ESTIMATING THE OPPORTUNITY COST OF TIME WHEN LABOR SUPPLY DECISIONS ARE INSTITUTIONALLY CONSTRAINED

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Plan B Paper

Submitted to the Department of Agricultural Economics
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

1995

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1. INTRODUCTION

Policy decisions concerning options for the recreational use of natural resources typically call for recreation demand and benefit measures that are not revealed by market prices and must therefore be estimated. Travel cost models use a proxy for the unobserved market price to estimate recreation demand. The "price" is typically equal to the sum of time and monetary costs of traveling to the recreation site in addition to any site access fees. This price proxy allows individual recreation demand schedules and their corresponding benefits to be estimated. The time element of the price proxy is converted to its price equivalent and is referred to as the "opportunity cost of time". Conventional methods use the marginal wage as the rate of conversion. Bockstael, Strand and Hanemann (1987) observe, however, that the opportunity cost of time is equal to the wage rate only when individuals are able to choose the hours they work. When individuals face institutional constraints on their labor supply decision, the marginal value of time is unobservable and is generally not equal to the wage rate.

The choice of a time valuation method influences demand estimates of any time-intensive good such as recreation. Time valuation methods that ignore the effects of institutional constraints when time valuation behavior is, in fact, influenced by such effects, will generate biased opportunity time cost estimates. The price proxy used in the travel cost model inherits any time value bias resulting from uncontrolled effects of institutional constraints. A biased price proxy in turn contaminates recreation demand estimates. Freeman (1993, p. 449) intuitively demonstrates that demand for recreation is underestimated when time cost estimates are too high and is overestimated when time cost estimates are too low. Empirical studies by Cesario (1976) and Bishop and Heberlein (1979) support the intuition that demand forecasts and benefit estimates of recreational service flows are highly sensitive to competing estimates of opportunity time costs. A time valuation approach that generates accurate time cost estimates for both constrained and institutionally unconstrained workers is needed in order to derive accurate recreation demand and benefit estimates.

Consumer decision theory of time allocation suggests that individuals' opportunity time costs are influenced by the imposition of constraints on their labor supply decisions. Prevailing time valuation approaches, however, either ignore institutional constraints or account for their influence but place overly-restrictive assumptions on the determination of who is actually constrained. The deficiencies in existing time valuation methods stem from survey designs that collect employment information too limited in scope to allow for the appropriate treatment of institutional constraints.

Conventional time valuation methods preclude assessment of the effects of labor constraints on time values because recreation surveys typically collect only limited employment data on individuals' wage rates and observed work hours. With no information on institutional constraints, time is often valued at the observed wage rate (or at some fraction of the wage rate) and added to monetary costs to construct a price proxy for all respondents. When wage rates are not available, predicted wage rates are sometimes used (see Smith, Desvouges and McGivney, 1983). The recreation demand equation is then estimated as a function of the price proxy. The majority of previous recreation demand and benefit analyses have relied on survey data that provides no information on labor supply constraints. It can be shown that conventional estimation procedures ignoring labor supply constraints generate biased time cost estimates where the sample includes individuals working fixed hours.

As an alternative to conventional approaches, Bockstael, Strand and Hanemann suggest a theoretically-consistent framework where recreation demand functions incorporate the effects of institutional constraints. In addition to the usual survey data collected on observed wages and work hours, they differentiate survey respondents on the basis of whether or not they have the discretion to select the number of hours worked and estimate a separate demand equation for each group. For those with flexible work hours who are identified as unconstrained, time is valued at the marginal wage rate as usual, summed with money costs of travel and entered as a single price proxy in a demand function. For those with fixed work hours who are identified as institutionally constrained, however, the conversion rate of time to its monetary equivalent is unobservable. Instead of constructing a single price proxy, time and money are entered as separate arguments in the demand equation for constrained respondents.

While the motivation behind Bockstael, Strand and Hanemann's method of accounting for the effects of labor constraints on time values is theoretically consistent, their assumption that all individuals with fixed work hours have unobservable opportunity time costs is too restrictive. As noted by Larson (1993), this assumption ignores the possibility that in the long run through the job search process, certain individuals may choose jobs with fixed hours that provide a wage rate equalling their opportunity cost of time. Where this is the case, the conversion rate of time to its monetary equivalent is observable even though work hours are fixed in the short run. The assumption made by Bockstael, Strand and Hanemann is unavoidable given the limited nature of data collected on institutional constraints, but it disregards important information nonetheless.

This paper proposes a new method of time valuation that overcomes the limitations of prevailing techniques. It shares the same advantage of theoretical consistency of the Bockstael, Strand and Hanemann method by allowing opportunity cost of time to diverge from the observed wage rate when individuals face institutional constraints on work hours. Unlike Bockstael, Strand and Hanemann, however, this technique accurately identifies those with observable time costs from those without and permits the unobserved time values to be estimated. Possessing time value estimates for all individuals allows for the construction of a single price proxy and the estimation of a single recreation demand equation.

This proposed approach differentiates respondents on the basis of whether they have fixed or flexible work hours, as Bockstael, Strand and Hanemann do. Then, borrowing a technique employed by labor economists such as Moffitt (1982), Ham (1982) and O'Leary (1991) for the estimation of desired labor supply, individuals with fixed work hours are asked whether they would work more hours, fewer hours or the same number of hours if they were given the choice. Those who have fixed work hours but would choose to work the same number of hours have institutional constraints that are not binding (the point made by Larson). Only those who have fixed work hours and would prefer to work a greater or a lesser amount will have time values that diverge from wage rates. Knowing the direction of desired hours with respect to observed work hours reveals the direction of the opportunity cost of time with respect to the observed wage. The boundary on opportunity time costs provided by the additional desired labor supply information permits unobserved time values to be econometrically estimated.

The organization of the analysis is as follows. Section 2 discusses a consumer decision framework which illustrates how optimal time allocation decisions for workers with flexible hours allows opportunity cost of time to be observed. The discussion is then extended to include labor constraints and shows that when time allocation decisions are constrained, time values are generally unobservable. A behavioral model of time valuation is then presented.

Section 3 describes the sample data used in this analysis of time valuation. The empirical procedures incorporating the effects of institutional constraints to estimate opportunity time costs are derived. Other time valuation methods that may be alternatively employed to acquire time costs are then surveyed and criteria that may be used to select the preferred time valuation approach are outlined. Section 4 implements the empirical procedures set out in Section 3 and presents the resulting time cost estimates that reflect the effects of institutional constraints.

These estimates are compared with time values from alternative methods that ignore labor constraints to examine the effects of institutional constraints on time valuation. The preferred time valuation approach is then selected. Finally, Section 5 offers concluding remarks and specific suggestions for future research in the areas of time valuation and recreation demand analysis.

2. CONCEPTUAL FRAMEWORK

This section describes the underlying consumer decision theory motivating consideration of institutional labor constraints in time valuation analysis. Reference to time values as "opportunity time costs" emphasizes that time is not consumed without cost. While individuals do not physically purchase time, the decision to put an hour of time to a particular use costs the individual the opportunity to put that same hour to an alternative use. If, for example, an individual may allocate a fixed amount of time either to work or to leisure, and these are the only two alternatives, devoting an hour of time to leisure requires the individual to forego the benefits that could have been had by working that hour instead. The monetary benefits of the alternative not chosen in a time allocation decision is the opportunity cost of time.

In the labor-leisure decision framework, individuals are assumed to gain utility both from leisure and from market goods that may be purchased with earned wages. The utility-maximizing individual will equate the marginal benefits of working with the marginal opportunity costs of working. The marginal benefit of working is usually the hourly wage rate which is determined by the employer and is assumed to be constant. The marginal opportunity cost of working increases with each additional hour that is allocated to work--leisure, if it is a normal good, becomes dearer as there is less of it. Those individuals with the discretion to do so will marginally allocate time to work until the opportunity cost of working equals the marginal wage rate. Those individuals working a fixed number of hours are generally unable to equate the opportunity cost of time with the wage rate because their labor supply decision is exogenously restricted.

Section 2.1 illustrates how, under the assumption that individuals' time allocation decisions are endogenous, the same process that maximizes an individual's utility through consumption of optimal amounts of leisure and market goods also allows the individual's opportunity cost of time to be observed. Section 2.2 demonstrates that the utility maximization process no longer allows opportunity cost of time to be observed once institutional constraints are imposed on the time allocation decision. It then shows how information on desired work hours may be exploited to reveal the direction of the opportunity cost of time with respect to the observed wage rate and how this direction may be used to estimate opportunity cost of time.

