[1]

To estimate the parameters of the model, a multi-step procedure was used. First, consistent estimates of the parameters of the wage equation were obtained with Heckman's (1976) censored sample regression procedure. The likelihood function, conditional upon these estimated values,[2] was then optimized. This two-step procedure yields consistent estimates of the parameters, but incorrect asymptotic standard errors. To obtain asymptotically efficient standard errors, these parameter estimates were used as initial values in a one-step Newton-Raphson iteration on the likelihood function in equation (20).

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[1] I owe this point to Tom MaCurdy and an anonymous referee.

[2] The likelihood function conditional upon estimated values of the wage equation parameters collapses to one which is identical to that proposed by Nelson (1974) and Olsen (1975) for models with unobserved stochastic censoring thresholds.

IV. EMPIRICAL RESULTS

The data used for the empirical analysis were taken from the 1967 National Longitudinal (Parnes) Survey of Mature Women age 30-34 in 1966. The sample selected contained 898 wives who worked at some time during 1966 and 939 who did not. Details of the data selection process and means and variances of the variables used in this study are provided in the Appendix.

Estimates of the market wage function are reported in Table 1. For comparative purposes, ordinary least-squares estimates of the wage offer equation are also presented. The coefficients on education, experience,[1] and urban are all statistically significant. The coefficient on education should be interpreted as the effect of completing an additional year of schooling rather than spending that year out of the labor force. Likewise, the experience coefficient represents the effect of spending at least six months in the labor force during a given year relative to spending that time out of the labor force. The small size of the age coefficient indicates little, if any, effect of either wage depreciation resulting from spending time out of the labor force or variations in the quality of schooling over time. Using a two-standard-deviation confidence ban (a 95% confidence interval), our results indicate that the age effect lies between plus and minus 1%.

Comparing these ordinary least-squares estimates with the "selectivity bias-free" estimates provides some evidence of the effect of the selectivity bias on individual parameter estimates. The major bias appears to be in the estimate of the intercept term, which accounts for the entire difference

[1]Experience is defined as the number of years since completion of school to 1966 in which the woman worked at least six months of the year.

Table 1

Married Women's Wage Offer Equations

Variable	Instrumental Variables Coefficient	Instrumental Variables Standard Error	Ordinary Least Squares Coefficient	Ordinary Least Squares Standard Error
Intercept	-.9556	.3273	-.8388	.1980
Education	.0826	.0116	.0806	.0077
Experience	.0298	.0694	.0230	.0030
Age	.0008	.0089	.0022	.0210
North	.0192	.0637	.0233	.0430
West	.0786	.0726	.0801	.0550
Urban	.1075	.0591	.1163	.0380
R^2			.1786	
(F)			(27.48)	
Predicted mean wages*				
Workers	1.97		1.92	
Nonworkers	1.36		1.68	
Full sample	1.65		1.80	

*Given the assumed form of the wage offer equation, wages are log normally distributed and the mean wage offer is calculated by

$$\bar{w} = e^{\hat{\alpha} Z_0 + \frac{1}{2} \sigma_2^2}$$

conditional and unconditional average wages at the sample means. The difference in the estimate of the effect of prior labor market experience, though small in absolute magnitude, is large relative to the size of the coefficient (23%). Likewise for the urban dummy (40%). It is encouraging to find that the selectivity bias has little effect on the education coefficient. Since the coefficients on age, north, and west have such relatively large standard errors, little can be concluded about the impact of the sample selection bias on these estimated parameters.

Table 2 presents estimates of the parameters of the hours of work and reservation hours functions. The asymptotic standard errors of the estimated parameters are given in parentheses.

The estimates presented in Table 2 conform, at least qualitatively, to those obtained in previous empirical studies of this demographic group (see, for instance, Heckman, 1974; Cogan, 1975; Schultz, 1975) and thus indicate that incorporation of time and money costs of entry do not alter the qualitative nature of the estimated labor supply parameters. An increase in the wife's wage increases annual hours of work among working women, though its effect is much smaller than those found in earlier studies of Heckman (1974) and Schultz (1975). The wife's education, her husband's income, and the number of preschool children in the home all exert a negative influence on her annual hours. Finally, there appears to be no life-cycle or cohort variations in hours worked among working women in the age range of the sample.

