

**A CHOICE ANALYSIS OF WAGE-HOURS JOINT  
DETERMINATION IN CHUNCHON AREA:  
THE CASE OF MALE LABOR SUPPLY**

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I. INTRODUCTION

In labor economics, the supply model of working hours is explained from workers' utility-maximizing behavior. The theoretically implied equality between a worker's wage and his marginal rate of substitution provides a basis for the analysis of labor supply curve and other preference parameters.

Over the years, various models have been developed that call into question one or two of several traditional about the behavior of labor supply. Lewis(1969) was among the first to investigate the possibility that firms are not indifferent to the number of working hours by their workers, due in part to the fixed costs involved in hiring a worker and maintaining him on the payroll. Barzel(1973) focuses on the impact on firms' demands for labor of the declining marginal productivity of an individual worker at high levels of labor supply. Rosen(1976) examines female labor supply using the method of constructed marginal prices, since criticized in Brown and Rosen(1982), and Brown(1983). Moffit(1984) also examines female labor supply using a discrete choice framework. Lundberg(1985) investigates male labor supply but constrains the wage - hours relationship to be linear, while Barzel(1973) suggests by theory it to have both upward-sloping and downward-sloping segments. Siow(1987) explores the effect on labor demand of technologies requiring the coordination of workers' schedules.

In each of these models, the profit-maximizing firm does not allow workers to freely choose the number of hours they will work at a fixed wage rate, leading to the presence of firm-imposed hours constraints and wage rates that depend on the number of working hours. When wages are a function of working hours or when workers face hours constraints, workers' marginal rates of substitution are not in general equal to their wages. Thus, the traditional approach to estimating

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labor supply elasticities based on this equality is inappropriate. Abowd and Ashenfelter(1981), and Siow(1987) present empirical evidence that wages do depend on the level of labor supply, while Wales and Woodland(1976), and Ham (1982) demonstrate empirically that ignoring the presence of hours constraints leads to a bias in estimated labor supply elasticities.

In this paper we specify and estimate an empirical model based on the idea that workers' wages and working hours are determined in an implicit market, which is first introduced by Rosen(1974). This model of wage - hours joint choice was originally described in Lewis(1969) and has been reexamined by Kinoshita (1987). The implicit market model contains the traditional model as a special case [see Kinoshita(1987)], yet it is flexible enough to allow for fixed costs of employment, nonconstant marginal productivity of an individual worker's labor supply, the need to coordinate work schedules, and other situations in which wages might be a function of working hours.

In the next section we briefly describe the decision of labor supply in an implicit market. In Section III we formulate the implicit market labor supply model. Section IV, and Section V specify and identify the implicit market labor supply model respectively. Section VI describes the data and the methodology and problem of estimation, and presents the empirical results. Conclusions are given in Section VII.

## II. LABOR SUPPLY IN AN IMPLICIT MARKET

The conventional model of labor supply assumes that a worker faces a parametric wage rate and chooses working hours subject to the resulting linear budget constraint. As has been frequently noted, in this model, it is assumed that an exogenous average wage rate is independent of working hours. However, the assumption of wage exogeneity is in doubt.<sup>1)</sup> Underlying this model is the assumption that each firm is indifferent to the number of hours his workers choose to work or, alternatively, that individual workers face a wide range of job options, with each job paying the same wage rate but demanding a different number of hours.

In the formal model of the implicit wage - hours market, both workers and firms have an interest in the number of working hours. The interaction of workers and firms in the market gives rise to a market level hedonic wage equation,

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<sup>1</sup> Oi(1962) argued that labor is a quasi-fixed input and consequently generates quasi-fixed costs to the firm; this implies that lower wage rates will be paid at low working hours than at high working hours. Barzel(1973) added to this fixed-cost factor the hypothesis that marginal productivity eventually declines at sufficiently high working hours, leading to a lower (marginal) wage. Barzel showed that the combination of fixed costs of work at low hours and declining marginal products at high hours leads to an S-shaped budget constraint, wherein the marginal wage rises initially but eventually falls.

relating the average hourly wages of a worker to the number of hours he works. The shape of the market hedonic wage equation is determined by the distribution of tastes across workers and the distribution of cost functions across firms. Both workers and firms optimize their utility functions and profit functions respectively subject to the exogenous hedonic wage equation, and in equilibrium each type of firm demands a single level of hours, and each worker supplies the number of hours associated with his chosen firm. Thus, there is a sorting of workers into firms on the basis of firm cost functions and worker tastes [see Rosen(1986)].

It should be noted that even if only some firms in the labor market place restrictions on their workers' labor supply, the labor market is likely to be characterized by two essential features of the implicit market model. First, the wage a worker earns in the labor market depends on the number of hours he works. Second, many workers choose their level of labor supply by choosing between firms, so that workers and firms are paired in a nonrandom fashion. This leads to correlations between worker and firm characteristics. These two features have important implications for the specification and estimation of an empirical labor supply model, which we explore in the next sections.