2.1. GENERAL UTILITY MAXIMIZATION

When individuals may freely make marginal time allocation adjustments, they will trade leisure for labor (or, equivalently, leisure for market goods) until the number of hours worked maximizes their utility. Some individuals faced with a specific wage rate may have preferences that lead them to allocate all of their time to work, consuming no leisure, or to allocate all of their time to leisure, earning no wage with which to purchase market goods. The analysis that follows ignores the possibilities of such "corner solutions" and assumes "interior solutions" where utility maximization requires consumption of positive amounts of both leisure and market goods. By solving the following consumer decision problem, the condition necessary for utility maximization is derived. This condition is used to illustrate that when individuals are free to make the choices that maximize their well-being, their opportunity cost of time is observed.

The consumer decision problem to be solved is

$$\max_{\text{over } C,\, L \text{ and } H} U(C,L) \text{ subject to}$$

$$C = WH + V \tag{2.1}$$

$$T = H + L \tag{2.2}$$

where expressions (2.1) and (2.2) respectively represent income and time constraints. C is the amount of consumer goods consumed, L is the number of hours of leisure consumed, W is the real marginal wage rate, H is the number of hours worked, V is real exogenous income and T is total time available. Note that the choice of hours worked, H, determines the amount of consumer goods and leisure consumed.

The LaGrangian is

$$\mathcal{L} = U(C,L) + \lambda(WH + V - C) + \mu(T - H - L)$$

and the pertinent first order conditions for an interior solution are

$$\partial\mathcal{L}/\partial C = U_C - \lambda = 0 \tag{2.3}$$

$$\partial\mathcal{L}/\partial L = U_L - \mu = 0 \tag{2.4}$$

$$\partial\mathcal{L}/\partial H = \lambda W - \mu = 0. \tag{2.5}$$

Expressions (2.3) and (2.4) may be used to derive the equality

$$\mu/\lambda = U_L/U_C. \tag{2.6}$$

Expression (2.6) states that the opportunity cost of time equals the marginal rate of substitution of leisure for consumer goods.

Expression (2.5) may be rewritten as

$$\mu/\lambda = W. \tag{2.7}$$

Thus,

$$\mu/\lambda = U_L/U_C = W. \tag{2.8}$$

Equation (2.8) is the general utility-maximizing condition for workers in the absence of institutional constraints on work hours. Equation (2.8) states that where the choice of hours worked, H, results in consumption of quantities of consumer goods and leisure that maximize utility, the opportunity cost of time equals the marginal rate of substitution of leisure for consumer goods which equals the marginal wage rate. This utility optimizing condition is depicted graphically in Figure 1.

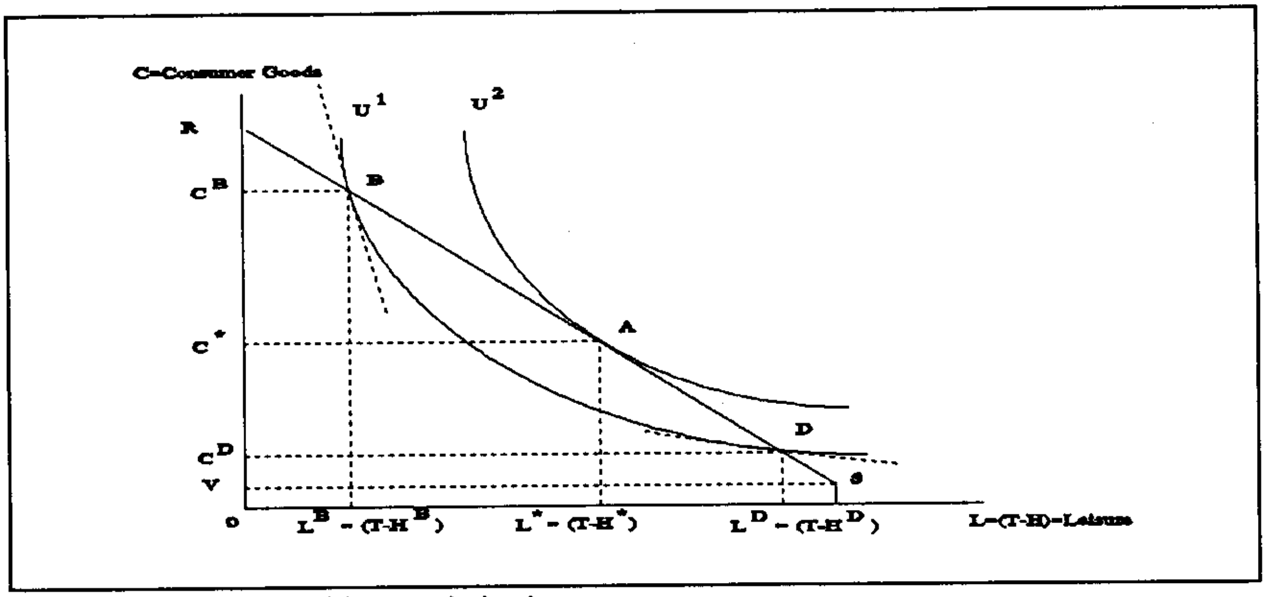

Figure 1. Individual Utility Maximization

In Figure 1, with consumer goods, C, on the vertical axis and leisure, L=T-H, on the horizontal axis, RS is the budget constraint whose slope equals -W. At point S, L=T and C=V. No time is spent working, H=0, which generates no work income. Only exogenous income is available for purchases of consumer goods. At point R, all available time is spent working, H=T, and L=0. C=WT+V, where WT is income generated by working T hours and V is non-work income. The indifference curves, U^1 and U^2, show all combinations of C and L that generate constant utility levels where U^2 represents a higher level of utility than U^1.

For an interior solution, expression (2.8) is represented by a point such as A in Figure 1. At point A, the slope of the indifference curve (the marginal rate of substitution of leisure for consumer goods, $-U_L/U_C$) is equal to the slope of the budget constraint, -W. Therefore, by (2.8), the opportunity cost of time equals the wage rate. At point A, H^* is the choice of total work hours that results in consumption of the optimal quantities of C^* consumer goods and L^* units of leisure that maximize utility for individual i.

At any feasible choice of work hours other than H^*, utility is not maximized. To illustrate, suppose an individual chooses to work H^B hours. This results in the consumption of C^B units of consumer goods and L^B units of leisure time. Given the budget constraint and the choice of H^B hours, this individual's consumption choices are represented by point B in Figure 1, providing the utility level U^1. The marginal opportunity cost of time (marginal rate of substitution), shown as the dashed line tangent to U^1 at point B, is greater than the wage rate. This individual could do better, or increase his utility, by adjusting his marginal opportunity cost of time to equal the wage rate. In this case, the adjustment is made by reducing hours worked from H^B to H^* which reduces consumption of market goods from C^B to C^* and increases consumption of leisure from L^B to L^*. This moves the individual from point B to point A and increases his utility from U^1 to U^2.

2.2. THE EFFECTS OF INSTITUTIONAL CONSTRAINTS ON UTILITY MAXIMIZATION

The analysis of utility maximization through optimal choices C^* and L^* as depicted in Figure 1 rests on the assumption that individuals are able to choose H^*. In otherwords, expression (2.8) holds when individuals' labor supply decisions are not restricted by institutional constraints. Time valuation is less straightforward when individuals face constrained work hours. Where restrictions are placed on the labor-leisure decision, the opportunity cost of time is generally unobservable.

The 40-hour work week is an example of an institutional constraint on work time faced by certain individuals. Some individuals may prefer to work fewer than 40 hours per week at the marginal wage rate offered but are required by their employer to work the full 40 hours. These workers are "overemployed". Other individuals may prefer to work more than 40 hours per week at the marginal wage rate offered but are restricted to working 40 hours. These workers are "underemployed". The opportunity cost of time for those who are overemployed or underemployed is not equal to the marginal wage rate because the observed trade of time for money does not reveal their true time/money preferences.

A third category of workers is "exactly employed", content to work exactly a 40-hour week at the marginal wage rate offered. Although exactly employed workers also face institutional constraints on work hours, the labor constraint does not interfere with their preferred allocation of time. The opportunity cost of time for these individuals is equal to the marginal wage rate because the observed trade of time for market goods coincides with their true time/money preferences.