In the reservation hours equation, both preschool children and the wife's age significantly raise the minimum number of hours a woman is willing to supply to the labor market. Increases in the husband's earnings also tend to increase the minimum number of hours but its effect is small

Table 2

Entry Cost Model Parameter Estimates

Variable	Hours of Work Function Coefficient (asymptotic standard error)	Reservation Hours Function Coefficient (asymptotic standard error)
Constant	2158.69 (510.43)	746.2 (361.82)
Log wife's wage	1210.91 (185.49)	- -
Wife's education	-91.54 (18.36)	-23.77 (21.35)
Number of children 0-6 years old	-120.41 (52.89)	109.74 (64.08)
Husband's earnings ($1,000)	-22.425 (9.07)	11.09 (10.35)
Wife's age	.468 (8.46)	17.36 (9.46)
Mean Hours		
Workers	1417.73	1257.38
Nonworkers	1145.34	1318.26
σ	714.70	867.98
ρ	.88	

and not statistically significant. Increases in the wife's level of education, on the other hand, reduce minimum hours, though its effect is also not significant.

The estimated mean reservation hours is large, for both working and nonworking women in the sample, indicating that time and money costs of labor market entry are of prime importance in affecting a married woman's labor supply decisions. For example, a 10% increase in the wage offer facing the average nonworking woman in the sample would not induce her to enter the labor market. However, a 15% increase would and she would supply 1,327 hours a year at this new wage. If there were an additional increase of 15% in her wage offer, her hours of work would increase by only an additional 180 per year.

The estimated parameters may be used to solve for the compensating variation measure of the costs of participation. In order to obtain this measure, it is necessary to derive the form of the compensated labor supply function from the assumed form of the uncompensated function. The uncompensated labor supply function (equation (10)) may be written succinctly as

(21) $$h_i = \gamma' Z_i + \gamma_1 N(W_i) + \gamma_2 Y_{H_i}$$

where Z_i' is the vector of other included right-hand-side variables. Using the Slutsky decomposition, we may write the slope of a compensated labor supply function associated with (21) as

(22) $$\left(\frac{\partial h}{\partial w}\right)^c = \frac{\gamma_1}{w} - h\gamma_2$$

The general form of the compensated function may be obtained from equation (22) easily. Equation (22) is a first-order linear differential equation whose general solution on an interval I is given by

$$(23) \qquad h_N^c(w) = e^{-\gamma_2 w} \int_{w^*}^{w} e^{\gamma_2 \tau} \frac{\gamma_1}{\tau} \, dt + c e^{-\gamma_2 (w - w^*)}$$

where w* is the intercept of the labor supply function extrapolated down to zero hours of work and c is an arbitrary constant. The particular solution at the reservation wage-hours point can be obtained with numerical methods.

Given the form of the compensated labor supply function, I have computed estimates of the annual fixed costs of work for the average working and nonworking women separately. These estimates are presented in Table 3 along with estimates of how these costs change with the number of preschool age children and years of education for the average woman in the data. Unfortunately, I have been unable to compute the standard errors of these estimates. Caution, therefore, should be exercised before attaching too much weight to their importance.

Table 3

Annual Costs of Work	
Workers	$ 907.74
Nonworkers	$1,080.97
Change in Costs of Work[a]	
One additional child age 0-6	$ 337.15
One additional year education	$ 112.29

[a]The effects are evaluated at the sample means.

