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ABSTRACT

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Taxes in a Labor Supply Model With Joint Wage-Hours Determination

by

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TAXES IN A LABOR SUPPLY MODEL WITH JOINT WAGE-HOURS DETERMINATION

BY HARVEY S. ROSEN[1]

Using cross-section data on white married women for the year 1967, a model of labor supply which permits statistical estimation of a "coefficient of tax perception" is studied. The model allows for the possibility that the wage may depend upon the number of hours worked. The results suggest that marginal tax rates have an important impact on labor market behavior.

1. INTRODUCTION

PAYROLL AND PROGRESSIVE INCOME taxes play an enormous role in the American fiscal system. It is therefore of some importance to know the extent to which they influence work incentives. The purpose of this study is to present some econometric evidence on the effects of taxes on married women, a group of growing importance in the American labor force.[2] A testable model of labor supply is developed which permits statistical estimation of a "coefficient of tax perception." Unlike previous models of labor supply, it allows for the possibility that the wage may depend on the number of hours worked. Contrary to much of the literature, the results of this paper strongly suggest that marginal tax rates do have an important impact on labor force behavior.

This section reviews briefly the past thought on this problem. Section 2 develops a model to explain work decisions when an individual faces a whole set of wage-hour combinations, rather than a given wage independent of the number of hours he works. In Section 3 this model is modified to permit an explicit test of whether or not taxes affect individuals' labor supply decisions. Estimation problems are discussed at length, and the empirical results are presented. A concluding section contains a summary and suggestions for future research.

Past Treatment of Taxes

Theoretical analyses of labor supply describe individual work decisions as the outcome of maximizing utility subject to a budget constraint based on the net wage (see, for example, [**8** and **19**]). A change in the tax rate facing an individual changes his net wage, but due to the fact that the income and substitution effects work in the opposite direction, the outcome of the change is logically indeterminate.

[1] I would like to thank M. Feldstein for his many valuable comments. I have also received useful suggestions from R. Freeman, S. Rosen, and two referees. Most of this work was completed under a dissertation grant from the Manpower Administration of the United States Labor Department.

[2] For a concise survey of the economic role of women in United States society, see the *Economic Report of the President*, 1973.

Since the impact of taxes cannot be determined by theory alone, a number of attempts have been made to gauge the effect empirically. In one type of such attempts, personal interviews are used to infer whether or not taxes influence work behavior. Perhaps the most frequently cited of these is Break's [6] survey of a group of British solicitors and accountants who were either partners or in business on their own. Some of Break's questions dealt with how the individuals determined their hours of work, whether they were aware of the marginal tax rates they faced, and if these marginal tax rates created any incentives or disincentives to work. Break's analysis of the responses suggested to him that "... disincentives, like the weather, are much talked about, but relatively few people do anything about them" [**6**, p. 549]. From this he drew the policy implication that "... in the United States, at least, income tax rates could be raised considerably ... without lowering unduly the aggregate supply of labor" [**6**, p. 549].

The study of Barlow, Brazer, and Morgan [**2**] tells much the same story. In their sample of affluent Americans, "Only one-eighth ... said that they have actually curtailed their work effort because of the progressive income tax .... Those facing the highest marginal tax rates reported work disincentives only a little more frequently than did those facing the lower rates" [**2**, p. 3].

It seems that some caution must be exercised in the interpretation of these survey results. Just because an individual cannot recite his marginal tax rate does not mean that he is unaware of the discrepancy between his gross and take-home pay. And the fact that individuals fail to admit that taxes (or, for that matter, other economic variables) enter their work decisions does not mean that it is necessarily true. Nevertheless, the survey results appear to have been quite influential. For example, in Pechman's important book, *Federal Tax Policy* [**21**], one is left with the impression that "The evidence suggests that income taxation does not reduce the amount of labor supplied by workers and managers" [**21**, p. 63].[3] Similarly, Lipsey and Steiner's [**18**] widely used text states that "Such meager evidence as exists ... goes against the commonly held view that a lowering of the existing levels of taxes would greatly increase the supply of effort in our economy" [**18**, p. 338].

Our discussion so far has dealt with the impact of taxes on labor supply in general. When we turn attention to the focus of this study, married women, the survey results yield the same basic conclusions. Barlow, et al. [**2**] observe that "Very few (men) reported that their wives' participation in the labor force ... was affected by taxes" [**2**, p. 3]. When asked why a wife who had once been in the labor force was no longer working, "... there were virtually no references to tax disincentives ..." [**2**, p. 148]. Although it was noted that at the highest incomes women tended to work less, no part of this phenomenon was attributed to high marginal tax rates. Rather, the responses indicated that these wives "... felt more free to occupy themselves with voluntary unpaid activities" [**2**, p. 149]. All of this is somewhat more surprising for married women than for men because United States tax laws may be viewed as placing a large burden on the earnings

[3] It should be noted that Pechman surrounds this statement with a number of qualifications

of married women. When a married couple chooses to enjoy the tax advantages of filing jointly, the first dollar earned by the wife is in effect taxed at the same marginal rate as the last dollar earned by the husband.[4]

When we examine the more econometrically oriented literature on the labor force behavior of married females, we find that its economic and demographic determinants have been studied intensively, but not enough attention has been focused on possible tax effects.[5] In his important study of the labor force behavior of married women, Cain [7] notes that "Despite the progressive income tax ... work rates of wives have risen rapidly and steadily since 1940." He finds this observation sufficient reason for assuming that taxes have not had a discouraging effect, so that it can be assumed that "... the income tax rates apply symmetrically to both husband's and wife's earnings, and that this rate is proportional to family income" [7, p. 19]. Despite this cognizance of the existence of taxes, the distinction between net and gross earnings is not made in the empirical analysis [7, p. 123].

Bowen and Finegan [5] follow an indirect and complicated procedure to ascertain the impact of taxes on labor force participation. Making certain simplifying assumptions, they find the differential effect of the level of other family income on the amount of tax on the wife's earnings. Having thus calculated the change in earnings due to the tax, they multiply it by a regression coefficient showing the effect of a difference in earnings on labor force participation. This regression coefficient is from an intercity regression using aggregate data [5, p. 580]. From this analysis, Bowen and Finegan conclude that the effect of taxes on the negative relationship between participation and other family income can, for all practical purposes, be regarded as "non-existent" [5, p. 138].

The studies of Hall [12] and Kosters [16] contrast favorably with those mentioned above in that their analyses relate labor supply to wages net of the marginal tax rate. However, this procedure takes the proposition that workers react to the net rather than the gross wage as a maintained hypothesis. No test of this hypothesis is ever offered.