### III. FORMULATION OF THE MODEL

In this section, the supply behavior of working hours by workers is explained. Assumptions:

(1) A worker has a expected utility function  $U(TI, H, S; a)$ , where  $TI$  is total income,  $H$  is working hours,  $S$  is a vector of factors affecting tastes for work, and  $a$  is a vector of utility function parameters. Total income  $TI$  is equal to labor income  $LI$  plus nonlabor income  $NI$ . Here, labor income  $LI$  is defined by  $WH$ , where  $W$  is the average wage rate or average hourly wages. The utility function is quasi-concave, and  $U_{LI} > 0$  and  $U_H < 0$ .

(2) The hedonic wage equation (HWE) takes the form  $W(H, X)$ , where  $X$  is a vector of productivity-enhancing characteristics. It is possible that  $S$  and  $X$  have some elements in common. It is assumed that  $W_H > 0$ . The shape of the HWE depends on the distribution of tastes for work across workers and the distribution of cost functions and technology characteristics across firms. Workers' preferences are reflected in indifference curves that indicate the tradeoffs between wages and working hours. Likewise, since working hours influence firm productivity and costs, iso-profit curves embody the tradeoff between wages and working hours. The HWE is the envelope of mutual tangencies between workers' indifference curves and firms' iso-profit curves [see Rosen(1974), (1986) for further discussion of this type of model].

(3) Working hours are indivisible, and multiple job holding is prohibited. When working hours are assumed to be indivisible goods, labors are differentiated in the market by their length, and wages will be a function of working hours.

(4) Empirically, we will work with a hedonic income equation (HIE) rather than a hedonic wage equation. The reason for working with labor income rather than hourly wages is that many workers are not paid on an hourly basis, and their hourly wage is often constructed from information on labor income and working hours. Labor income is a more generally applicable measure of compensation. The hedonic income equation is of the form  $LI(H, X; b)$ , where  $b$  is a vector of HIE parameters.

The worker maximizes utility subject to the HIE plus nonlabor income as follows.

$$\begin{aligned} &\text{Maximize } U(TI, H, S; a) \\ &\text{s.t. } TI = LI(H, X; b) + NI \end{aligned}$$

Then the Lagrangian function is

$$R(TI, H, S, X, \lambda) = U - \lambda[TI - LI - NI] \quad (1)$$

where  $\lambda$  is a Lagrangian multiplier. The first-order conditions are

$$\frac{\partial R}{\partial TI} = \frac{\partial U}{\partial TI} - \lambda = 0 \quad (2)$$

$$\frac{\partial R}{\partial H} = \frac{\partial U}{\partial H} + \frac{\lambda \partial LI}{\partial H} = 0 \quad (3)$$

and

$$\frac{\partial R}{\partial \lambda} = -TI + LI + NI = 0 \quad (4)$$

From these equations, We have

$$-\frac{\partial U / \partial H}{\partial U / \partial LI} = \frac{\partial LI}{\partial H} \quad (5)$$

Equation (5) leads to the conclusion that, at the worker's optimum, his marginal rate of substitution between labor income and working hours will be equal to the derivative of the hedonic income equation (HIE) with respect to working hours. In other words, the worker's optimal level of labor supply is determined implicitly by the equation (5).<sup>2)</sup>

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<sup>2</sup> We assume that the second-order conditions are satisfied. As it is assumed only that  $\partial LI / \partial H > 0$ , the equilibrium may not be unique. But for simplicity, We assume that uniqueness is also satisfied.

Our empirical methodology exploits the assumption that the worker chooses his labor income - working hours choice bundle by equating his marginal rate of substitution between labor income and working hours to the gradient of the hedonic income equation. By jointly estimating this first-order condition [equation (5)] along with the HIE, we are able to identify the parameters of the utility function and the HIE. Since the parameter vector  $b$  appears in both of equation (5) and the HIE, cross-equation restrictions are imposed to aid in model identification, and tested to evaluate the model.

#### IV. SPECIFICATION OF THE MODEL

##### 4.1 Specification of the Hedonic Income Equation

Economic theory gives us little guidance regarding the functional form of the relationship between labor income and working hours. We can be sure that no relevant range of the HIE will involve less income for more hours, but we can not be certain *a priori* whether average hourly wages will increase or decrease in working hours or whether that relationship is monotonic.<sup>3</sup> Thus, we specify the HIE as a polynomial in log form :

$$\ln LI = b_0 + b_1 \ln H + b_2 (\ln H)^2 + b_3 X + \varepsilon_{Li} \quad (6)$$

where  $\varepsilon_{Li}$  is a random error term representing unobserved characteristics of the worker. Equation (6) contains as a special case the assumption that the worker faces a linear budget constraint. To see this, start with the identity  $\ln LI = \ln W + \ln H$ . If we substitutes for  $\ln W$  using the income equation in the conventional model  $\ln LI - \ln H = \ln W = b_0 + b_1 X + \varepsilon_{Li}$ , the result is a version of equation (6) in which  $b_1$  equals one and  $b_2$  equals zero.

##### 4.2 Specification of the Two-Equation System

In this paper, we are to analyze the empirical relationship between labor income (or average hourly wages) and working hours. We are able to estimate the HIE in isolation. However, the HIE can also be estimated jointly with a lab-

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<sup>3</sup> Lewis(1969) makes this point. Kinoshita(1987) shows that if a firm's elasticity of output with respect to additional workers minus the proportion of its total costs represented by the fixed costs of employing labor is greater than its elasticity of output with respect to additional hours per worker, then that firm's job offer will be on a portion of the HIE where average hourly wages are declining in working hours. He asserts that this is an unlikely situation but cites no empirical findings to support that statement.

or supply equation, with the cross-equation restrictions implied by utility-maximizing behavior enforced to help identify labor supply parameters.