The estimates of the annual fixed costs are large, though not unreasonably so. For working women, this annual participation cost expressed as a percentage of the average annual earnings of working women is 28.3%. As expected, the estimated cost facing nonworkers exceeds that facing workers, with the differential being $113.23. The estimated effect of an additional preschool-age child, evaluated at the sample means, is of the expected sign and quite large. At the sample means the difference in the number of preschool children accounts for 80 percent of the difference in the fixed costs of working between working and nonworking women. Education has a positive effect on the annual costs of participation. An additional year of education increases the annual costs of work by over $100. Michael (1973) and others have argued that education raises nonmarket production. If so, then one might expect that more educated women would have better allocative skills, and hence lower costs of entry. However, there are other factors which would tend to produce a positive relationship between education and the costs of participation. More highly educated women live in higher income households which tend to locate further from central business districts than low-income households (see Kain, 1962 and Muth, 1969). Thus transportation costs would be higher for more educated women. Also, more highly educated women attach a higher value to their nonmarket time, and hence place a higher value on a given amount of time lost in entering the market.

The assumed form of the labor supply function, in particular, hours as a linear function of log wages is one commonly used to estimate labor supply functions of married women. It would be of interest to know whether allowing for a discontinuity in the market supply function results in parameter estimates that differ from those of this conventional formulation. To aid in characterizing the restrictions implied by the conventional model, return for the moment to the empirical model (equations (10) - (12)). Under the assumption of no costs of participation, reservation hours (h_R) are identically zero for all observations. Thus, equation (11) is eliminated from the model and the restricted model becomes

$$(24) \qquad h_i = \gamma_0 + \gamma_1 N(W_i) + \gamma_2 Y_{H_i} + \gamma_3 C_{3_i} + \gamma_4 E_i + \gamma_5 A_i + \varepsilon_{0_i}$$

$$(25) \qquad N(W_i) = \alpha_0 + \alpha_1 E_i + \alpha_2 X_i + \alpha_3 U_i + \alpha_4 A_i + \alpha_5 WE_i + \alpha_6 N_i + \varepsilon_{2_i}$$

Equation (24) may be expressed in a slightly different form to yield the wage at which the woman would be willing to supply a given amount of labor. This form of the labor supply function, termed the shadow wage function, is given by

$$(26) \qquad N(W_{s_i}) = \frac{-\gamma_0}{\gamma_1} + \frac{1}{\gamma_1} h_i - \frac{\gamma_2}{\gamma_1} Y_{H_i} - \frac{\gamma_2}{\gamma_1} C_i - \frac{\gamma_3}{\gamma_1} E_i - \frac{\gamma_4}{\gamma_1} A_i - \frac{\varepsilon_{0_i}}{\gamma_1}$$

Equations (25) and (26) characterize the conventional model. This model was first proposed by Heckman (1974a). Without detracting from Heckman's contribution, note that it imposes two restrictions relative to a model that allows for costs of entry. First, it imposes the restriction of continuity in the supply function for all hours. Second, it imposes a proportionality relationship between the parameters of the labor supply and reservation-wage equations. The reservation-wage equation is defined as the shadow-wage equation (25) at zero hours of work. Each parameter is proportional to the corresponding parameter in the hours of work equation with the factor of proportionality being the slope of the labor supply function.[1]

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[1] It should be pointed out that this restriction is relaxed by Heckman in the generalized version of the model which he proposes in his 1974b paper.

If entry costs are important in the data, one would expect the estimates of the conventional model to systematically exceed in absolute value those of the entry cost model. To see this, consider the graph in Figure 3. In this graph, h_T represents the "true" labor supply function when there are costs of participation. The existence of fixed costs is reflected by the discontinuity at the reservation wage. A constraint of zero costs of entry in the model implies a constraint of continuity in the labor supply function, i.e., that the height of the labor supply function at its origin (the shadow price of time as full-time leisure) equals the reservation wage. Imposing this constraint on data which has at least some nonworkers will result in an estimated labor supply function that looks like h_E and the effect of the wage on hours of work will be overstated. This result will, in general, hold for all estimated parameters.