It seems, then, that a curious dichotomy has developed in the literature. The survey interview studies leave one with the feeling that taxes do not matter very much, implicitly seeming to suggest both very small uncompensated supply elasticities and lack of tax perception. The most recent econometric studies ignore the latter finding and *assume* that individuals react to taxes with perfect rationality. In succeeding sections we try to develop a model which provides a framework for investigating the actual extent of "tax illusion."

[4] It could, of course, be argued that tax laws have a large impact on the "second earner," not necessarily the wife. However, in this paper we follow the reasoning of Bowen and Finegan: "It seems reasonable to suppose that in most families the (potential) earnings of the wife are more 'marginal' than the earnings of the husband and that the marginal tax rate to which the family is subject is therefore viewed as being particularly applicable to the wife's earnings" [5, p. 136].

[5] See, for example, Bowen and Finegan [5], Cain [7], and Hall [12]. It is not my purpose here to give a comprehensive summary of the recent empirical literature on labor supply. This has been done already by Rea [22, p. 81]. I merely want to indicate typical ways in which taxes are handled.

2. SIMULTANEOUS WAGE-HOURS DETERMINATION FOR AN INDIVIDUAL

The first step in determining the impact of taxes on labor supply is to construct a theory of how work decisions are made. In the standard theory of labor supply, the individual faces a wage which does not vary with the number of hours worked (except for the case of overtime). (See, for example, [**13** and **23**].) In other words, if an individual's utility is a function of income and leisure, then his budget constraint is a straight line whose slope is the wage.

However, it is not at all clear that the gross wage is independent of the number of hours worked. If we imagine the possibility of different markets for jobs with varying numbers of hours, there is no reason to expect that these markets will clear at the same wage. If, for example, relatively more people want to work part time than full, we would expect, ceteris paribus, the wage for full-time workers to be higher than those for part time. A *Wall Street Journal* article of March 7, 1973 suggests the existence of just such a phenomenon: "... the supply of people who want to work part of the day vastly exceeds the demand even though demand is rising rapidly" [**29**, p. 1]. A glance at Figures 2.1 and 2.2 suggests that these sorts of considerations may be very important for married women. Figure 2.1 is a histogram for usual hours of work per year for the individuals in our sample.[6] Figure 2.2 is the same for hours per week. Clearly, a nontrivial amount of part-time working is occurring. Thus, a theory of the labor supply of married women which fails to take into account possible relations between hours worked and the wage may be deficient.

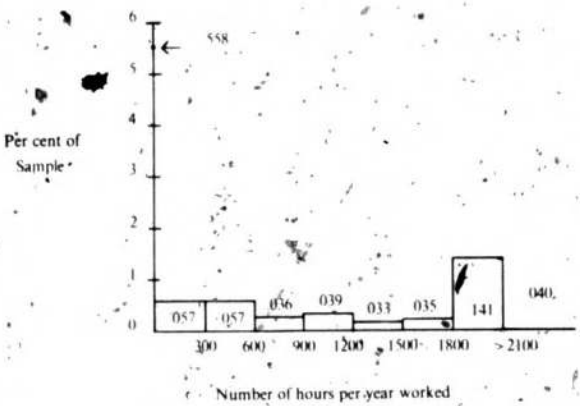

FIGURE 2.1

[6] The source of data will be described in the next section.

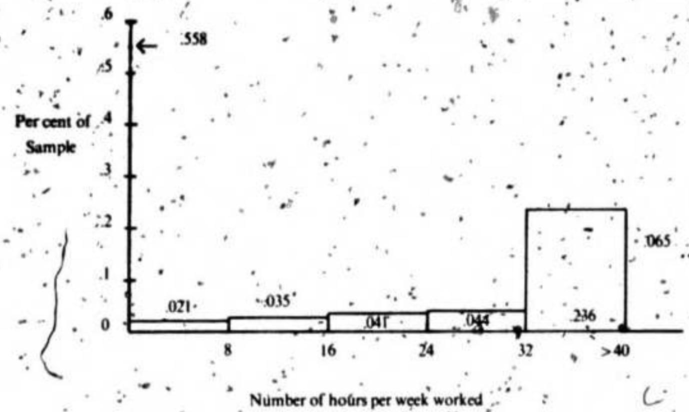

FIGURE 2.2

The Lewis Model

Of course, none of this constitutes a theoretically sound explanation for why the wage might vary with the number of hours of work. Such a rationalization has been provided by H. G. Lewis [17]. What follows is essentially a summary of his analysis which is included here because Lewis' paper is as yet unpublished in English.[7] The key to why the wage might vary with hours worked is the fact that "...employers commonly are not indifferent with respect to the hours of work of their employees" [17, p. 5]. For example, their employment offers often include restraints on the choice of hours, and frequently they ask laborers to work overtime.

Such phenomena are unexplained by the usual treatment of demand for a factor because it ignores quasi-fixed labor costs, i.e., those costs associated with the employment of labor which do not vary with the amount of output (e.g., costs of putting an individual on the payroll, job-training costs, etc. (see [20])). Once we admit to the existence of the quasi-fixed labor costs, it can be shown that the assumption of independence between the wage and hours worked leads to absurd results. To demonstrate this, first note that the employer's cost of employing the ith worker (C_i) is $C_i = w_iH_i + v$, where w_i is the gross wage of the ith worker, H_i is the hours worked by the ith worker, and v is the quasi-fixed labor cost associated with the worker, assumed to be constant across workers. If we let n equal the number of workers and $\bar{H}$ be the average number of hours per worker, then the employer's total labor cost per unit of labor input ($\bar{C}$) is $\bar{C} = w + (v/\bar{H})$. Under the assumption that cost per unit of labor input is to be minimized, the solution

[7] This section draws upon the unpublished English version, "Employer Interests in Employee Hours of Work" (undated).

is to set $\bar{H} = H_i$ (all i) = total time in the period. This result is absurd, and the absurdity stems from the assumption that w is independent of H. A more reasonable result is obtained by assuming that instead of a wage independent of hours, there is a whole locus of possible wage-hour combinations, $w = w(H)$. Lewis calls this the "market equalizing wage curve," but we shall refer to it simply as the wage-hours locus (WHL). Just as in the standard analysis the firm and laborers take the wage as given, here they take the WHL as a given. And just as in the standard analysis the wage depends on the familiar set of characteristics that determines productivity, so does the value of the wage at any particular number of hours of work depend on the same characteristics. It can be shown that given the assumptions which have been made thus far, in order for the cost-minimizing selection of a wage-hours combination to be a noncorner solution, the wage-hours locus must slope upward: $w'(H) > 0$.