We suggest two versions of the two-equation labor supply system. The first specification, System A, is a conventional labor supply model. In this model, the supply equation is assumed to take the form:

$$\ln H = a_0 + a_1 \ln W + a_2 \ln NI + a_3 S + \varepsilon_H \quad (7)$$

where  $\varepsilon_H$  is a random error term representing unobserved tastes for work. Equation (7) is estimated simultaneously with a wage equation of the form  $\ln W = b_0 + b_1 X + \varepsilon_W$ , an approach commonly seen in the literature on the conventional labor supply model. The results from this specification provide a benchmark with which to compare the estimates from our implicit market labor supply model to be explained below.

The second specification, System B, assumes the different functional form for preferences with System A and allows labor income (or average hourly wages) to depend on working hours. We assume that preferences can be approximated by a direct translog utility function of the form:<sup>4</sup>

$$\ln U = a_0 + a_1 \ln TI + a_2 D \ln H + a_{12} \ln TI \ln H + a_{11} (\ln TI)^2 + a_{22} (\ln H)^2$$

where

$$D = g_0 + g_1 S + \varepsilon_H$$

$$E(\varepsilon_H) = 0, E(\varepsilon_H^2) = \sigma_H^2$$

Heterogeneity in tastes for work is represented by D, which is assumed to be a function of the observable taste variables S and the unobserved taste variable  $\varepsilon_H$ . Given this utility function, the marginal rate of substitution between income and working hours is

$$-\frac{TI}{LI} \left[ \frac{a_2 g_0 + a_2 g_1 S + a_{12} \ln TI + 2a_{22} \ln H + a_2 \varepsilon_H}{a_1 + a_{12} \ln H + 2a_{11} \ln TI} \right] \quad (8)$$

The HIE for System B is equation(6). Labor supply is determined in accordance with equation(5), by equating the slope of the HIE with the marginal rate of sub-

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<sup>4</sup> The translog function belongs to the family of flexible functional forms. A flexible functional form is defined as one which could provide a second-order differential approximation to an arbitrary twice continuously differentiable function that satisfies the appropriate regularity conditions at any point in an admissible domain.

stitution given in equation(8):

$$\begin{aligned}
 & - \frac{TI}{LI} \left[ \frac{a_2 g_0 + a_2 g_1 S + a_{12} \ln TI + 2a_{22} \ln H + a_2 \varepsilon_H}{a_1 + a_{12} \ln H + 2a_{11} \ln TI} \right] \\
 & = b_1 + 2b_2 \ln H
 \end{aligned} \tag{9}$$

## V. IDENTIFICATION OF THE MODEL

### 5.1 Identification of the Hedonic Income Equation

In the HIE, working hours are the characteristic being traded in the implicit market, and must be treated as an endogenous variable.<sup>5)</sup> The HIE is identified if there exist sufficient instrumental variables for working hours that are not themselves included in the HIE. The variables related to the firm seem like natural choices as instrumental variables. However, due to the fact that workers and firms are not randomly matched, unobserved characteristics of the worker  $\varepsilon_{it}$  may be correlated with the characteristics of his chosen firm. Thus, firm-related variables can not be considered to be instrumental variables. In stead, we use the S vector of utility function, which contains worker-specific taste shifters, and interactions between X and S as instrumental variables. Since exclusion restrictions must be made for identification, we assume that certain S variables and interactions between X and S are excluded from the HIE. Our discussion below of the results of estimating the HIE reports the results of tests to various identification assumptions.

### 5.2 Identification of the Two-Equation System

System B is based on the implicit market model, in which the budget constraint is nonlinear and labor income and working hours are jointly chosen. Thus wages and hours must be treated as endogenous variables in the structural labor supply equation of this specification [see Epple(1987)]. The two-equation system can be identified if we have enough instrumental variables to identify the labor supply equation.

In the context of our two-equation system, the problem of finding instrumental variables for the labor supply equation is similar to the problem discussed above of finding instruments for the HIE. Again, difficulties arise because the worker in choosing his level of labor supply is at the same time choosing his

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<sup>5)</sup> The endogeneity of working hours is explained in more detail in Subsection 2 of Section VI.

firm. Therefore, firm characteristics are potentially correlated with a random error term representing unobserved tastes for work in the labor supply equation. Thus, firm-related variables would be unacceptable as instrumental variables for the labor supply equation.