The consumer decision problem derived in section 2.1 may be rewritten in order to express the utility-maximizing condition for all workers including those in the set of employment categories described above and is expressed as

$$\max_{\text{over } C, L \text{ and } H} U(C,L) \text{ subject to}$$

$$C = WH + V \tag{2.9}$$

$$T = H + L \tag{2.10}$$

$$H = \bar{H} \tag{2.11}$$

where expressions (2.9) and (2.10) respectively represent the income and time constraints faced by all consumers and expression (2.11) represents the additional constraint faced by consumers with fixed work hours. Notation is consistent with that in the general consumer decision problem of Section 2.1. $\bar{H}$ is the number of institutionally-constrained work hours.

With the additional constraint shown in (2.11), H is no longer a decision made by the consumer but rather is fixed by the employer at $\bar{H}$. Since $\bar{H}$ is fixed, the quantity of leisure consumed is fixed at T-$\bar{H}$ and the quantity of market goods is fixed at W$\bar{H}$+V. Consumption of leisure time and market goods cannot be adjusted because work hours are institutionally constrained.

Taking into account the labor supply constraint given in expression (2.11), the LaGrangian is written as

$$\mathcal{L} = U(C,L) + \lambda(WH + V - C) + \mu(T - H - L) + \gamma(H - \bar{H})$$

where the first order conditions for an interior solution are

$$\partial\mathcal{L}/\partial C = U_C - \lambda = 0 \qquad (2.12)$$

$$\partial\mathcal{L}/\partial L = U_L - \mu = 0 \qquad (2.13)$$

$$\partial\mathcal{L}/\partial H = \lambda W - \mu - \gamma = 0. \qquad (2.14)$$

Expressions (2.12) and (2.13) may be used to derive the equality

$$\mu/\lambda = U_L/U_C. \qquad (2.15)$$

This equality states that the marginal opportunity cost of time is equal to the marginal rate of substitution of leisure for consumer goods. Solving expression (2.14) for μ/λ and equating this with expression (2.15), the utility-maximizing equality given the constraint imposed on work hours is derived as

$$\mu/\lambda = U_L/U_C = (W - \gamma/\lambda). \tag{2.16}$$

The marginal opportunity cost of time, μ/λ, may be thought of as the desired wage rate necessary to induce an individual to want to work the number of hours to which he is constrained. Throughout the analysis that follows, μ/λ will be denoted as W^* to emphasize this interpretation of opportunity time costs. Expression (2.16) is accordingly rewritten:

$$W^* = U_L/U_C = (W - \gamma/\lambda). \tag{2.17}$$

Expression (2.17) is the general utility-maximizing condition for all workers. It states that the opportunity cost of time is equal to the marginal wage rate minus an additional term whose sign is determined by γ. γ may be interpreted as the change in utility in response to changing the institutional constraint on work hours by one unit, say from 40 to 41 hours per week. This change in utility may be positive or negative or may be zero. λ is the change in utility in response to a one dollar increase in income and is positive. The term γ/λ, then, is the monetary equivalent of the change in utility resulting from a one unit increase in the number of hours to which an individual is constrained.

For individuals with unconstrained work hours, the constraint in expression (2.11) does not apply and equation (2.17) collapses to equation (2.8) where $W^*=W$. For exactly employed workers who are content to work the institutionally-determined number of hours, the institutional constraint on work hours does not interfere with preferred allocation of time because $\bar{H}$ exactly equals H^*. Substituting $\gamma=0$ into expression (2.17) results in expression (2.8) and the opportunity cost of time simply equals the marginal wage rate. For both unconstrained and exactly-employed individuals then, the available choice of H^* allows optimal consumption of market goods and leisure, C^* and L^*, represented by point A in Figure 1.

Underemployed individuals would work more hours if they could. In Figure 1, a point such as D represents the combination of leisure and market goods of a representative underemployed worker. Institutionally-constrained hours are represented by $\bar{H}^D$ which is less than desired hours, H^*. Increasing $\bar{H}^D$ from 40 to 41 hours would decrease the amount of leisure consumed and increase the amount of market goods consumed. The new combination would be represented by a point on budget constraint RS between points D and A, indicating an increase in utility. The increase in utility from changing the constraint on work hours is associated with a positive sign on γ. By equation (2.17), the opportunity cost of time when γ is positive is less than the wage rate. Therefore, $\bar{H}^D < H^*$ implies $\gamma > 0$, which in turn implies $W^* < W$.

Overemployed individuals would prefer to work fewer hours. In Figure 1, a point such as B where $\bar{H}^B$ work hours are required, represents the constrained utility-maximizing combination of leisure and market goods. Increasing $\bar{H}^B$ from 40 to 41 hours decreases the amount of leisure consumed and increases market goods that may be purchased. The new combination would be represented by a point on the RS budget constraint between B and R and utility would decrease. A decrease in utility indicates that γ is negative which indicates by (2.17) that the opportunity cost of time is greater than the wage rate. Thus, $\bar{H}^B > H^*$ implies $\gamma < 0$, which subsequently implies $W^* > W$.

The direction of opportunity time cost with respect to wage is revealed by the relationship between actual and desired labor supply and is summarized by the following:

$$
\begin{aligned}
&W^* = W \text{ if } H^* = \bar{H}, \\
&W^* > W \text{ if } H^* < \bar{H} \text{ and} \qquad (2.18) \\
&W^* < W \text{ if } H^* > \bar{H}.
\end{aligned}
$$

The underlying behavioral model of time valuation that will be used to estimate (2.17) is

$$W^{*} = f(T, V; Z) \tag{2.19}$$

where the opportunity cost of time, W^{*}, is a function of total available time, T, exogenous income, V, and a vector of sociodemographic characteristics, Z, thought to explain differences in time valuation among individuals. The next section describes how the relationships in (2.18) may be exploited to predict unobserved time costs and sets out the empirical techniques used to estimate the behavioral model of interest in (2.19).

3. EMPIRICAL FRAMEWORK

3.1. THE DATA

The data used in the following time valuation analysis come from the Pilot Survey of Michigan Anglers (PSMA) conducted in 1993. This survey supports a pilot study designed to estimate recreational sportfishing demand in the state of Michigan. The PSMA was conducted in a sequence of five separate interview waves by survey workers at Michigan State University's Survey Research Division using a Computer-Aided Telephone Interview (CATI) system. The resulting data describe respondent behavior during 1993.

Random digit dialing was used to contact 1215 Michigan residents in the initial wave of the survey. Respondents who were likely to go fishing or boating in 1993 were recruited into a panel study. In the panel, four-hundred and eleven respondents identified as "potential anglers"[1] were asked employment questions. One-hundred and eighteen indicated that they did not have a paying job.[2] From the 293 survey respondents with paying jobs, a final subsample of 126 with characteristics pertinent to the behavioral model of time valuation was chosen for the following analysis.

3.2. SAMPLE SELECTION AND ASSIGNMENT OF MARGINAL WAGE VALUES

The selection of the final sample of 126 respondents from the larger group of 293 is diagrammed in Figure 2. Respondents were differentiated on the basis of whether they had fixed or flexible hours. They were additionally identified as hourly or salaried workers.[3]

Figure 2. Sample Selection Rules for Employed Respondents from the 1993 Pilot Survey of Michigan Anglers.

[1] Potential anglers were defined as individuals who had fished in 1993, or who were "somewhat likely" or "very likely" to fish in 1993, or who had purchased a fishing license for 1993.

[2] Of the 118 without a paying job, fifty-five were retired, forty-three were homemakers, two were students, eight were unemployed, nine gave responses other than those listed as choices and 1 refused to answer.

[3] "Salaried workers" also includes respondents paid on commission, or in any other non-marginal form of employment compensation such as truck drivers who are paid by the load or contractors who are paid by the contract.

All individuals with flexible work hours were asked what they would be paid for working an additional hour--a potentially more precise measure of marginal opportunity cost of time than the reported wage. Those providing a valid additional hourly pay rate were included in the final sample and were assigned marginal wage values equal to their additional hourly rate of pay. Those giving an invalid response were unconditionally excluded. Invalid responses consisted of "refused", "don't know" or $0.00 per hour.

Salaried workers were excluded from the sample because of the potential introduction of measurement error when hourly wage rates are calculated from annual income. The exceptions were those salaried respondents with flexible hours who gave a valid additional hourly pay rate. This additional hourly pay rate is taken as an accurate reflection of marginal opportunity cost of time and assigned as the marginal wage rate for the 15 salaried workers meeting the rules of exception. Hourly workers with fixed hours were included in the final sample and assigned marginal wage values equal to their hourly rate of pay.