The important result that has been established is that one cannot expect the wage to be independent of the number of hours worked.[8] Indeed, if the existence of quasi-fixed labor costs is the only wrinkle added to the standard model, then we can unambiguously predict that the more hours worked the higher will be the wage. However, further complications to the standard analysis readily come to mind. For example, it is usually assumed implicitly that labor input per man-hour does not vary over the work period. However, one can imagine a model where at the beginning of the work period there are delays in getting started, and at the end there is fatigue, so that output per hour is a function of amount of time worked. In other words, the elasticity of output with respect to number of workers need not equal the elasticity with respect to hours per worker.[9] Such a consideration also suggests that the wage will depend upon number of hours worked, only there is now no assurance that $w'(H)$ is always positive. The point to be emphasized is that there are good reasons to expect that the wage will depend on hours of work, although there is no a priori way of knowing the exact form of the relation.

Supply of Labor in the Presence of a Wage-Hours Locus

Our principal problem is to re-interpret the standard theory of labor-leisure choice when the individual faces, not a given wage, but a given locus of wage-hours combinations.[10] Consider, then, a married woman whose utility is a function of consumption,[11] nonmarket activity, and other variables, $U = U(C, H, Z)$ where C is consumption, H is hours of work, and Z is a vector of m parameters which influence the tradeoff between income and nonmarket activity (e.g., number of

[8] An approach complementary to that of Lewis is viewing the problem in the framework of the theory of equalizing differences. See S. Rosen [25].

[9] Feldstein [9] examines a model in which a number of workers and output per worker enter a Cobb-Douglas production function as separate arguments. Using British data, he finds that the elasticity of output with respect to hours substantially exceeds that with respect to men. See Barzel [3] for further arguments along this line.

[10] In this paper we do not discuss the demand for labor in the presence of a wage-hours locus. See H. Rosen [24, pp. 14–16] for a sketch of some considerations which would enter such a discussion.

[11] Note that in this model, the distribution of consumption among members of the family unit is not determined.

pre-school children). This utility function is to be maximized subject to the budget constraint: $C = w(H, X) \cdot H \cdot [1 - T(H, X)] + Y$ where $w(\cdot)$ is the WHL, H is the number of hours worked, X is a vector of n characteristics which determine the value of the WHL at any given number of hours (e.g., years of education), $T(H, X)$ the average tax rate at H hours of work, and Y is net nonlabor income plus husband's earnings. It is important to note that in this formulation of the problem the husband's income-leisure decision is assumed to be given and there are no cross-substitution effects; the wife's behavior is determined conditional on that of the husband, whose work effort for simplicity can be thought of as institutionally determined.[12] There are countless other complications which can be—and have been (see, for example, [4])—added to this basic model as, for example, making the husband's work effort endogenous or breaking up nonmarket activity into its components and analyzing them separately. It is hoped that the simple model provides an adequate framework for the issues of this paper.

Diagrammatically, the utility maximization process takes place as pictured in Figure 2.3. OC is the level of other family income, net of tax. Curve CD shows

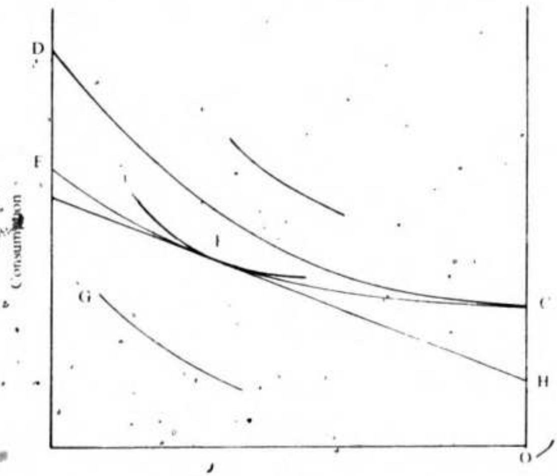

FIGURE 2.3

income as a function of hours of work on the assumption that $w(H, X)$ is increasing in H. In the presence of a progressive tax, however, the relevant constraint is CE, which is derived by subtracting from each point of CD the amount of tax paid by the wife when she works the corresponding number of hours.

[12] This should not be interpreted as an assertion that taxes have no impact on the work behavior of married males. Other dimensions of labor supply such as years of education, occupational choice, and time of retirement may very well be influenced by the tax system.

To complete the analysis we must introduce the individual's preferences. Three typical indifference curves are depicted in the diagram. Utility is maximized at a point like F where the indifference curve labeled i is tangent to CE. Several points must be made in regard to the characterization of this equilibrium:

(i) The necessary condition for utility maximization is that the slope of the indifference curve equal the slope of the budget constraint. The slope of the budget line is equal to net marginal earnings which, in the standard case, is equal to the net wage. However, with a WHL, marginal earnings and the wage are no longer equal:

$$\frac{dE}{dH} = \frac{d[H \cdot w(H)]}{dH} = Hw'(H) + w(H) \neq w(H),$$

where E is earnings.

(ii) Unlike the standard model in which the budget constraint is straight (or in the case of a progressive tax, where the budget constraint has a negative second derivative), it is not sufficient for a utility maximum that the indifference curves be convex. Rather, we require the more stringent assumption that the curvature of the indifference curve be "sharper" than that of the budget line. That is, the second derivative of the indifference curve must be greater than that of the budget constraint.[13]

(iii) We can imagine constructing a straight line GH tangent to indifference curve i at point F. As far as the behavior of the individual is concerned, the budget line might just as well be GH as curve CE; they yield identical predictions. Note, however, that although line GH has the same slope as curve CE at point F, it has a different intercept. This fact will become important in the empirical analysis.

The results of this section can be summarized conveniently in several equations. The individual's market opportunities are given by her wage hours locus:

(1) $$w = w(H, X).$$

The number of hours she chooses to work is that H which will maximize utility subject to the constraint implied by (1):

(2) $$\max_{H} \{U(C, H, Z) + \lambda[C - w(H, X) \cdot H \cdot [1 - T(H, X)] - Y]\},$$

where λ is the Lagrangian multiplier. We turn now to the problem of investigating this system empirically.

3. ESTIMATION

In this section we discuss the problems involved in putting the system composed of (1) and (2) into estimable form. In the process of doing so, we are able to formulate a test for whether or not married women correctly perceive the marginal tax rates they face. The model is estimated by several different techniques and the results strongly suggest that it is *net* marginal earnings which matter in the work decision.

[13] We assume a unique solution.

Data

The data for this study are from the *1967 Survey of Work Experience for Women 30 to 44*, collected by the United States Department of Labor under the direction of Professor Herbert S. Parnes and his collaborators at The Ohio State University. The survey data and design are described in Manpower Research Monograph No. 21 [**28**]. These data are a rich source of information about the labor force behavior of mature women. The survey reports some data which were unavailable to earlier researchers.[14] Unfortunately, the survey was lacking information on such variables as the state of residence and the amount of capital gains income, data which would have been useful in making better estimates of the marginal tax rates.