The general principle from the implicit market literature is that demander attributes should not be used as instruments for the supply equation and supplier attributes should not be used as instruments for the demand equation. Bartik (1987), Epple(1987), and Kahn and Lang(1988), all of whom demonstrate this principle in one way or another, suggest using variables that identify separate implicit markets as instrumental variables. In our model, workers with different values for  $X$  are in different labor markets in that they face different sets of wages - hours opportunities. Thus, if the values of  $X$  variables are determined prior to the worker's labor supply decision and firm choice, and if they do not affect tastes for work, then they are acceptable instrumental variables.<sup>6)</sup> Of course, for an  $X$  variable to be useful in identifying the labor supply equation, it must be excluded from the  $S$  vector. However, interactions between these excluded  $X$  variables and  $S$  variables can be used for identification [see Kahn and Lang(1988)]. Given this and our assumptions regarding which  $X$  variables are determined prior to the worker's labor supply decision, we have sufficient instrumental variables to identify the labor supply equation.

Recently, there has developed a substantial literature on requirements for the identification of structural parameters in implicit markets. In the context of our problem, one necessary condition for identification is that the effect of hours on the marginal rate of substitution not be a linear function of the effect of hours on the gradient of the HIE [see Brown and Rosen(1982), and Brown(1983)]. Our empirical specifications satisfy this condition. In addition, Epple(1987) presents identification conditions describing the number of instrumental variables required to identify a structural equation in an implicit market setting, as well as the types of variables that can serve as instrumental variables. With regard to the number of instrumental variables needed, identification conditions for a structural equation in an implicit market parallel those for an equation in a standard simultaneous system.<sup>7)</sup> The difficulty for us using the implicit market framework lies in finding acceptable instrumental variables. Many variables that might be considered exogenous at first glance may be correlated with the error term of the structural equation as a result of the sorting that goes on in the implicit market. In addition, since the two-equation system contains the labor supply parameters,

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<sup>6)</sup> There is the additional possibility that values of some  $X$  variables are a result of decisions that were made prior to the labor supply choice but that were influenced by an unobserved factor that also affects tastes for work. This possibility is not unique to the implicit market setting but is a potential problem for all simultaneous equations approaches to labor supply estimation.

<sup>7)</sup> An examination of Epple's(1987) Table 2 makes this clear.



cross-equation restrictions implied by utility-maximizing behavior can be enforced to help identify the parameters when the two-equation system is estimated.

## VI. EMPIRICAL IMPLEMENTATION OF THE MODEL

### 6.1 Data

In order to estimate the model above, we use the 1991 Cross-Section Data, which come from the questionnaire survey on individual workers in Chunchon area.

Our sample is limited to male workers between 18 and 65 years of age who were working or only temporarily out of work at the times of the survey. Sample members must not have changed their Job in 1991 so that wages and hours figures refer to a single employment situation. Multiple-job holders<sup>8)</sup> and farmers are excluded, but self-employed workers are not.

The labor supply variable is the worker's annual working hours on all jobs in 1991, and the labor income variable is the worker's income from labor in 1991. Nonlabor income is determined by subtracting the worker's labor income from the worker's total income from all sources. Average hourly wages are constructed by dividing labor income by annual working hours. Tenure is measured by months with the employer at the end of 1991, and experience by years spent as a full-time worker. Workers working more than 4,000 or less than 1,500 hours annually are excluded from the sample to prevent outliers from having undue influence on the results. Observations with missing or impossible values for any of the variables used in the analysis are eliminated from the sample. Summary statistics for the full data set are presented in Table 1.

### 6.2 Estimation

The first formal contributions to hedonic price theory were made by Court (1941) and Tinbergen (1951, 1956). Tinbergen demonstrated the dependence of hedonic wage functions on the distributions of worker and firm characteristics and the parameters of utility and production functions. Given distributional and func-

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<sup>8</sup> The formal implicit market model assumes that each worker holds only one job. In the formal model, each worker chooses a point on the HIE, and at that point there is a tangency between a single firm's isoprofit curve and a worker's indifference curve [see Kinoshita (1987)]. However, the characterization of the worker's labor supply decision in an implicit market allows for the possibility that workers hold two jobs if points on the HIE can represent the sum of labor income and hours from two jobs. In this situation, a worker's indifference curve is not tangent to the isoprofit curve of a particular firm for which he works. This complicates any attempt to identify demand-side parameters with labor income and hours data, so an estimation procedure that is based on this tangency can be hindered. Therefore, multiple-job holders must be excluded.

tional form assumptions, he showed that utility and production function parameters may be recovered from estimated hedonic parameters. Rosen(1974) developed an empirical methodology for estimating demand and supply parameters if no explicit solution for the hedonic price function is available. Since he first proposed a procedure for estimation in an implicit market, it has been standard practice to estimate the hedonic price or wage equation by OLS, but recently the propriety of this approach has been questioned [see Bartik(1987), Eppl(1987), and Biddle and Zarkin(1988)].

The problem with Rosen's approach is that the econometric problem of hedonic estimation is not due to a standard identification problem caused by demand - supply interaction, as has been often assumed. Estimation procedures based on this assumption lead to biased results. An individual worker's decision can not affect firms in the hedonic model because an individual worker does not affect the hedonic price or wage function. There is a hedonic estimation problem but from another source. The hedonic estimation problem in an implicit market is caused by the endogeneity of both wages and working hours when workers face a nonlinear budget constraint.<sup>9</sup> The endogeneity of wages and working hours arises because the implicit market model implies that they are jointly chosen. An instrumental variables solution to this problem is suggested using instruments that exogenously shift the budget constraint (HIE) [see Bartok(1987)].<sup>10</sup>

There are also reasons to believe that working hours is an endogenous variable in the HIE. That belief comes from errors in measurement of the working hours variable, a correlation between unobserved characteristics of the worker  $\varepsilon_{Li}$  and working hours  $H$ , and a correlation between  $\varepsilon_{Li}$  and unobserved tastes for work  $\varepsilon_{\mu}$ . Therefore, OLS estimates of the parameters of the HIE will be biased. This means that the HIE and the two-equation system must be estimated by an instrumental variables procedure to avoid bias.