Some respondents in the PSMA study work multiple jobs. In the final sample, one-hundred and thirteen respondents reported working a single job while 13 worked two jobs. Employment information was collected for each job. Average weekly work hours were summed for those with multiple jobs to form a single "aggregate" job. If the respondent worked flexible hours at either job, the aggregate job was considered to also have flexible hours and the additional hourly rate of pay was assigned as the marginal wage rate. If both jobs offered flexible hours, the aggregate job was considered to have flexible hours and the lower of the two additional hourly pay rates was assigned as the wage rate. Where both jobs required fixed hours, the aggregate job was determined to have fixed hours and the lower of the two hourly wage rates was used as the marginal wage.

The final sample of employed respondents, then, consists of salaried workers with flexible hours and hourly workers with either fixed or flexible hours. Sample characteristics are described in Table 1. The average survey respondent worked approximately 42 hours per week in 1993 at a wage rate of $13.17 per hour with exogenous annual income totaling $16,786. The typical respondent has received slightly more than 13 years of schooling, is 37 years of age and has one or two children under the age of 18 living in the household. Forty-three percent of the sample is female and 60% live in metropolitan areas.

Table 1. Mean Characteristics of Survey Respondents from the 1993 Pilot Survey of Michigan Anglers.

Variable	Total sample [N=126]	Equilibrium employed [N=73]	Overemployed [N=19]	Underemployed [N=34]
WAGE	13.17 (8.02)	14.21 (9.61)	13.59 (5.06)	10.71 (4.36)
HOURS	41.61 (10.84)	40.90 (11.40)	47.37 (10.50)	39.93 (8.86)
EDUCATE[a]	13.06 (2.07)	13.21 (2.20)	13.11 (2.13)	12.74 (1.75)
EXPER[a]	18.16 (10.53)	17.93 (10.90)	18.79 (9.49)	18.29 (10.57)
GENDER[a]	0.43 (0.50)	0.49 (0.50)	0.32 (0.48)	0.32 (0.47)
METROPOL[a]	0.60 (0.49)	0.60 (0.49)	0.63 (0.50)	0.56 (0.53)
AGE	37.22 (10.63)	37.14 (11.09)	37.90 (9.06)	37.03 (10.70)
KIDS18	1.37 (1.36)	1.23 (1.23)	1.21 (1.27)	1.76 (1.62)
VINCOME	16786.00 (23534.00)	15319.00 (28024.00)	22437.00 (13283.00)	16777.00 (16278.00)

a-Indicates explanators of opportunity time cost.

WAGE: gross hourly wage rate in 1993.
HOURS: average weekly hours worked in 1993.
EDUCATE: years of schooling.
EXPER: years of work experience defined as (EDUC-AGE-6).
GENDER: binary gender indicator [male=0; female=1].
METROPOL: binary indicator for metropolitan area of residence [non-metropolitan area=0, metropolitan area=1][4].
AGE: age in years.
KIDS18: number of children under age 18 in the household.
VINCOME: exogenous (non-work) annual income, calculated as household income minus annual earnings.

[4] Counties of residence are coded as metropolitan areas or as non-metropolitan areas according to the Michigan Population Update (March 1993) classifications which are based on 1990 Census data.

3.3. EMPLOYMENT REGIME ASSIGNMENT

Section 2.2 developed a theory of time valuation applicable to each of four exhaustive employment regimes to which workers may belong: flexible work hours, fixed/exactly employed, fixed/overemployed, or fixed/underemployed. For estimation purposes, it is useful to regroup observations by the structure of the observed data. Table 2 describes how binary indicator variables are used to assign employment regimes to observations with similarly-structured data.

Table 2. Binary Indicator Employment Regime Assignment for Respondents from the 1993 Pilot Survey of Michigan Anglers.

	FLEXIBLE HOURS[a] [N=46]	FIXED HOURS [N=80]		
		EXACT[a] [N=27]	OVER [N=19]	UNDER [N=34]
I	1	1	0	0
Y	0	0	1	0

a-Employed in equilibrium

I=1: Unconstrained
Y=1: Overemployed

The binary indicator variable, I, is used to separate those with continuous opportunity time cost data, I=1, from those without continuous data, I=0. Flexible hour workers and fixed/exactly employed workers have continuously observable opportunity time costs and are assigned the value I=1. Fixed/overemployed and fixed/underemployed workers are assigned the value I=0.

Overemployed and underemployed respondents have opportunity time costs that are not observable. What is observed, however, is the direction of opportunity cost with respect to the wage rate. By identifying a binary indicator variable with the direction of opportunity cost of time and treating the wage rate as a threshold, the observed data (the binary variable values) take on a discrete structure which may be exploited to estimate the magnitude of the unobservable opportunity time costs. The binary variable, Y, takes on the value 1 for overemployed respondents and takes on the value 0 for respondents who are not overemployed.

Every respondent in the sample is assigned values for I and for Y. For respondents employed in equilibrium, I=1 and Y=0. Overemployed workers carry the binary indicator combination of I=0 and Y=1. Underemployed respondents are identified with the combination I=0 and Y=0.

Returning to Table 1, the last three columns describe respondent characteristics by employment regime. Overemployed and underemployed respondents were more likely to be men than women. The underemployed worked less and earned less per hour than average. The theory developed in Section 2 indicates that average marginal opportunity cost for underemployed workers should be lower than the average observed hourly wage of $10.71. The overemployed worked more and earned more per hour than average. Theory suggests that average opportunity cost of time for overemployed workers should be greater than the average observed wage of $13.59 per hour. Exogenous annual income for the typical overemployed respondent was $22,437, approximately 34% higher than the average survey respondent. An equal number of men and women are employed in equilibrium and make up slightly more than half of the sample. They are paid more per hour and work fewer hours than average. The average opportunity cost of time for those employed in equilibrium is $14.21 per hour.

3.4. USING EMPLOYMENT REGIME INFORMATION TO ESTIMATE OPPORTUNITY COST OF TIME

The underlying behavioral model of time valuation is

$$\log(W_i^*) = X_i\beta + u_i \tag{3.1}$$

where the dependent variable, $\log(W_i^*)$, is the log of opportunity time cost, X_i is the vector of independent variables explaining individual variation in time valuation, and u_i is the error term which is assumed to be independent of X_i and is distributed as Normal $[0,\sigma^2]$. If opportunity time costs were continuously observed for all respondents in the sample (no workers faced institutional constraints), the behavioral model could be estimated by ordinary least squares (OLS). If opportunity time costs were unobserved for all survey respondents (all respondents faced institutional constraints) and the distributional assumption $u_i \sim$ Normal (0,1) were made, the discrete indicator variable Y_i, where

$$Y_i = 1 \text{ if } \log(W_i^*) > \log(W_i) \text{ and} \qquad (3.2)$$
$$Y_i = 0 \text{ if } \log(W_i^*) < \log(W_i),$$

could be used in a probit estimation to analyze expression (3.1).

As indicated in the previous section, the PSMA sample contains respondents with continuous and discrete data. Neither procedure described above is appropriate for estimation of this type of mixed sample. OLS produces biased estimates of opportunity time costs and probit analysis discards valuable information available on unconstrained workers' opportunity time costs.

For a sample containing continuous and discrete data, joint maximum likelihood estimation (MLE) is an appropriate method. The MLE method searches for and reports parameter values that maximize the probability of observing the data in the sample, assuming that a specific distribution (the normal distribution in this case) generated the data. Separate conditional probability density functions associated with continuous and discrete data give the probabilities that an individual will be employed in equilibrium, overemployed or underemployed. These probability density functions are used to derive log likelihood functions for each respective employment regime. The separate log likelihood functions are then jointly maximized to obtain estimates of the parameters in equation (3.1).

There are a total of N respondents in the sample. N_1 are employed in equilibrium, N_2 are overemployed and N_3 are underemployed so that $N_1 + N_2 + N_3 = N$.