For our equations, only the data for white married women not in families receiving public assistance are used, a sample of 2,545 observations. The labor effort of public assistance families probably merits separate investigation.[15]

Problems in Estimation

In order to estimate the model, specific functional forms must be given for equations (1) and (2). For equation (1), the only problem is selection of a suitable representation for the WHL. However, the solution for H implied by (2) is too complicated to serve as a framework for empirical testing. A useful approximation is provided by reference to the discussion surrounding Figure 2.3 above. There it is made clear that the budget constraint can be characterized by two parameters, the slope of the line tangent to the indifference curve at equilibrium (i.e., net marginal earnings), and the intercept of this line. Hours of work, then, is a function of these two parameters and the characteristics which influence the shapes of the indifference curves.

After some experimentation the following functions were selected to describe the behavior of the jth individual:[16]

(3) $$\ln w_j = \beta_1 H_j + \sum_{i=2}^{n+1} \beta_i X_{ij} + u_j,$$

(4) $$H_j = \delta_1 (1 - t_j) ME_j + \sum_{i=2}^{m+1} \delta_i Z_{ij} + \varepsilon_j,$$

[14] For example, there is information on the number of years in and out of the labor force over the individual's life.

[15] This approach is also taken by investigators like Hall [**12**]. There is, however, some evidence in a study by Hurd [**14**, pp. 8, 10] that the exclusion of families on public assistance is not likely to influence the estimation of parameters very much.

[16] Equation (3) imposes monotonicity on the WHL, although it does not impose the direction of the monotonicity. A more restrictive functional form which was tested constrained the relation between earned income (E) and hours to an S shape:

$$E_j = \beta_1 \ln(1/H_j) + \sum_{i=2}^{n+1} \beta_i X_{ij} + u_j.$$

It did not fit the data as well as (3).

where ME_j is marginal earnings ($\equiv \partial(w(H, X) \cdot H)/\partial H$), t_j is the marginal tax rate, u_j and ε_j are random errors, and the Z_i's have been redefined in order to include the income variable, adjusted to account for the linearization of the budget constraint.

Given the inverse semi-logarithmic WHL of (3), we can derive a specific algebraic expression for ME_j:

$$ME_j = \frac{\partial(e^{\Sigma \beta_i X_{ij}} e^{\beta_1 H_j} \cdot H_j)}{\partial H_j} = e^{\Sigma \beta_i X_{ij}}(\beta_1 H_j e^{\beta_1 H_j} + e^{\beta_1 H_j})$$
$$= e^{\Sigma \beta_i X_{ij}} e^{\beta_1 H_j}(\beta_1 H_j + 1).$$

As the system currently stands, it allows no test of the hypothesis that net rather than gross marginal earnings are important in the work decision. Just as in the Hall and Kosters papers [**12** and **16**] referred to in Section 1, rational perception of taxes is a maintained hypothesis. But consider changing (4) slightly and writing it as follows:

$$(4') \qquad H_j = \delta_1(1 - \rho t_j)ME_j + \sum_{i=2}^{m+1} \delta_i Z_{ij} + \varepsilon_j.$$

The only difference between (4) and (4′) is the inclusion of a parameter ρ which multiplies the marginal tax rate. We can interpret ρ as a coefficient of tax percention. In the studies which ignore marginal tax rates, it is implicitly assumed that $\rho = 0$. For those who assume that individuals react to net marginal earnings, the assumption is $\rho = 1$. We propose to estimate ρ without constraining it to either of these values. This is done by rewriting (4′) as,

$$(4'') \qquad H_j = \delta_1 ME_j - \delta_1 \rho(t_j ME_j) + \sum_{i=2}^{m+1} \delta_i Z_{ij} + \varepsilon_j.$$

An estimate of ρ is obtained by dividing the coefficient of $t_j ME_j$ by the coefficient of ME_j and multiplying by minus one: $\rho = -(-\delta_1 \rho/\delta_1)$.

The following are the X_i of equation (3); they are the variables which determine the gross hourly wage[17] an individual can earn at any given number of hours worked:[18] $ED1_j = 1$ if the respondent completed high school; $ED2_j = 1$ if the respondent's education extended beyond high school; $TRAIN_j = 1$ if the respondent had on-the-job training; $CITY_j = 1$ if the respondent was employed in a standard metropolitan statistical area; $AGE1_j = 1$ if the respondent's age was between 35 and 39; $AGE2_j = 1$ if the respondent's age was between 40 and 44; $EXP1_j = 1$ if the respondent's years in the labor force were greater than 5 and less than 16; $EXP2_j = 1$ if the respondent's years in the labor force were greater than or equal to 16; $VOCA_j = 1$ if the respondent attended a vocational training school; $HEALT_j = 1$ if the respondent's health affects the type of work taken;

[17] Respondents were asked to state their wages and the unit of time over which their wages were paid (e.g., hourly, daily, weekly, etc.). The hourly wage was calculated by dividing the wages figure by the number of hours in the appropriate unit of time.

[18] The following convention is used to define dichotomous variables: "$Z_i = 1$ if β" means Z takes the value of one if β is true for individual j, and zero otherwise.

$INC1_j = 1$ if other family income is greater than \$1,500 and less than \$3,000;
$INC2_j = 1$ if other family income is greater than \$3,000 and less than \$5,000;
$INC3_j = 1$ if other family income is greater than \$5,000 and less than \$10,000;
$INC4_j = 1$ if other family income is greater than \$10,000 and less than \$20,000;
$INC5_j = 1$ if other family income is greater than \$20,000.

Of the variables included, all but the income variable seem obvious candidates for explaining the level of the individual's wage. Other family income may proxy the "type" of job chosen by the wife—an individual whose family's income is high may, ceteris paribus, choose a less arduous job than one whose family's income is lower, and therefore, according to the theory of equalizing differences, have a lower wage. On the other hand, income may be an additional way to control for "quality" of the individual—husbands with high incomes may marry or be married to "high quality" wives.

The Z_i of equation (4″) include the following variables: $CHILD1 = 1$ if the respondent has 1 child under age of 6; $CHILD2 = 1$ if the respondent has 2 children under age of 6; $CHILD3 = 1$ if the respondent has 3 or more children under age of 6; AT[19] $= 1$ if the respondent's index of attitude toward women working is greater than 9; $HEALA = 1$ if the respondent indicates that health limits her amount of work; $INC1 = 1$ if other family income, net of taxes, is greater than \$1,500 and less than \$3,000;[20] $INC2 = 1$ if other family income, net of taxes, is greater than \$3,000 and less than \$5,000; $INC3 = 1$ if other family income, net of taxes, is greater than \$5,000 and less than \$10,000; $INC4 = 1$ if other family income, net of taxes, is greater than \$10,000 and less than \$20,000; $INC5 = 1$ if other family income, net of taxes, is greater than \$20,000.