The argument for treating working hours as an endogenous variable in the HIE can be extended to other variables in the  $X$  vector that represent personal attributes affecting productivity and are correlated with working hours. For example, suppose that union status is correlated with hours because nonunion jobs tend to require more hours. Suppose also that workers with larger incomes prefer jobs demanding fewer hours. Then, workers with larger values of  $\varepsilon_{Li}$ , other things

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<sup>9</sup> The primary difficulty in estimation arises because the endogeneity of the wage makes the individual budget constraint "smoothly" nonlinear - that is, nonlinear but everywhere differentiable. Such constraints frequently arise in the theory of hedonic prices, of which the problem here is a special case [see Rosen(1974) for a recent treatment and Houthakker(1952) and Theil(1952) for early discussion]. This estimation problem can be addressed by approximating the constraint by a set of discrete choice points; this makes the problem tractable [see Moffitt(1984)].

<sup>10</sup> The practical problem for empirical headline research is finding instruments whose exogeneity can be defended with some plausibility.

**[Table 1]** Variables Used in the Analysis

Variable	Mean	Standard Deviation
Working Hours	2,812(Hours)	540
Labor Income	7,669(Thousand Won)	3,904
Nonlabor Income	951(Thousand Won)	474
Total Income	8,616(Thousand Won)	4,234
Average Hourly Wages	2.73(Thousand Won)	1.38
Local Unemployment Rate	2.35(%)	0.65
Children under 17	1.76(Persons)	1.65
Tenure in Months	156.22(Months)	133.90
Experience	14.63(Years)	7.04
Age	39.87(Years)	9.80
Dummy Variable:		
1 If Born in Chunchon	0.35	0.44
1 If Disabled	0.04	0.15
1 If Married	0.79	0.25
1 If College Degree	0.18	0.35
1 If Homeowner	0.65	0.41
1 If Self-Employed	0.13	0.46
Education :		
Less Than or Equal to 6	0.26	0.48
Less Than or Equal to 9	0.23	0.32
Less Than or Equal to 12	0.36	0.64
More Than 13	0.15	0.42
Occupation :		
Professional, Administrative, and Managers	0.18	0.41
Clerical	0.26	0.73
Sales	0.19	0.54
Service	0.18	0.86
Production	0.19	0.64
Number of Observations	980	

being equal, are more likely to choose a job in a union workplace, leading to a correlation between union status and  $\varepsilon_{Li}$ . This line of reasoning suggests the existence of a correlation between  $\varepsilon_{Li}$  and any X variable whose value is determined

when the worker chooses his firm and, thus, his level of hours. Variables like sex and race, whose values are determined outside the labor market, can clearly be considered exogenous. But other variables are not so clear-cut, and the econometrician must decide which variables are likely to pose a serious endogeneity problem. For the purposes of our model, we assume that the worker's formal educational attainment, geographical location, and broad occupational category are determined prior to the particular labor market choice we are analyzing, and we take the position that any biases arising from violations of these assumptions are of second-order importance; variables like tenure and union status are more problematic. In the following subsection, we report the results of statistical tests for the endogeneity (or the exogeneity) of these variables as well as the endogeneity of working hours in the HIE.

### 6.3. Empirical Results

#### 6.3.1 The Hedonic Income Equation

Table 2 reports the results of estimating the HIE, using both ordinary least squares (OLS) and instrumental variables (IV). The first two rows contain the estimated coefficients of log hours and log hours squared for the two regressions. These coefficients reflect the relationship between labor income and hours. Figure 1 shows graphically the relationship between labor income and hours implied by these coefficients, and Figure 2 shows the implied relationship between average hourly wages and hours.<sup>11</sup> The OLS estimates are quite different from the IV estimates, and as Figures 1 and 2 indicate, they have different implications for the shape of the HIE. The OLS estimates imply that labor income increases at a decreasing rate as labor supply increases, while average hourly wages decrease continuously. The IV estimates imply that labor income increases at an increasing rate with hours. Average hourly wages behave in roughly the same way as labor income, marking the minimum point at about 1,800 hours.

If wages are independent of working hours, as is assumed in the conventional model of labor supply, the coefficient of hours in the HIE is one, and the coefficient of hours squared is zero. We conducted an F-test of this restriction for both the OLS and the IV versions of the HIE. The resulting statistics, reported in the third row of Table 2, show that both the OLS and IV estimates are inconsistent with the restriction and with the hypothesis that wages are independent of working hours.

The difference between the OLS and IV estimates of the hours coefficients

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<sup>11</sup> Labor income is the multiplication of average hourly wages and hours. Therefore, average hourly wages can be earned by dividing labor income by hours.