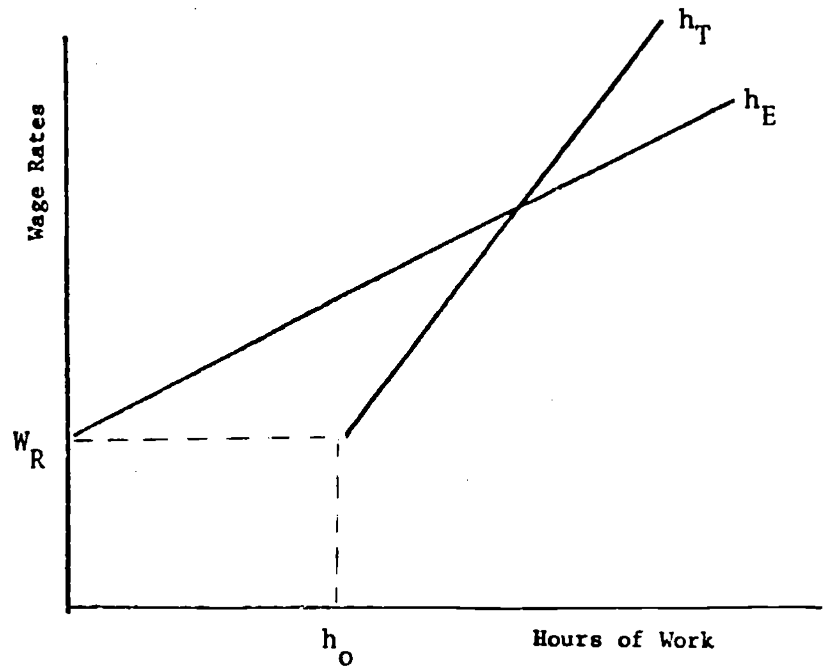

Figure 3

To determine whether the two models lead to important differences in parameter estimates, Heckman's (1974) maximum likelihood procedure was applied to the data to estimate the parameters of the conventional model. This estimate along with those of the entry cost model are provided in Table 4. Differences in estimated parameters are both systematic and large.[1]

Table 4

Hours of Work Function[a]

Variable	Entry Cost Model	Conventional Model
Constant	2158.691 (510.43)	3872.9037 (510.11)
Log wife's wage	1210.906 (185.49)	3357.0092 (212.43)
Wife's education	-91.545 (18.36)	-199.4556 (28.69)
Husband's earnings	-22.425 (9.07)	-92.8 (14.48)
Children 0-6 years old	-120.41 (52.89)	-628.7724 (65.18)
Wife's age	.468 (8.46)	-40.0193 (12.95)

[a]Standard errors are given in parentheses.

[1]In Figure 3, the intercept of the estimated labor supply function (the estimated reservation wage), is drawn so that it equals the true reservation wage (W_R). In reality, it is not clear whether the conventional model will lead to an over or under estimate of the reservation wage if both time and money costs are present.

The estimated wage coefficient is almost three times as large in the conventional model, the education coefficient twice as large, the husband's earnings coefficient four times as large, the children coefficient five times as large, and the age coefficient one hundred times as large.

To further assess the comparability of the two models, some additional statistics were computed. Both the conventional model and the entry cost model jointly estimate the probability of working and hours of work among the workers. The sample labor force participation rate is .491. The estimated mean probability of working with our proposed procedure is .494, while that of the conventional model is .52. Using a 50 percent rule, the proportion of successful predictions of labor force status with the fixed cost model is .718; with the conventional model it is slightly higher, .725. Thus, the two approaches appear to predict the work-not work decision equally well.

To compare the relative accuracy of the two models in predicting hours of work, the sum of squared deviations of actual hours of work from predicted hours of work for the subsample of labor force participants was computed. The sum of squared deviations for the conventional model is four times as large as that for the entry cost model.

To make a final assessment on the comparability of the two models, consider the graph in Figure 4 of the labor supply functions estimated with the two models. Let $\bar{W}$ be the wage at which the labor supply functions estimated from the two models intersect one another. If nonzero reservation hours are important in the data, the conventional model would be expected to underpredict hours of work among the workers with wages below $\bar{W}$ relative to the entry cost model. The reverse should be true for workers with wages above $\bar{W}$. For wages below $\bar{W}$, the mean residual (actual minus predicted)