In regard to this formulation, it should be noted that variables such as age and education do not appear. It has been suggested that such variables explicitly belong in this equation because they may proxy attitudes toward work [7, p. 22]. However, since the data for this study already include an index of attitudes toward work, this is not done.[21]

A major problem in the estimation of our system is that for individuals absent from the labor force, the wage cannot be observed. In order to deal with this problem we adapt a technique which has been developed by other investigators (see, for example, [**12** and **22**]): fit the wage-hours locus for the individuals who work, and use this function to impute wages to the non-workers.[22] The question

[19] The attitudinal index rates attitude towards women working on a scale of 3 to 15. It is constructed on the basis of responses to questions dealing with the propriety of women working in the presence or absence of their husbands' approval.

[20] Net other income is defined as gross other family income times one, minus the average tax rate on other family income. Before use in the hours equation, this figure is corrected for the intercept adjustment associated with the linearization of the budget constraint. The data were not sufficiently detailed to take account of the different tax treatments accorded to various types of income. In particular, there were no data on capital gains.

[21] It is, however, possible that age belongs in the equation because of life cycle considerations. (See Weiss [**30**, p. 311].) Therefore, the hours equation was also estimated with dichotomous age variables as regressors. This resulted in only minor changes in the other coefficients.

[22] Heckman [**13**] and Gronau [**11**] have shown that under certain circumstances this procedure may lead to a bias in the estimation of labor supply parameters. It is not clear what the effect of this bias would be on the *ratio* of ME to tME. When the equation was estimated for workers only, the estimate of ρ was largely unchanged. It might be of interest to re-do the analysis using Heckman's technique, although his normality assumption seems inappropriate.

of an appropriate estimation technique for the WHL thus arises. Since it is likely that u_j and ε_j are correlated, then H_j on the right-hand side of (3) is correlated with u_j, and ordinary least squares will yield inconsistent estimates. The wage-hours locus is therefore fitted by two-stage least squares, the instruments being the X_i and Z_i.

Turning now to equation (4″), the first difficulty to cope with is what value of ME_j to use; since net marginal earnings vary with the number of hours worked, at what number of hours should ME_j be evaluated? One's initial response might be that the actual number of hours worked is the appropriate measure. But this answer is faulty, as can be shown by reference to Figure 3. Consider two married

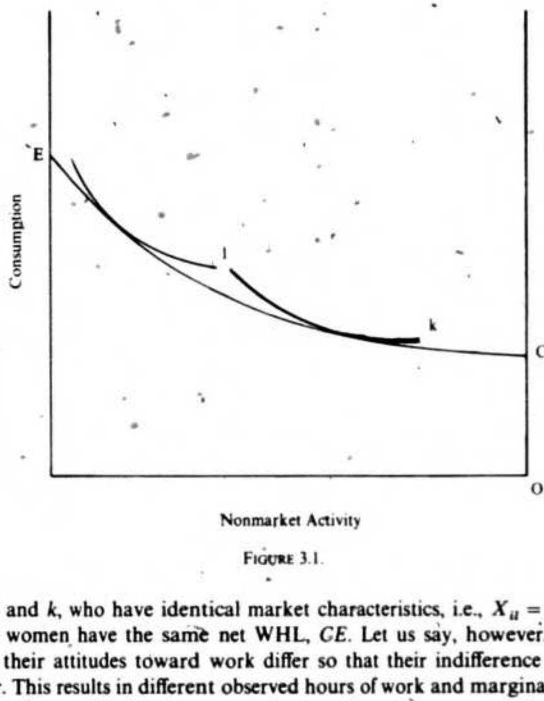

FIGURE 3.1.

women, l and k, who have identical market characteristics, i.e., $X_{il} = X_{ik}$, all i. Then the women have the same net WHL, CE. Let us say, however, that (for example) their attitudes toward work differ so that their indifference maps are dissimilar. This results in different observed hours of work and marginal earnings for the two women. Clearly, the net marginal earnings of l are greater than those of k, although they face the identical set of opportunities. Therefore, by indicating in equation (4″) that l is in some sense facing better opportunities than k is misleading and will bias the results.

Ideally, then, we would want to represent the whole opportunity locus in equation (4″). Since this cannot be done, the locus is approximated by evaluating net marginal earnings at some standard number of hours for all individuals in the sample. The hope is that the differences in net marginal earnings at this point will adequately represent differences in the wage-hours loci facing different individuals. Thirty hours per week and 1500 hours per year were selected as the standard number of hours at which marginal earnings and marginal tax rates were calculated.[23] Note that since the X_j are exogenous, and ME_j and $t_j ME_j$ are evaluated at a standard number of hours, there is no correlation between these variables and ε_j so that ordinary least squares may be used for estimation.[24]

There remains one more technical problem before we can estimate our system, the intercept adjustment associated with the linearization of the budget constraint. For each individual a lump sum amount must be added to net other family income.[25] Since the derivation of the formula for this lump sum is just an analytical geometry exercise with little economic interest, it has been relegated to Appendix A. The result proved there is that net other family income must be corrected by addition of the expression,

$$1500m - T_{1500} + H \exp\left(\beta_1 H + \sum_{i=2}^{n+1} \beta_i X_i\right)\Bigg|_{H=1500}$$

where T_{1500} is the amount of tax paid on the wife's earnings at 1500 hours, m is the slope of the budget constraint at the same point, and the other variables are as defined above.

To summarize the estimation procedure: The WHL (3) is estimated for the sample of women who work. The results of this equation are then used to construct marginal earnings for members of the entire sample. These are calculated at a standard number of hours (30 hours per week or 1500 hours per year). With these variables in hand, equation (4") can then be estimated by ordinary least squares.[26]

Results

Let us first consider the results for the WHL, shown in Table I. Estimation has been done for both hours per week and hours per year. The most striking result

[23] Income tax is calculated for each family on the assumption that the family files jointly and takes a standard deduction of ten per cent of adjusted gross income, with a minimum of $200 plus $100 for each exemption, and a maximum of $1,000. The personal exemptions are $600 for each, the husband, wife, and dependents. Payroll tax is also calculated. Results were not very sensitive to the choice of standard number of hours.

[24] There is, however, another reason why ordinary least squares may be inappropriate for the estimation of (4") which will be discussed in detail later in this section.

[25] This problem may be regarded from another point of view. Essentially we are trying to represent the budget constraint by two parameters, its slope and height at 1500 hours. However, since the convention in economics is to measure the height of the budget constraint at zero hours of work, we project the height at 1500 hours on the vertical axis by finding the vertical intercept of the budget line. This approach does not deal perfectly rigorously with the nonlinearity of the budget constraint; it induces some downward bias in the estimate of the response of hours to net marginal earnings.