The probability density for an individual who is employed in equilibrium with continuously observable opportunity time costs is

$$f(\log W_i;\ \beta,\ \sigma^2) = \frac{1}{\sigma}(2\pi)^{-\frac{1}{2}}\ e^{-\frac{[\log(W_i) - X_i\beta]^2}{2\sigma^2}} \tag{3.3}$$

where $i=1,2,\ldots,N_1$. Taking the log of (3.3), the log likelihood function for the N_1 unconstrained individuals is

$$\begin{aligned} &\log L_1\ (\beta,\ \sigma^2) \\ &\quad = -\frac{N_1}{2}\log 2\pi - \frac{N_1}{2}\log\sigma^2 - \frac{1}{2\sigma^2}\sum_i [\log(W_i) - X_i\beta]^2 \end{aligned} \tag{3.4}$$

The probability that any individual is underemployed is

$$\begin{aligned} &Pr(Y_i = 0 \mid X_i,\ I_i = 0;\ \beta,\ \sigma^2) \\ &\quad = Pr[\log(W^*_i) < \log(W_i)] \\ &\quad = Pr[X_i\beta + u_i < \log(W_i)] \\ &\quad = Pr[u_i < \log(W_i) - X_i\beta] \\ &\quad = Pr[\frac{u_i}{\sigma} < \frac{\log(W_i) - X_i\beta}{\sigma}] \\ &\quad = \Phi\left[\frac{\log(W_i) - X_i\beta}{\sigma}\right] \end{aligned} \tag{3.5}$$

where $\Phi(.)$ is the cumulative distribution function for the standard normal distribution and $i=(N_1+1), (N_1+2),\ldots,(N_1+N_2)$. Taking the log of (3.5), the log likelihood function for the N_2 underemployed individuals is

$$\log L_2\ (\beta,\ \sigma^2) = \sum_i \log\Phi \left[\frac{\log(W_i) - X_i\beta}{\sigma}\right] \tag{3.6}$$

The probability that any individual is overemployed is

$$Pr(Y_i = 1 \mid X_i,\ I_i = 0;\ \beta,\ \sigma^2) = 1 - \Phi\left[\frac{\log(W_i) - X_i\beta}{\sigma}\right]. \tag{3.7}$$

where $i=(N_1+N_2+1), (N_1+N_2+2),\ldots,N$. Taking the log of (3.7), the log likelihood function for the N_3 overemployed individuals is

$$\log L_3\ (\beta,\ \sigma^2) = \sum_i \log\left(1 - \Phi\left[\frac{\log(W_i) - X_i\beta}{\sigma}\right]\right) \tag{3.8}$$

The final step is to derive the joint log likelihood function for all workers in all employment regimes. This is simply the sum of expressions (3.4), (3.6) and (3.8):

$$\log L\ (\beta,\ \sigma^2) = \log L_1\ (\beta,\ \sigma^2) + \log L_2\ (\beta,\ \sigma^2) + \log L_3\ (\beta,\ \sigma^2). \tag{3.9}$$

Applying maximum likelihood techniques to expression (3.9) results in the MLE parameter estimates $\hat{\beta}^T$ and $\hat{\sigma}^{2T}$. When β and σ^2 in the population regression

$$E(W^*_i \mid X_i) = \exp(\frac{\sigma^2}{2})\ \exp(X_i\beta) \tag{3.10}$$

are replaced with $\hat{\beta}^T$ and $\hat{\sigma}^{2T}$, respectively, individual opportunity time cost estimates that incorporate the effects of institutional constraints on time valuation may be obtained.

3.5. ALTERNATIVE TIME VALUATION APPROACHES

Section 3.4 introduced a new method of time valuation, hereafter called the "time value" (TV) approach, that accounts for the effects of institutional constraints on opportunity time costs and expands available options for valuing time. This study seeks ultimately to suggest which among available time valuation options provides the most accurate time value estimates. A brief overview of the competing time valuation techniques is therefore in order.

To estimate recreation demand in a single equation (rather than the multiple demand equation method of Bockstael, Strand and Hanemann), time must be translated to its monetary equivalent at some rate of conversion. The most prevalent technique converts time costs to money costs at the rate of observed marginal wage for all respondents. This will be referred to as the "observed wage" (OW) approach. Alternatively, a wage equation may be used to obtain predicted wage which is then used as the conversion factor for the full sample. This will be distinguished as the "predicted wage" (PW) technique. The key feature to note of these two time valuation techniques is the implicit assumption that institutional constraints do not create a significant divergence between opportunity cost of time and the marginal wage rate and may be effectively ignored.

The competing hypothesis, that institutional constraints do influence opportunity time costs, motivates three additional time valuation methods. The first method is the "time value" (TV) approach. The TV technique is operationalized as described in the previous section and the resulting predictions of opportunity time costs are used as the time conversion rate for all respondents. In a somewhat different manner of accounting for institutional constraints, hybrid approaches may be used to convert time costs to money costs. There are two different hybrids. In accordance with the theoretical relationship of equality between wage and opportunity cost of time for those employed in equilibrium, both hybrid methods value time at the observed marginal wage rate only for those who would not change the number of hours worked. The "OW-PW" hybrid uses PW predictions as the conversion rate for those who are overemployed and underemployed while the "OW-TV" hybrid uses TV predictions to convert time for institutionally-constrained workers.

3.6. SELECTING THE PREFERRED TIME VALUATION APPROACH

In selecting a preferred method from among the approaches discussed above, a question of central interest is whether including or ignoring institutional constraints in the estimation of opportunity cost of time best describes true time valuation behavior. Given a model of time valuation such as that in expression (3.1), this question may be answered by statistically comparing the TV parameter estimates of the time cost model that reflect the incorporation of institutional constraints with the PW regression coefficients that ignore the effects of labor supply constraints.

Three possible outcomes may result from the comparison of the TV and PW estimates. First, TV estimates may be closer than PW estimates to the true parameter values. Where this is the case, including institutional constraints explains actual time valuation behavior significantly better than ignoring institutional constraints. Disregarding the effects of institutional constraints produces biased opportunity time cost estimates. A second possible outcome is that PW estimates may be closer to actual parameter values than TV estimates. Ignoring the effects of institutional constraints better describes true time valuation behavior and TV estimates incorporating institutional constraints contain more error than do PW estimates. Finally, the two sets of estimates may not be significantly different from one another. When this is true, the simpler time valuation approach that ignores the effects of institutional constraints and the more complex and data-intensive time valuation technique that reflects the influence of labor supply constraints explain actual time valuation behavior equally well.

This comparison of TV and PW estimates provides a logical first step in the selection process of a preferred time valuation approach. If the comparison finds the TV and PW approaches equal in ability to describe true time valuation behavior, TV and PW estimates are equivalent, as are OW-TV and OW-PW estimates. Further evaluation to select the preferred time valuation method may then be limited to the simpler OW, PW and OW-PW approaches. If TV and PW estimates differ, all five approaches must examined more closely to rank performance.

Vuong (1989) proposes a non-nested likelihood ratio-based test that may be readily performed to examine the competing hypotheses regarding the impacts of institutional constraints on opportunity cost of time. In a traditional hypothesis testing framework, the null hypothesis stating that the TV and PW approaches describe the true data generating process equally well is tested against the alternatives that one model specification does better.

To operationalize Vuong's test, define the parameter estimates from the PW approach as $\hat{\theta}^W$, where $\hat{\theta}^W=(\hat{\beta}^W, \hat{\theta}^{2W})$ and the individual log-likelihood values evaluated at $\hat{\theta}^W$ as

$$\log l_i^W (\hat{\theta}^W; X_i) = \hat{l}^w_i. \tag{3.11}$$

Similarly, let $\hat{\theta}^T$ be the parameter estimates from the TV model, where $\hat{\theta}^T=(\hat{\beta}^T, \hat{\theta}^{2T})$ and denote the individual log-likelihood values evaluated at $\hat{\theta}^T$ as

$$\log l_i^T (\hat{\theta}^T; X_i) = \hat{l}^T_i. \tag{3.12}$$

Vuong's test statistic is

$$V = \frac{\sum_i \left\{ \hat{l}^T_i - \hat{l}^W_i \right\}}{\left\{ \sum_i \left[\hat{l}^T_i - \hat{l}^W_i \right]^2 \right\}^{1/2}} \quad . \tag{3.13}$$

where V is asymptotically distributed as Normal (0,1).

The null hypothesis may be expressed as

$$H_0: \ E\,(l_i^T - l_i^W) = 0 \tag{3.14}$$

which means that the TV and the PW approaches are equivalent. The competing hypotheses are

$$H_{A1}: \ E\,(l_i^T - l_i^W) > 0, \tag{3.15}$$

meaning that the TV approach explains the population better than the WP approach, and

$$H_{A2}: \ E\,(l_i^T - l_i^W) < 0 \tag{3.16}$$

which means that the WP approach explains the population better than the TV approach.