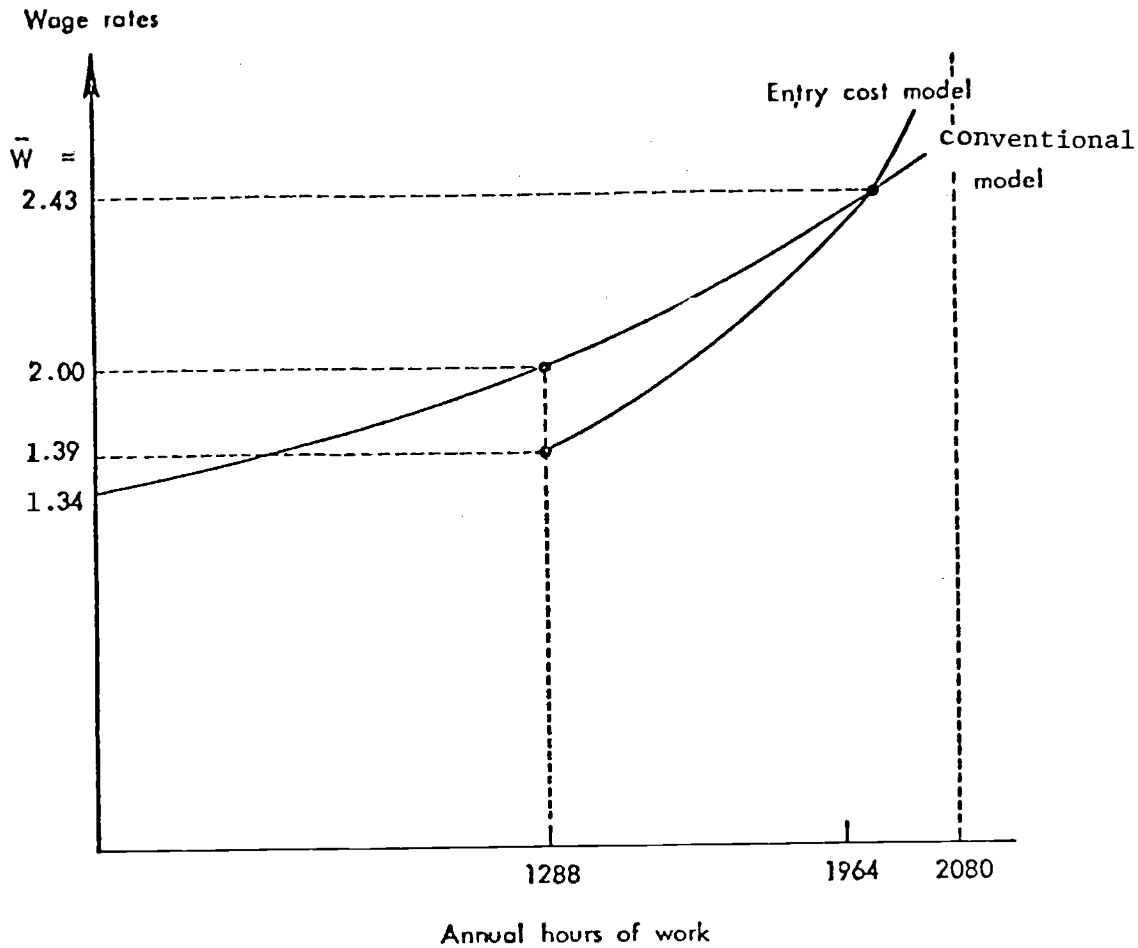

Figure 4. Average married women's estimated labor supply functions

for the entry cost is +70.6; for the conventional model, it is +1293.3. For wages above $\bar{W}$, the entry cost yields a mean residual of -729.8, and for the conventional model it is -1379.6.

These comparisons indicate that the conventional model is misspecified relative to the entry cost model. It is tempting to conclude that the misspecification arises because fixed costs of labor market entry are ignored. However, this is not necessarily correct. It might be that fixed costs of entry are unimportant in generating observations on hours of work and that labor supply functions are nonlinear; being relatively flat at low wages and relatively steep at high wages. If so, allowing for a discontinuity might provide a good approximation to the relatively flat portion of the supply function. Hence, it might give the appearance of the importance of fixed costs of entry when, in fact, these costs are unimportant. The point is that without observable data on fixed costs, evidence of their effects can only be obtained indirectly and, as a consequence, results of tests for their existence may depend crucially on the assumed functional form of the labor supply equation. However, regardless of whether or not fixed costs are important in generating the data, the conventionally used labor supply function for married women is misspecified. It is likely that the rather large own-wage elasticities estimated for these women reported in earlier studies is a direct result of this misspecification.