**[Table 2]** The Hedonic Income Equation

	OLS	IV
Log Hours	8.67 (2.71)	82.02 (3.39)
(Log Hours) <sup>2</sup>	-1.43 (3.58)	-7.66 (3.12)
F Test : Restrictions Implied by Conventional Model	27.72	11.26
Hausman Test : Endogeneity of Hours	21.61	
R <sup>2</sup>	0.43	0.28

Note: 1) Asymptotic t-ratios are in parentheses.

2) Variables also included in regressions:

Tenure, (Tenure)<sup>2</sup>, Experience, (Experience)<sup>2</sup>, Local Unemployment Rate, (Local Unemployment Rate)<sup>2</sup>, Six Dummy Variables, Three Educational Dummies, and Four Occupational Dummies.

3) Instrumental Variables used for IV estimation:

Tenure, (Tenure)<sup>2</sup>, Experience, (Experience)<sup>2</sup>, Local Unemployment Rate, (Local Unemployment Rate)<sup>2</sup>, Six Dummy Variables, Three Educational Dummies, Four Occupational Dummies, Children under 17, Nonlabor Income, Age, and Several Interactions between Variables and Variables.

presumably reflects a bias in the OLS estimates caused by the endogeneity of hours in the HIE. The fourth row of Table 2 reports the  $\chi^2$  statistic from a Hausman test of the joint exogeneity of Log Hours and Log Hours Squared. The hypothesis that the OLS and IV estimates of the coefficients on these two variables have the same probability limit is easily rejected. Thus, we conclude that the OLS estimates are biased.

The X variables we include in the regressions are human capital and demographic variables commonly found in the HIE. We list them in Table 2. We also list the instrumental variables used in the IV estimation. Comparison of the two lists shows that Nonlabor Income, Children under 17, and Age are among the variables excluded from the X vector to help identify the model. We tested the effect of these variables by estimating versions of the HIE that included these variables and could not reject the null hypothesis of no effect at the significance level of 5%.<sup>12)</sup> In addition, our results are robust to the relaxation of these exclusion restrictions.

<sup>12</sup> We conducted our test with IV estimates because the correlation of these variables with hours in the HIE combined with the endogeneity of hours in the HIE could bias OLS estimates of the coefficients of these variables.

There is the possibility that Tenure and Tenure Squared of the X variables listed in Table 2 might be correlated with the error term of the HIE,  $\varepsilon_{Lh}$ , as a result of sorting. We investigated this possibility by conducting a Hausman test and found little evidence that treating these two variables as exogenous biased the estimates of the HIE.

Our estimates from the IV estimation imply that, if a worker earning the sample mean income (7,669 thousand Won) and working the sample mean hours (2,812 Figure 1. Labor Income - Hours Relationship hours) were to increase his annual labor supply by 100 hours, his labor income would increase by 460 thousand Won (about 6%), and his average hourly wages would rise from 2.65 thousand Won to 2.72 thousand Won (about 3%). At this point, the worker's average wage is about half his marginal wage (i.e., the gradient of the HIE). This difference between the average wage and the marginal wage is one of the main features distinguishing the implicit market model of labor supply from the conventional model.