[26] It should be noted that identification is achieved despite the absence of any variables in the WHL which are excluded from the hours equation. This is because there are specific constraints on the way the variables from the former appear in the latter. As Fisher [10] points out in his discussion of models which are linear in the parameters, identification can be achieved by putting constraints on how variables enter an equation, as well as by the usual exclusion methods. Similar considerations apply to our model.

to emerge from these equations is that in both cases the hours variable is positive and significantly different from zero. The weekly WHL indicates that, in our sample, a married woman who usually works one hour more per week than another will have a wage two per cent higher than her sister worker. From another point of view, consider a married woman who is working half time, 20 hours per week. A woman who works ten per cent more (22 hours per week) will be expected to have a gross hourly wage higher by more than four per cent.

TABLE I
THE WAGE-HOURS LOCUS
INVERSE SEMI-LOGARITHMIC SPECIFICATION

	Dependent Variables	
Independent Variables[a]	ln w	ln w
Hours per week	.02168*	
	(.01009)	
Hours per year		.0002403
		(.00009287)
ED1	.2235	.1562
	(.04976)	(.03714)
ED2	.4496	.3903
	(.04781)	(.04377)
AGE1	−.08119	−.09480
	(.02926)	(.03029)
AGE2	−.08170	−.08773
	(.02913)	(.02935)
TRAIN	−.002315	.02336
	(.04633)	(.03830)
CITY	05893	.06408
	(.02549)	(.02459)
EXP1	1751	.06856
	(02540)	(.04841)
EXP2	2474	.1214
	(04567)	(08232)
VOCA	.08077	.07760
	(02622)	(02622)
HEALT	−.08402	−.07405
	(.03692)	(.03658)
INC1	−.2277	−.1618
	(.08098)	(06977)
INC2	−.1123	−.05105
	(0.06596)	(.05635)
INC3	−.01117	.02163
	(.05321)	(.05120)
INC4	.1971	.1862
	(.06537)	(.06214)
INC5	.07009	.004803
	(1771)	(.1773)
Constant	−.4998	.03450
	(.3551)	(.1043)
S.E.E.	.336	.335

[a]For definitions of the variables, see Section 3. Numbers in parentheses are standard errors in this and all following tables.

A similar story can be told about the yearly wage-hours locus. A married woman who works 100 hours per year more than another can be expected to have a wage more than two per cent higher. Alternatively, a woman working 1100 hours per year can be expected to have a wage more than two per cent higher than one who works 1000 hours. It is not quite clear why the weekly WHL should yield a greater percentage change in the wage for a percentage change in hours worked than the yearly WHL. This is perhaps due to the fact that some individuals who work less than, say, 1800 hours per year, are not really "part time". They may be working full time in seasonal occupations. Nevertheless, it is clear that in both cases we are dealing with nontrivial magnitudes. Casual observations about the relationship of part-time work and wages seem to be borne out by the evidence: less work means a lower wage.

The signs of the other coefficients in the WHL generally accord with a priori expectations, although not completely. More education, employment in the city, length of time in the labor force, and prior attendance at a vocational school tend to increase the wage. Greater age and health affecting the type of job decrease the wage. The on-the-job training variable in both equations is insignificant, and in the weekly WHL it has the wrong sign. The income dummies show no particular trend and are insignificant, perhaps indicating that the different directions in which other family income may move the wages are approximately offsetting.

We turn our attention now to the estimates of the hours worked equations in Table II. Before examining the wage and tax variables, it is interesting to note that the coefficients of the other variables are generally as expected: (i) the more children under six years of age, the fewer the hours of work, (ii) women who have a favorable attitude toward the notion of women working tend to work more, and (iii) generally, an increase in other family income lowers the amount of work, although the relationship is not strictly monotonic. The health variable has an insignificant coefficient of the incorrect sign.

However, the novel aspect of these equations is the presence of the "tax rate times marginal earnings" variables. As was explained above, ρ can be calculated by dividing the coefficient of this variable by the coefficient of the wage and multiplying by negative one. The estimates of ρ so obtained are .72 for the weekly hours case and 1.11 for the yearly hours case. Given the fact that such rough approximations had to be made in the calculation of the marginal tax rates (see footnote 23), it seems quite remarkable that the estimates are so close to unity. In particular, both estimates are within one standard deviation of one, and for the hours per year equation, it is more than two standard deviations away from zero.[27] (For the hours per week equation it is about 1.6 standard deviations away from zero.)

Lest there be a possibility that these results are the consequence of the particular functional form of the WHL, the hours equation was re-estimated for a semi-logarithmic WHL. Since the stories told by this set of equations are about the same as those already discussed, these results are reported in Appendix B. The important point is that they yield estimates of ρ of .862 (standard deviation =

[27] The standard deviation for ρ was calculated by use of the approximation $\text{var}(r) \doteq (1/x^2) \times [\text{var}(y) + r^2 \text{var}(x) - 2r \text{cov}(y, x)]$ where $r = y/x$. See Kish [15, p. 207]

.326) and 1.32 (standard deviation = .337) for the weekly and yearly cases, respectively. If anything, these results are sharper than those discussed in the last paragraph. The married women in our sample do indeed seem to react to marginal tax rates rationally.

TABLE II
HOURS EQUATION*

Independent Variables	Dependent Variables: Hour/Week	Dependent Variables: Hours/Year
ME	8.229	459.0
	(1.44)	(76.32)
ME × *t*	−5.929	−508.6
	(4.55)	(222.2)
CHILD1	−9.33	−456.9
	(.837)	(37.14)
CHILD2	−12.60	−611.7
	(1.192)	(53.18)
CHILD3	−14.99	−762.9
	(1.988)	(88.26)
AT	4.755	230.8
	(.7203)	(31.81)
HEALT	1.346	138.7
	(2.413)	(106.6)
INC1	3.876	214.6
	(2.260)	(106.0)
INC2	3.290	196.1
	(2.052)	(92.06)
INC3	−3.437	−1.485
	(2.155)	(94.17)
INC4	−13.27	−366.3
	(3.009)	(129.5)
INC5	−4.43	−5.55
	(6.001)	(232.7)
Constant	.652	−173.07
	(2.922)	(146.1)
ρ	.721	1.11
	(.446)	(.340)
S.E.E.	17.8	786.9

* Estimation technique is ordinary least squares. Variables are defined in Section 3.