If the null hypothesis cannot be rejected, it may be concluded that the time valuation approach ignoring the consequences of institutional restrictions on individuals' labor supply decisions comes as close to describing the true data generating process as does the more complex technique accounting for the effects of time allocation constraints. Both the TV and PW approaches generate equally-precise time cost estimates. Further examination of model performance may be restricted to the OW, PW and OW-PW approaches.

If the null hypothesis of equivalent model performance is rejected, there are grounds to prefer one model over its alternative. If Vuong's test statistic is positive in sign, H_{A1} is the appropriate alternative hypothesis and the TV approach has the better ability to describe the time valuation behavior in the population. For the given specification of the time valuation model, opportunity cost of time is sensitive to restrictions placed on labor supply decisions. PW estimates contain significant bias. If the magnitude of the bias is considerable, neither the PW nor the OW-PW techniques will be the preferred approach and further examination may be restricted to the OW, TV and OW-TV approaches. If the bias is relatively minor, the prediction performance of all five approaches should be evaluated in terms of additional criteria.

A negative sign on the test statistic indicates that H_{A2} is the appropriate alternative hypothesis and that PW estimates are closer to the true time valuation parameters than TV estimates. For the specified model of opportunity cost of time, institutional constraints do not significantly influence time valuation. TV estimates contain bias and if the bias is substantial, neither the TV nor the OW-TV approaches will be preferred. If, however, the magnitude of the bias is relatively modest, the inaccuracy of the estimates may be forgivable if this type of approach provides an improvement in terms of other evaluative criteria.

Vuong's test and the qualitative measure of bias magnitudes help to narrow the field of preferred time valuation techniques. To complete the selection process, two additional evaluative criteria are employed. Both are qualitative "goodness of fit" measures based on how well the time cost estimates generated by each approach conform with what theory maintains is the correct relationship between marginal wage and marginal opportunity cost of time. Each criterion provides a different appraisement of predictive accuracy. The first goodness of fit criterion measures the percentage of observations for which an approach predicts a time cost that is greater than (less than) observed wage when the respondent indicated that he was overemployed (underemployed). This "percent correctly predicted" criterion may be calculated only for institutionally-constrained individuals. The second goodness of fit criterion is a measure of average predictive accuracy, comparing the mean predicted opportunity cost of time with average reported wage for each of the three employment regimes (equilibrium-employed, overemployed and underemployed).

In the following section, equation (3.1) is estimated by the TV and PW approaches and the results are presented. These results are then used to operationalize Vuong's non-nested test and to determine whether either time valuation technique may be ruled out of the selection process. The predictive accuracy measures permit final selection of a preferred approach for estimating opportunity cost of time in this sample.

4. EMPIRICAL RESULTS

4.1. MODEL SPECIFICATION

Until now, specification of the model of time valuation has been kept very general to simplify notation. At this point, however, a specific functional form must be selected for empirical implementation of the theory developed in Section 2 and of the general estimation procedures set out in Section 3. While there is little in the opportunity cost of time literature to steer selection of model specification and functional form, the utility-maximizing condition derived in Section 2.2 provides some clues.

Equation (2.17) indicated that opportunity cost of time is the sum of two components: wage and a term that depends on the divergence between desired work hours and constrained work hours. In the event that institutional constraints do not influence time valuation, the opportunity time cost model is a wage equation. Specification of the opportunity cost of time equation, then, would include individual characteristics determining equilibrium wage. In the event that institutional constraints do influence opportunity time costs, equation (2.19) indicates that opportunity cost of time depends not only on wage determinants, but on exogenous income and individual determinants of desired labor supply as well. The PSMA data includes exogenous income and an additional variable that is typically found to influence individuals' desired supply of labor. This additional variable that would enter a desired labor supply function is KIDS18, the number of children in the household under the age of 18.

The original specification of the opportunity cost of time model, then, included the following regressors: ONE (a constant term), EDUC (years of formal education), EXPER (years of general work experience calculated as AGE-EDUC-6), GENDER (a binary variable equalling 0 if male, 1 if female), METROPOL (another binary variable equalling 1 if the respondent lives in a metropolitan area and 0 otherwise), KIDS18, and VINCOME (exogenous income).

As a preliminary specification test of whether desired labor supply determinants available in the PSMA data set influence opportunity cost of time, a likelihood ratio test was performed to determine whether KIDS18 and VINCOME were jointly significant. Results of the test indicated that KIDS18 and VINCOME were not jointly significant at the 5% level. These two variables were subsequently dropped from the final model specification.

The final model of time valuation is explicitly expressed as

$$\log(W^*_i) = \beta_0 + \beta_1 EDUC_i + \beta_2 EXPER_i + \beta_3 GENDER_i + \beta_4 METROPOL_i + u_i \tag{4.1}$$

where $i=1,\ldots,N$, u_i is independent of X_i and $u_i \sim$ Normal $(0,\sigma^2)$.

The dependent variable is the natural log of opportunity cost of time. Because the distribution of wages is typically skewed while the distribution of the logarithm of wages tends to more closely follow the normal distribution, the semi-log functional form is commonly found in the wage literature. Given that nearly 60% of PSMA survey respondents have opportunity time costs identical to observed wage, the semi-log form is adopted here.

4.2. REGRESSION RESULTS

Invoking the conventional assumption that institutional constraints do not produce a significant divergence between observed wage and opportunity cost of time, the PW approach may be used to estimate equation (4.1). When the assumption is relaxed to allow for the possibility that institutional constraints influence time valuation, expression (4.1) may be estimated using the TV approach. Both TV and PW regressions were run in LIMDEP 6.0 (Greene, 1991). The "minimize" command was used to minimize the negative of the log-likelihood function given in equation (3.9). Parameter estimates obtained from the TV and PW models are presented in Table 3. All four of the determinants commonly found to be significant in wage equations (EDUC, EXPER, GENDER, and METROPOL) are statistically significant in both the TV and PW regressions.

Table 3. Parameter Estimates from Time Value and Predicted Wage Regressions[a]

Variable	Time Value (TV) Model Estimates	Predicted Wage (PW) Model Estimates
CONSTANT	0.907 (0.416)	1.162 (0.280)
EDUC	0.096* (0.032)	0.082* (0.021)
EXPER	0.017* (0.006)	0.015* (0.004)
GENDER	-0.497* (0.130)	-0.508* (0.088)
METROPOL	0.217** (0.126)	0.200* (0.091)
SIGMA	0.590 (0.055)	0.441 (0.026)
LOG-LIKELIHOOD	-105.123	-75.489

a-standard errors are given in parentheses.
*-significant at the 5% level.
**-significant at the 10% level.

The semi-log functional form of equation (4.1) generates parameter estimates, $\hat{B}_k = \partial \log \hat{W}^* / \partial X_k$, that are interpreted as semi-elasticities. Results in the wage literature are commonly reported as the percent change in wage due to a one unit increase (ceteris paribus) in a regressor. To obtain comparable regression results, the transformation $\exp(\hat{\beta}_k) - 1$, where k=1,2,...,6, is applied to parameter estimates in Table 3[5].

An additional year of education increases opportunity cost of time by 9.92 percent in the TV specification and by 8.59 percent in the PW model. These rates of return to an additional year of education correspond closely to the range of 7.9-10.2% reported by Robert J. Willis (1986) in his survey of earnings functions and wage determinants. An additional year of experience has a modest economic effect, increasing opportunity cost of time by 1.68% in the TV model and by 1.54% in the PW model.

Evidence of a significant and economically large difference in time valuation on the basis of gender exists. The TV approach shows that marginal opportunity cost of time for women is 64% less than for men on average and the PW approach estimates that womens' average time value is 66% of mens'. This gender differential in time valuation is consistent with gender differentials found in studies of earnings discrimination. Using time series data from the U.S. Department of Labor for years 1967 to 1984, McConnell and Brue (1986) show that womens' median weekly earnings are consistently 61-65% less than those of men. Geographic area of residence is also found to influence individuals' valuation of time. Respondents living in

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[5]

$\frac{W_1^* - W_0^*}{W_0^*}$ is the % change in opportunity cost of time.