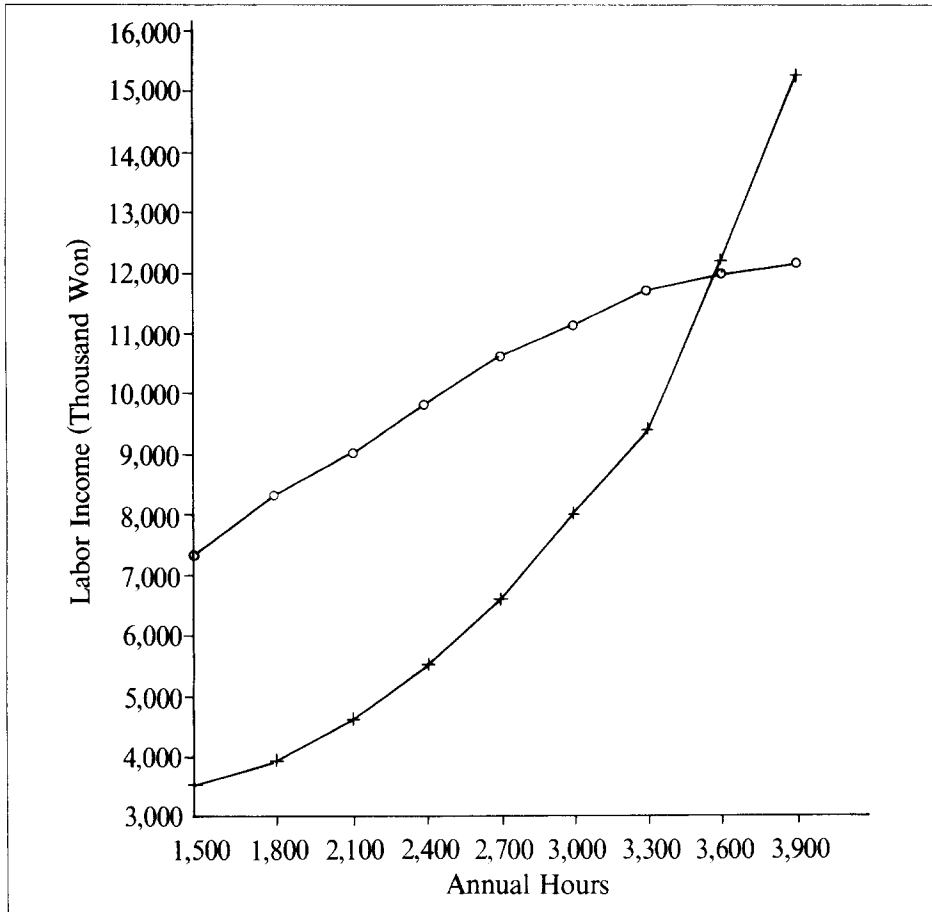
### 6.3.2 The Two-Equation System

To provide a benchmark with which to compare the results of estimating our implicit market labor supply model, we first estimate a conventional simultaneous model of wage - hours determination, i.e., System A. The two equations of System A are estimated jointly by three-stage least squares (3SLS) using the instrumental variables listed in Table 2.

The results of estimating System A are presented in the first column of Table 3. The estimated wage effect, which in this model can be interpreted as a wage elasticity of labor supply, is 0.02. The coefficient of nonlabor income is negative but insignificant.<sup>13</sup> This is not an uncommon finding in previous studies of labor supply [see Moffitt(1984)]. The taste-shifting variables have statistically significant coefficients, and they affect labor supply in the expected ways: the married work more, and the homeowners work less; age and the presence of children in the home seems to have little effect on labor supply behavior. Overall, the estimates of System A are reassuring in that they show our sample to be a typical one with respect to wages and hours.

The second column of Table 3 reports estimates generated by System B, which involves the hedonic income equation and the translog labor supply equation. The system is jointly estimated by nonlinear 3SLS, with the cross-equation restrictions implied by the theory imposed. The coefficients of Log Hours and Log Hours Squared have the same sign pattern as the IV estimates in Table 2, but they are different in magnitude. These estimates imply that labor income rises with hours at an increasing rate throughout the range of the sample. The change

<sup>13</sup> This estimate must be interpreted as a nonlabor income elasticity of labor supply.

**[Figure 1]** Labor Income - Hours Relationship

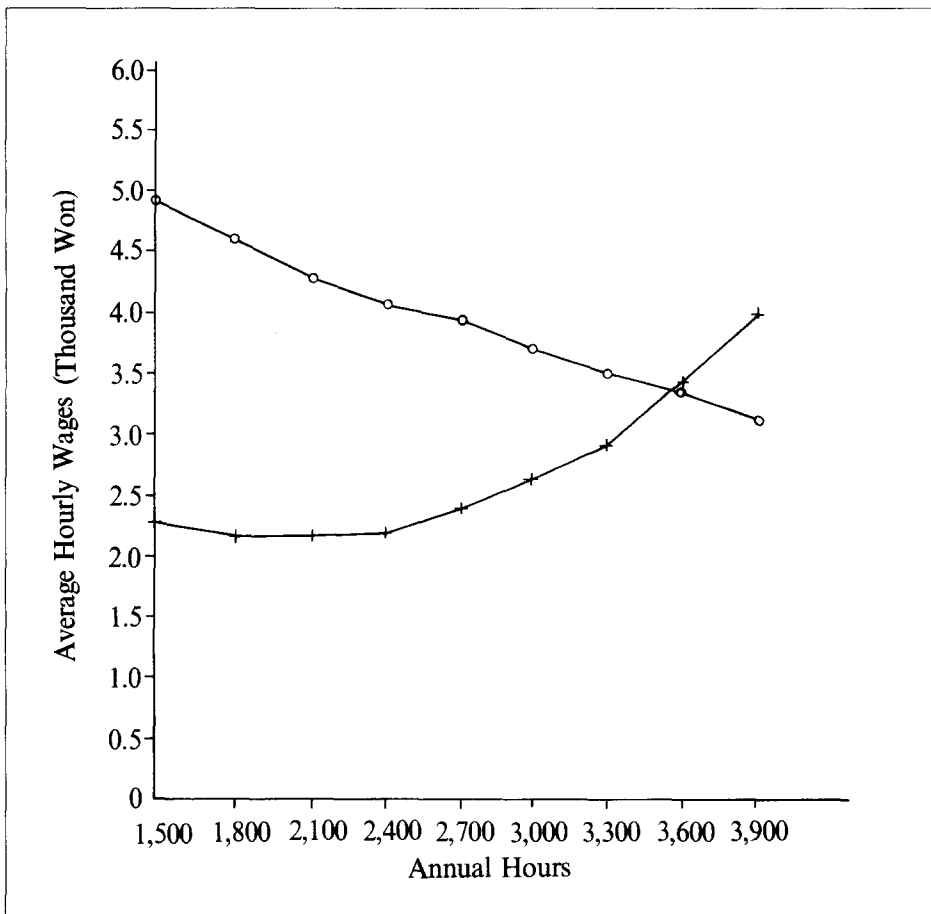
Note: Symbols o and + indicate OLS and IV respectively.

in estimates is a result of the cross-equation restrictions that are imposed when the system is estimated. A Hausman test comparing coefficients of the hours terms produced by the system to those of Table 2 yields a test statistic of 8.11. This statistic has a probability value of 0.02, indicating that the cross-equation restrictions should be rejected.