V. CONCLUSIONS

The major conclusion drawn from the analysis presented in this paper is that costs of labor force participation, measured both in terms of their estimated dollar amount and their estimated effects on labor supply behavior, appear to be important, at least in the demographic group analyzed here. For the average woman in the data the costs of work amount to approximately 28 percent of annual earnings. These costs impart a discontinuity in the average woman's labor function of almost 1300 hours per year, which is larger than half-time work. Also, differences in the number of preschool-age children in the home appear to be a major factor contributing to these costs and account for virtually all the difference between the costs of work facing working and nonworking women. From the comparisons of estimators, there is evidence that the conventionally used empirical model of labor supply which ignores fixed costs leads to substantial overestimates of the true labor supply parameters.

These conclusions must be qualified somewhat. Estimation of the costs of work requires extrapolation of the compensated labor supply function from the level of the discontinuity to the origin. In this region there are relatively few observations. It is also not clear how sensitive the costs estimates are to the function form chosen. Serious consideration should be given to these issues before attaching too much weight to the estimates of the annual costs of work. Also, the model assumes that women can freely choose and vary their hours of work. Yet, casual empiricism suggests that there may be minimum hours of work constraints imposed by employers for many types of jobs. The large constant term in the reservation hours function may primarily reflect these constraints rather than the effects of fixed costs of work in the supply side.

APPENDIX

The data used for the empirical analysis was taken from the National Longitudinal Survey of Mature Women. The NLS data file consists of five annual surveys of a multi-stage probability sample of women aged 30-44 in 1966. In this study only the information contained in the first interview (1967) was used. The basic sample drawn from the 1967 survey consisted of approximately 2700 observations on white households in which both the husband and wife were present. Given the problems of separating reported income into the return to labor and capital for individuals who are self-employed or owned a farm, households in which either spouse reported being self-employed were dropped from this basic sample. After these exclusions about 2300 observations remained. Further exclusions (360 observations) were made because of missing or incomplete information on the core variables of this study, such as income, age, education, etc. Finally, an additional 110 observations on households in which the husband performed no market in 1966 were dropped from the sample.

The remaining sample used for the empirical analysis consisted of 1829 households. Of these, 898 contained wives who worked at some time during 1966 and 931 who did not. Table A.1 provides the means and variances of all the variables used in our empirical analysis.

Table A.1

Sample Statistics

Variable	Households with Working Wives: Mean	Households with Working Wives: Variance	Households with Nonworking Wives: Mean	Households with Nonworking Wives: Variance
Urban	.4788	.2496	.4919	.25
North	.5089	.2499	.5188	.25
West	.1971	.1582	.2050	.163
Experience	9.46	41.29	4.33	22.8
Wife's education	11.496	6.00	11.23	6.54
Wife's hours of work	1368.3	$.604\times10^6$	-	-
Wife's wage rate	2.00	3.92	-	-
Wife's age	38.40	18.59	37.74	19.28
Number of children 0-6 years old	.326	.404	.787	.806
Number of observations	898		931	

Definitions of Variables

Urban — dummy variable which assumes a value of one if the household resided in a city of over 250,000 in 1967.

North — dummy variable which assumes a value of one if the household resides in the Northeast or North central states as defined by the Census.

West — dummy variable which assumes a value of one if the household resides in the western states as defined by the Census.

Experience — number of years up to 1966 since marriage that the woman worked at least six months.

Wife's education — number of years of education completed by the wife.

Wife's wage rate — calculated by dividing earnings in 1966 by annual hours of work in 1966.

Wife's hours of work — weeks worked in 1966 multiplied by usual number of hours worked per week.

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