If $\Delta X_k = 1$, then $\frac{\hat{W}_1^* - \hat{W}_0^*}{\hat{W}_0^*} = \frac{e^{\hat{\beta}X + \hat{\beta}_k} - e^{\hat{\beta}X}}{e^{\hat{\beta}X}} = e^{\hat{\beta}_k} - 1.$

metropolitan areas have time values that are 22.0% higher than those living in non-metropolitan areas according to the PW model and 24.0% higher according to the TV model.

4.3. COMPARATIVE RESULTS OF TIME VALUATION APPROACHES

This section compares performances of the competing time valuation techniques to establish which approach generates the most accurate opportunity time cost values. The first step in the selection process involves determining whether actual time valuation behavior is best described by including or excluding the potential effects of institutional constraints on opportunity time costs. Designating the TV and PW techniques as competing model specifications, Vuong's likelihood ratio-based test was performed with the resulting test statistic of -5.03. The critical value at the 5% level is 1.65. Since the normal distribution is symmetric, the absolute value of the test statistic may be used for the hypothesis test and is seen to be much larger than the 5% critical value. This result confirms that the TV and PW estimates are statistically different at the 5% level. The null hypothesis of equivalent model performance developed in expression (3.14) is rejected. The negative sign of Vuong's test statistic indicates that of the two alternative hypothesis, H_{A2}, described in expression (3.15), best describes how time is valued in the population. Taken together, the sign and magnitude of the test statistic verify that institutional constraints on labor supply significantly influence time valuation in this model specification. The simpler PW is preferred over the TV approach that uses additional information on labor supply constraints.

The results of Vuong's test indicate that PW parameter estimates are closer to the true values than are TV estimates. This being the case, if the divergence between PW and TV time cost predictions is considerable, the degree of inaccuracy attributable to incorporating the effects of institutional constraints on opportunity cost of time would noticeably carry over to the travel cost price proxy. Considerable inaccuracy of the TV predictions of opportunity time costs would effectively rule out the TV approach from the selection process. If, however, the time values predicted by the competing estimation techniques are close, the PW approach may not be so easily dismissed. The parameter estimates from the PW approach are very similar to those from the TV approach. When the respective parameter estimates are used to forecast opportunity cost of time, the PW technique predicts an average marginal opportunity time cost of $13.14 while the TV approach estimates an average time value of $13.46 per hour. The average difference of $0.32 is not sufficient to rule out the TV technique at this point. Final selection of a preferred time valuation method requires further examination of all five time valuation approaches.

The final criteria permitting selection of a preferred time valuation approach are qualitative goodness of fit measures. The percent correctly predicted criterion measures the percent of time costs predicted for institutionally-constrained respondents that have the correct relationship to observed wage (greater or less than) as dictated by the theory set out in Section 2.2. These percentages for the four time valuation approaches using predicted time costs as conversion rates are presented below in Table 4. Since the OW-TV hybrid approach uses TV predictions for constrained workers, the OW-TV and TV percentages are the same. Similarly, the OW-PW hybrid technique uses PW predictions for respondents facing institutional constraints, so OW-PW and PW percentages correctly predicted are also equivalent.

Table 4. Percent Correctly Predicted for TV/OW-TV and PW/OW-PW Approaches

	TV/OW-TV Approaches	PW/OW-PW Approaches
Overemployed Correctly Predicted	68% (13/19)	63% (12/19)
Underemployed Correctly Predicted	29% (10/34)	32% (11/34)
Total Constrained Correctly Predicted	43% (23/53)	43% (23/53)

The TV and OW-TV approaches have only slightly greater predictive accuracy than the PW or OW-PW approaches for overemployed workers, forecasting time values greater than the wage rate for 13 of the 19 who would prefer to work less. For the underemployed, the TV and OW-TV techniques perform only slightly better than the PW and OW-PW approaches, with 32% correctly predicted. The bottom row in Table 4 indicates that overall performance of all four of the approaches is generally poor. In terms of predicting time values for constrained workers, the four time valuation techniques return predictions in accordance with theory for only 43% of the constrained sample. This indicates that for 57% of institutionally-constrained respondents, observed wage is closer to the true opportunity cost of time than any of the predicted time values from the other approaches.

The criteria used in this selection process may be categorized as absolute measures or as relative measures. Absolute measures detect the presence of an effect, while relative measures examine the impact of the effect. For example, Vuong's test detected a significant influence of institutional constraints on time valuation. In absolute terms, the results suggested that more accurate estimates result from incorporating the effects of institutional constraints. In relative terms, however, examination of the impact of ignoring institutional constraints indicated that the influence of institutional constraints on time valuation was not economically significant.

The criterion of percent correctly predicted is an absolute measure of predictive accuracy. The final selection criterion is a relative measure of predictive accuracy evaluating how well the conversion rates of each time valuation approach fits with what theory maintains is the correct relationship between marginal wage and marginal value of time for each employment regime. Theory specifies different relationships for the different employment regimes. Therefore, mean opportunity time costs predicted by each approach are generated for each of the three employment regimes. These mean predicted time costs are then compared with the average observed wage for each of the employment regimes. These averages are reported in Table 5.

Table 5. Average Observed Wage and Mean Predicted Opportunity Time Costs by Employment Regime[a]

	Observed Marginal Wage Rate	TV Predictions	OW-TV Predictions	PW Predictions	OW-PW Predictions
Equilibrium employed	$14.21 (9.61)	$13.29 (5.30)	$14.21 (9.61)	$12.92 (4.85)	$14.21 (9.61)
Over employed	$13.59 (5.06)	$14.12 (3.91)	$14.12 (3.91)	$13.82 (3.67)	$13.82 (3.67)
Under employed	$10.71 (4.36)	$13.47 (4.52)	$13.47 (4.52)	$13.24 (4.21)	$13.24 (4.21)

a-Standard errors are given in parentheses.

For those employed in equilibrium, theory states that opportunity cost of time is equal to the observed marginal wage rate. The equality of the theoretically-correct relationship between value of time and wage allows one to measure the average prediction error in each time valuation approach for those who are working their preferred number of hours. It can be seen in Table 5 that, on average, predictions from the TV model underestimate opportunity cost of time for unconstrained individuals by 6.5%, while the PW model underestimates the value of time by 9.1%. For equilibrium-employed workers, the observed wage, OW-TV and OW-PW approaches have no predictive error.

Opportunity time costs for constrained workers are unobservable and predictive error cannot be calculated as it may be for unconstrained workers. However, theoretically-consistent predictions of opportunity time costs should, on average, be greater than the mean reported wage for the subsample of overemployed respondents and less than the mean reported wage for the underemployed subsample. Table 5 clearly shows that all of the TV, OW-TV, PW or OW-PW average predictions for overemployed workers agree with what is maintained by theory to be accurate for individuals who would prefer to work less. None of these approaches generate average predictions that are consistent with theory for the underemployed.

For overemployed workers, the TV, OW-TV, PW and OW-PW approaches correctly predict average opportunity time costs that are greater than the subsample mean wage of $13.59. There are no further theoretical guidelines to suggest whether the PW mean predicted time value of $13.82 or the TV average predicted time cost of $14.12 is closer to the true mean opportunity cost of time for those who would work less. Therefore, all four approaches using either the TV or PW predictions as conversion rates are assumed to be equally acceptable for the subsample of individuals who would prefer to work less.

For underemployed workers, theory indicates that average opportunity cost should be less than the subsample mean wage of $10.71. The TV, OW-TV, PW and OW-PW approaches, however, predict average opportunity time costs greater than the subsample mean wage. The conversion rate preferred on the basis of containing the least amount of error according to theory is the observed marginal wage rate. Among the other approaches, the PW and OW-PW time cost predictions contain less error than the TV and OW-TV predictions, but are, on average, inconsistent with the correct relationship between marginal wage and marginal value of time as determined by theoryfor those who would work more.

When the five time valuation approaches are ranked according to the collective criteria discussed above, the OW approach is selected as the preferred time valuation technique. The OW approach provides the most accurate of all available time values for 85% of the sample--observed wage is the precise conversion rate for the 73 respondents who are employed in equilibrium and is the best available conversion rate for the 34 who are underemployed. The hybrid OW-PW and OW-TV techniques by design also provide precise conversion rates for the 73 equilibrium-employed. The OW-PW approach additionally gives the most accurate conversion rate for 12 of the overemployed respondents while the OW-TV technique gives the most accurate conversion rate for 13 of the overemployed. The OW-PW and OW-TV approaches, then, provide the most accurate conversion rates for 68% and 67% of the sample respectively. The TV and PW approaches are the least preferred of the five time valuation techniques. The TV method has slightly better predictive accuracy than the PW method, but also overestimates opportunity cost of time for the equilibrium-employed slightly more than does the PW method.