The estimated coefficients of the hours and total income terms in the utility function are all significantly different from zero, while the coefficients of the taste-shifting variables are insignificant. The implications of translog utility function parameters for labor supply behavior are not readily apparent. For 82% of the sample, the point estimates of the utility function parameters imply indifference

curves between income and working hours with positive first and second derivatives, in accordance with conventional assumptions about preferences. However, conventionally shaped indifference curves are not enough to satisfy the second-order condition for utility maximization in the presence of a nonlinear budget constraint. The second-order condition requires that the second derivative of the indifference curve be greater than the second derivative of the budget constraint at the chosen level of hours. This condition is satisfied by 29% of our sample.

[Figure 2] Wage - Hours Relationship



Note: Symbols o and + indicate OLS and IV respectively.



**[Table 3]** The Two-Equation System

	System A	System B
<b>Hedonic Income Equation Parameters</b>		
Log Hours	—	31.11 (2.41)
(Log Hours) <sup>2</sup>	—	−5.32 (3.02)
<b>Labor Supply Equation Parameters</b>		
Log Wage	0.02 (1.94)	—
Log Nonlabor Income	−4.85 (1.05)	—
Log Total Income	—	1.09 (4.26)
Log Hours	—	−1.38 (9.20)
Log Total Income X Log Hours	—	0.75 (9.36)
(Log Total Income) <sup>2</sup>	—	2.12 (3.55)
(Log Hours) <sup>2</sup>	—	−1.82 (16.06)
Children under 17	0.002E-7 (4.34)	0.006E-2 (1.11)
Age	0.008E-2 (2.87)	−0.016E-4 (0.62)
Married	0.012 (2.93)	0.009E-4 (0.03)
Homeowner	−0.003 (7.90)	−0.083E-7 (0.95)

Note: 1) Asymptotic t-ratios are in parentheses.

2) In System B, the labor supply equation parameters are considered to be the utility function parameters, and the HIE parameters [Log Hours and (Log Hours)<sup>2</sup>] are also included in the labor supply equation parameters.

3) Additional variables included in the wage equation and the HIE, and instruments used in estimation are the same as those listed in Table 2.

To get a better idea of the relationship between hours and nonlabor income implied by our estimates, we have calculated the elasticity of labor supply with respect to an increase in nonlabor income, that is, the labor supply response to a vertical shift in the budget constraint. It only makes sense to calculate this elasticity for the members of the sample that satisfy the second-order conditions, and, among those workers, the elasticity has a mean of -1.35 and a standard deviation of 2.67. This estimated elasticity is larger than previous estimates of the effect of wealth on labor supply [see Moffitt(1984)], but it should be kept in mind that because of the nonlinear budget constraint this elasticity is not the same as the conventional nonlabor income elasticity of labor supply. Also, our results in the first column of Table 3 suggest that the conventional model biases the estimated nonlabor income effect toward zero.

## VII. CONCLUSIONS

In this paper we have formulated, specified, and estimated an empirical model of labor supply based on the idea that wages and hours are jointly determined in an implicit market. The implicit market model of labor supply is appropriate for labor markets in which both workers and firms have an interest in the number of working hours. The implicit market model contains the conventional model as a special case, as has been frequently noted, which assumes that exogenous wages are not a function of working hours.

We have demonstrated that labor income and average hourly wages depend on working hours in a nonlinear way and that the OLS estimates of the hedonic income equation are biased. The IV estimates of the wage - hours relationship show that labor income increases at an increasing rate with hours. Average hourly wages behave in actually the same way as labor income. For both the OLS and the IV versions of the HIE, we conducted an F-test to test the hypothesis that wages are independent of working hours. The results show that the hypothesis is easily rejected. The difference between the OLS and IV estimates of the hours coefficients presumably reflects a bias in the OLS estimates caused by the endogeneity of hours in the HIE. We tested the effect of the variables, i.e., Nonlabor Income, Children under 17, and Age, excluded from the X vector to help identify the model, by estimating versions of the HIE that included them. Our results are robust to the relaxation of these exclusion restrictions.

We estimated the conventional labor supply model by 3SLS using the instrumental variables. Overall, the estimates are reassuring in that they show our sample to be a typical one with respect to wages and hours. The implicit market labor supply model was estimated by nonlinear 3SLS, with the cross-equation restrictions implied by the theory imposed, under the assumption that preferences can be approximated by a translog utility function. The resulting indifference curves between income and hours have the conventional curvature for most of our sam-

ple. However, conventionally shaped indifference curves are not enough to satisfy the second-order condition for utility maximization in the presence of a nonlinear budget constraint. Thus, this condition is satisfied by only 29% of our sample. The cross-equation restrictions of the implicit market model are rejected in the translog specification. From the point estimates of the parameters in the implicit market model, we have calculated the nonlabor income elasticity of labor supply. This elasticity is not the same as the conventional nonlabor income elasticity of labor supply because of the nonlinear budget constraint. The conventional model biases the estimated nonlabor income effect toward zero.

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