We have obtained an answer, then, to the question of whether or not taxes change perceived marginal earnings. However, this does not quite answer the question of whether or not taxes influence labor force behavior. The extent to which changes in net marginal earnings translate into differences in the hours of work must also be determined. Before attempting to use the coefficients of Table II to infer uncompensated elasticities, a word of caution is necessary. In order to use the coefficient of net marginal earnings to predict a given individual's response to a change in net marginal earnings, it must be assumed that preferences for work across individuals are independent of this response parameter. With this reservation in mind, we have calculated uncompensated elasticities at the mean for hours per week and hours per year, with respect to net marginal earnings. For the hours per week formulation, the elasticity is about 1.01, for the hours per year version, about 1.6. These figures suggest substantial responsiveness of the hours worked by married women to changes in their net marginal earnings. And as the results below will indicate, the statistical methods used thus far have been biasing these figures downward, so in reality they are even higher.

Tobit Analysis

In our sample more than half of the individuals do not work. They are concentrated at the lower bound of the supply of labor function, i.e., zero hours of work. However, in cases where the regressand is bounded and there is a concentration of observations at the bound, the classical regression model is inappropriate (see [**27**]). In order to cope with this problem we employ a statistical technique developed by Tobin [**27**], often referred to as "tobit". This technique is now described briefly.

Let I_j be an index which is a linear function of the regressors,

$$I_j = \delta_1 ME_j - \delta_1 \rho(t_j ME_j) + \sum_{i=2}^{m+1} \delta_i Z_{ij}.$$

Let I_j^* be distributed $N(0, \sigma^2)$. Assume individual behavior is determined by,

$$H_j = \begin{cases} 0 & \text{if} \quad I_j < I_j^*, \\ I_j - I_j^* & \text{if} \quad I_j \geq I_j^*. \end{cases}$$

Then it can be shown that if there are w workers and n nonworkers, the likelihood of the sample is,

$$L = \prod_{i=1}^{n} \left[1 - F\left(\frac{I_i}{\sigma}\right) \right] \prod_{i=1}^{w} \frac{1}{\sigma} f\left(\frac{I_i - H_i}{\sigma}\right),$$

where $f(\cdot)$ is the value of the standard normal distribution and $F(\cdot)$ is the cumulative standard normal distribution.

Parameter estimates are obtained by differentiating this likelihood function and solving the normal equations. Amemiya [**1**] has shown that this procedure is consistent and the parameter estimates are asymptotically normal. The negative inverse of the matrix of second derivatives therefore yields estimates of the variance-covariance matrix of the estimates. For a description of an algorithm to solve the nonlinear normal equations, see Rosett and Nelson [**26**].

A certain amount of care must be exercised in the interpretation of the resulting coefficients, which are found in Table III. Each coefficient shows how the *index* changes with respect to a right-hand side variable, not how expected hours itself changes. Thus, we cannot use the results of this table directly in order to calculate elasticities. Nevertheless, the interpretation of ρ is exactly as before: if $\rho = 1$, it indicates that the index depends on net marginal earnings, and since hours of

TABLE III
TOBIT ESTIMATES

Independent Variables*	Weekly	Yearly
ME	25.53	1187
	(3.261)	(168.4)
ME × *t*	−20.64	−1235
	(10.22)	(483.8)
CHILD1	−20.90	−1029
	(1.850)	(82.1)
CHILD2	−31.08	−1483
	(2.806)	(126.0)
CHILD3	−35.56	−1887
	(5.034)	(229.7)
AT	8.523	448.0
	(1.528)	(67.09)
HEALA	3.248	248.7
	(4.931)	(215.5)
INC1	18.14	596.3
	(5.330)	(225.7)
INC2	13.08	459.5
	(4.773)	(196.6)
INC3	−.1815	8.36
	(4.896)	(201.2)
INC4	−27.38	−984.4
	(6.740)	(283.7)
INC5	−19.79	−387.9
	(13.14)	(553.3)
Constant	−50.15	−2160
	(6.938)	(326.1)
ρ	.80	1.04
	(.318)	(.291)
σ	32.9	1445

* Variables are defined in Section 3.

work depends on the index (the precise form of this dependence will be stated below), then it follows that hours of work depends on the net marginal earnings. It is assuring to note that with this more appropriate method of estimation, the result on tax perception have improved. Both of our estimates of ρ, .80 and 1.04, are within one standard deviation of one and more than two standard deviations away from zero.

As has just been noted, the index must be transformed in order to determine number of hours. The estimated expectation of hours is,

$$\hat{H}_j = \hat{I}_j F\left(\frac{\hat{I}_j}{\hat{\sigma}}\right) + \hat{\sigma} f\left(\frac{\hat{I}_j}{\hat{\sigma}}\right), \tag{5}$$

where the $\hat{}$ indicates an estimated value and the other notation is the same as before [**27**, p. 26]. Due to the algebraic complexity of this expression, elasticities were calculated by means of a simulation rather than by substituting into an analytical solution. To be more specific, (5) was evaluated at the mean value of net marginal earnings, with *CHILD*1, *AT*, and *INC*3 set equal to one, and all the other right-hand side variables set equal to zero. Then net marginal earnings was incremented by one per cent and the consequent percentage change in estimated hours of work calculated. This procedure yielded hours elasticities with respect to marginal earnings of about 2.2 for weekly hours and 2.3 for yearly hours.[28] These values are higher than those from ordinary least squares estimation. The labor supply of married women appears to be highly responsive to net marginal earnings.

Given the fact that previous studies[29] have used different samples, different assumptions about which individuals are excluded from the sample, as well as different left-hand side variables, it is not clear what meaning a comparison of our results with earlier ones would have. Probably the only safe statement which can be made is that the outcomes of this analysis are broadly consistent with those econometric studies which have preceded it:

> ... those (wives) with higher wages work substantially more than those with lower wages in the same income group. Within a wage group, those with higher incomes work much less than those with lower incomes. (The) results seem to confirm the general belief that wives are quite sensitive to economic variables in their decisions about working [12, p. 131].

However, ours differs from past studies in that we have allowed for mutual determination of hours and wages on the individual level, and have not imposed any assumptions about tax perception.[30]

4. IMPLICATIONS AND QUALIFICATIONS

The literature review of Section 1 revealed a certain amount of skepticism on the importance of taxes as a determinant of work effort. There seemed to be two bases for this skepticism: (i) individuals do not correctly perceive the marginal tax rates that face them, and (ii) the wage doesn't matter much in the work decision anyway. The evidence of this study indicates that, at least for white married women, these assertions are incorrect. They do not suffer from tax illusion, and the elasticities involved are not "small". We also showed that a model in which the wage is independent of number of hours worked is too simple to give an adequate description of a group like married women, for whom part-time work is quite prevalent.

The information that married women's labor supply is highly responsive to net marginal earnings gives rise to several questions: How large is the welfare loss associated with the income taxation of married women? If income splitting were eliminated, how might the distribution of family income be changed? Finally, is it likely that the tax system influences the overall economic role of women in American society? These questions are beyond the scope of the present paper, but the analysis provides a foundation for answering them.

[28] The reader is again cautioned about the hazards in the interpretation of the elasticities; see above.

[29] See Hall [12, pp. 149–156] for a cataloging of some of these studies.

[30] The results on rational tax perception, however, do not depend on the existence of a wage-hours locus. See H. Rosen [24] for a discussion of tax perception in the context of the standard model in which the wage is exogenous.

This subject, of course, is far from closed. The results of this study could be improved in several ways. Some account could be taken of the fact that the imputed marginal earnings of nonworking individuals may be biased upward. The longitudinal nature of the Parnes data might be used to construct "permanent" analogues to our variables like income. Further investigation of the extent to which the wife's work decision feeds back on the husband's decision is needed also. However, it seems fair to assert that, at least in this sample, people *do* do something besides talk about income taxation. Taxes are not like the weather.

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APPENDIX A

The purpose of this appendix is to derive the expression for the intercept adjustment associated with the linearization of the budget constraint. The wage-hours locus is given by

$$w = \exp(\beta_1 H)\exp\left(\sum_{i=2}^{n+1}\beta_i X_i\right),$$

where the variables are defined in the text. (See Section 3.)

In Figure A.1 CD is the budget constraint, CE is the constraint adjusted for taxes, and GH is the tangent to CE at 1500 hours, the "standard number" of hours of work. As the text suggests, we want to characterize each individual's net WHL at 1500 hours by two numbers: the slope and the intercept

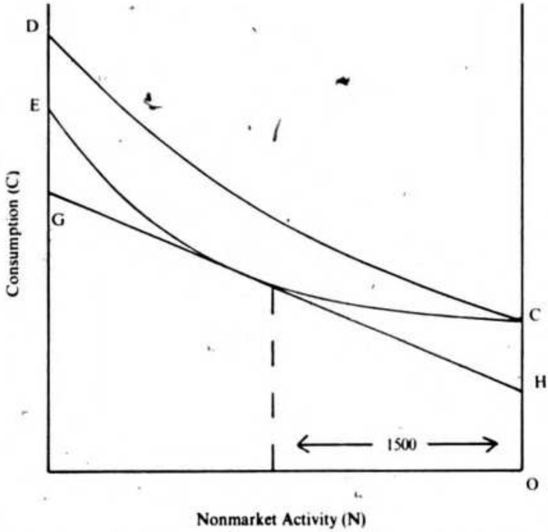

FIGURE A.1.

of line GH. It has already been shown that the slope is

$$m = -(1-t)\exp\left(\sum_{i=2}^{n+1}\beta_i X_i\right)\exp(\beta_1 H)(\beta H+1)\Big|_{H=1500}$$

The problem which remains is to calculate OH.

Consider line GH. We know that it can be written as $(C - C_{1500})/(N - (\bar{N} - 1500)) = m$, where C_{1500} is the distance between GH and the abscissa when there are 1500 hours of work, and $\bar{N}$ is the time endowment. When hours of work are zero, we have $C = 1500m + C_{1500}$. But this is the required distance, OH. Since we have solved for m above, all that remains is to calculate C_{1500}. This is net

TABLE IV

THE WAGE-HOURS LOCUS
SEMI-LOGARITHMIC SPECIFICATION

	Dependent Variables	
Independent Variables[a]	*w*	*w*
ln hours per week	.9618	
	(.6292)	
ln hours per year		.4594
		(.2132)
ED2	.3198	.2185
	(.1124)	(.0929)
ED3	.9656	.8468
	(.1248)	(.1091)
AGE1	−.2167	−.2513
	(.07378)	(.07695)
AGE2	−.2004	−.2194
	(.07502)	(.07524)
TRAIN	.01802	.03083
	(.1122)	(.09824)
CITY	.031[illegible]5	.05966
	(.07295)	(0.6252)
EXP3	.2746	.03120
	(.06419)	(.1351)
EXP4	.4740	.1819
	(.1136)	(.2088)
VOCA	.1350	.1479
	(.06596)	(.06551)
HEALT	−.2076	−.1804
	(.09483)	(.09169)
INC1	−.3549	−.2530
	(.1956)	(.1739)
INC2	−.2001	−.09034
	(.1693)	(.1414)
INC3	.000511	.06308
	(.1371)	(.1282)
INC4	.4450	.4395
	(.1695)	(.1585)
INC5	−.04435	−.1830
	(.4425)	(.4472)
Constant	−1.860	−1.509
	(2.136)	(1.357)
S.E.E.	.84	.83

[a] Variables are defined in Section 3.

other family income (NOFI) plus gross earned income at 1500 hours,

$$wH = \exp\left(\beta_1 H + \sum_{i=2}^{n+1} \beta_i X_i\right) \cdot H \Big|_{H=1500}$$

minus the amount of tax paid on the wife's earnings at 1500 hours, T_{1500}. By substituting we arrive at

$$OH = 1500m - T_{1500} + \text{NOFI} + H \exp\left(\beta_1 H + \sum_{i=2}^{n+1} \beta_i X_i\right) \Big|_{H=1500}$$

APPENDIX B

In this appendix we report the results for the WHL and hours equations with a WHL of the form:

$$w_j = \beta_1 \ln H_j + \sum_{i=2}^{n} \beta_i X_{ij} + \varepsilon_j,$$

where the notation is described in Section 3. The wage-hours loci in Table IV again indicate that the wage increases with the number of hours of work. The qualitative effects of the X_i are similar to those

TABLE V

HOURS EQUATIONS

	Dependent Variables	
Independent Variables[a]	Hours/Week	Hours/Year
ME	10.80	453.4
	(1.593)	(85.92)
ME × *t*	−9.312	−602.3
	(4.536)	(229.9)
*CHILD*1	−9.491	−459.4
	(.842)	(37.54)
*CHILD*2	−12.90	−596.9
	(1.203)	(53.69)
*CHILD*3	−15.39	−756.5
	(2.001)	(89.13)
AT	4.962	247.1
	(.723)	(31.93)
HEALA	1.215	141.9
	(2.426)	(107.35)
*INC*1	2.446	278.8
	(2.213)	(105.9)
*INC*2	3.181	222.1
	(1.918)	(93.16)
*INC*3	−2.624	87.64
	(2.011)	(93.24)
*INC*4	−11.24	−221.0
	(2.87)	(127.11)
*INC*5	−3.912	140.6
	(5.53)	(228.5)
Constant	−5.549	−179.5
	(3.31)	(168.7)
ρ	.862	1.328
	(.326)	(.337)
S.E.E.	17.90	791.9

[a] Variables are defined in Section 3.

reported in Table I. The same is true for the Z_i of the hours equations in Table V. (Of course, for the hours equations different intercept adjustments had to be calculated than those which are given in Appendix A.)

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