5. CONCLUSIONS

This paper develops a new framework for the estimation of opportunity cost of time that is proposed as a theoretically-consistent alternative to conventional ad hoc time valuation. Drawing on recent advances in the labor supply literature, the proposed technique elicits from survey respondents the direction of desired work hours with respect to observed work hours which reveals the direction of opportunity cost of time bounded either from above or from below by the observed marginal wage rate. This additional information allows unobserved individual time values to be estimated. Possessing estimates of opportunity time costs that reflect the influence of institutional constraints permits construction of an unbiased price proxy which may be used in a single travel cost demand specification to estimate demand for recreation.

The hypothesis that institutional restrictions on work hours influence time valuation is tested. The influence is found to be statistically, but not economically, significant. The economic magnitude of the bias in time values resulting from omission of the influences of institutional constraints appears to be very small. Predictive accuracy criteria determine that using observed marginal wage as the rate of conversion of time costs to money costs is the most preferable strategy among those considered in this analysis.

The results indicating that opportunity time costs and marginal wage rates do not diverge decidedly when work hours are institutionally constrained lend support to Larson's framework within which individuals' opportunity time costs are equal to their marginal wage rates even when work hours are fixed when recreation choices are taken as short-run decisions conditioned on long-run labor supply. Further support for this notion is found in the PSMA survey results. One third of the respondents facing institutional constraints would work the same hours if the constraint were lifted. These respondents were employed in equilibrium, working fixed hours at wages that correspond with their marginal value of time. In the long-run, individuals for whom marginal opportunity cost of time does not equal marginal wage rate may change jobs to obtain their desired wage. To do so, they must incur costs of the job search. Utility-maximizing individuals will incur the costs of job search if the divergence between opportunity cost of time and marginal wage rate is at least as large. The larger the divergence, the more likely is the individual to search for alternative jobs offering more desirable packages of wages and hours. Therefore, individuals observed to be overemployed or underemployed are likely to have small differences between marginal wage and opportunity cost of time because this divergence is bounded by search costs.

The data set used in this analysis consists of only 126 observations and systematically excludes salaried workers with fixed work hours. Running these same analyses on a larger, more comprehensive data set is recommended as a next step. If results from subsequent analyses are consistent with the preliminary results from this study, appropriate recreation demand and benefit estimates may be obtained in a single demand equation where the time element of the price proxy is converted to its monetary equivalent at the marginal wage rate. If, however, the influence of institutional constraints on time valuation is found to be statistically and economically significant, efforts to procure unbiased time cost estimates are warranted. Demand estimates obtained through the Bockstael, Strand and Hanemann method should be compared with estimates obtained from the single demand equation specification permitted by calculation of a price proxy that reflects the influence of institutional constraints to determine the preferred strategy.

APPENDIX A: SELECT SURVEY QUESTIONS FROM THE 1993 PILOT SURVEY OF MICHIGAN ANGLERS

A16 The following questions will help us generalize the results and learn about how work-time requirements affect recreation. Remember all answers are strictly confidential.

Do you have a paying job?

<1> YES
<5> NO
<8> DONT KNOW
<9> REFUSED

[IF THE RESPONDENT ANSWERED QUESTION A16 WITH A RESPONSE OTHER THAN <1>, QUESTION A17 FOLLOWED, WHILE A RESPONSE OF <1> TO QUESTION A16 PROMPTED QUESTION A20]

A17 Which of the following best describes your current employment situation?

Would you say you are retired, homemaker, student, seasonally off work, unemployed and looking for work, or unemployed but not looking for work?

<1> RETIRED
<2> HOMEMAKER
<3> STUDENT
<4> SEASONALLY OFF WORK
<5> UNEMPLOYED AND LOOKING FOR WORK
<6> UNEMPLOYED AND NOT LOOKING FOR WORK
<7> OTHER[specify]
<98> DONT KNOW
<99> REFUSED

A20 How many different paying jobs do you have?

<1-5> DIFFERENT PAYING JOBS
<98> DONT KNOW
<99> REFUSED

[ALL OF THE FOLLOWING QUESTIONS WERE REPEATED FOR EACH OF THE DIFFERENT JOBS REPORTED BY THE RESPONDENT]

A21b What is your occupation?

A21 How many months of the year do you work at your job?

<1-12> MONTHS PER YEAR
<98> DONT KNOW
<99> REFUSED

Aa21 What months do you work at this job?

A21d In a normal week, during the months that you are working, how many hours do you usually work at your job?

<1-80> HOURS PER WEEK
<98> DONT KNOW
<99> REFUSED

A22 For this job, how many days of paid vacation do you get each year?

<0-365> PAID VACATION DAYS
<d> DONT KNOW
<m> REFUSED

A23 Now we want to ask whether you can set the hours you work for pay.

Does your employer let you choose the number of hours you work for pay?

<1> YES
<5> NO
<7> OTHER[specify]
<8> DONT KNOW
<9> REFUSED

[QUESTION A24 WAS ASKED UNLESS THE RESPONSE TO QUESTION A23 WAS <5>]

A24 If you decided to work an extra hour at your job, what would you get paid for working that extra hour?

<0-997> DOLLARS
<d> DONT KNOW
<m> REFUSED

A24a ENTER CENTS HERE:

<0-99>
<d> DONT KNOW
<m> REFUSED

A25 For your job, are you paid hourly or are you on a salary?

<1> HOURLY
<2> SALARY
<3> OTHER[specify]
<8> DONT KNOW
<9> REFUSED

[QUESTION A26 WAS ASKED IF THE RESPONSE TO QUESTION A25 WAS <1>, OTHERWISE QUESTION A27 FOLLOWED]

A26 What is your hourly wage for your job?

<1-997> DOLLARS
<d> DONT KNOW
<m> REFUSED

A26a ENTER CENTS HERE:

<0-99>
<d> DONT KNOW
<m> REFUSED

A27 What is your gross annual salary before taxes from your job?

<1-999997> DOLLARS
<d> DON'T KNOW
<m> REFUSED

[IF RESPONDENTS ANSWERED <d> OR <m> TO EITHER QUESTIONS A26 OR A27, THEY WERE PROMPTED WITH WAGE OR SALARY CATEGORIES, RESPECTIVELY]

[RESPONDENTS UNABLE TO CHOOSE OWN HOURS (ANWSWERED <5> TO QUESTION A23) WERE ASKED THE FOLLOWING QUESTION FOR EACH JOB REPORTED]

AN25 For your job as a {fill occupation}, you told us that you usually work about {fill hours} hours per week and you are not able to choose the hours you work for pay. Suppose you could choose how many hours per week you work for pay without affecting any benefits you currently receive.

For example, if you work 10% more hours per week, your earnings would go up 10%, and if you work 10% fewer hours per week, your earnings would go down 10%, but either way your benefits would remain the same.

If your employer would let you, would you usually work more total hours per week, the same total hours per week, or fewer total hours per week?

<1> MORE TOTAL HOURS PER WEEK
<2> SAME TOTAL HOURS PER WEEK
<3> FEWER TOTAL HOURS PER WEEK
<8> DON'T KNOW
<9> REFUSED

APPENDIX B: 1993 PSMA RAW DATA

CASEID	I	Y	WAGE	HOURS	EDUCATE	EXPER	GENDER	METROPOL	AGE	KIDS18	VINCOME
10005	1	0	7	40	12	9	1	1	27	3	28981
10013	0	1	23	60	14	15	0	1	35	0	8682
10028	0	0	11	55	14	12	0	1	32	2	15175
10032	1	0	8	40	14	35	1	1	55	0	68301
10044	1	0	24	8	14	43	1	1	63	0	13622
10059	0	0	15	40	12	13	0	1	31	3	21302
10078	0	1	12	42	14	23	1	0	43	0	30508
10082	1	0	25	55	12	15	0	1	33	2	-28037
10086	1	0	7	60	14	9	1	1	29	2	-7778
10100	0	1	15	48	12	19	0	1	37	3	27563
10200	0	1	14	40	18	3	1	1	27	0	7841
10201	1	0	40	55	16	17	0	1	39	3	-20092
10206	1	0	17	40	12	23	0	1	41	4	32143
10216	1	0	18	40	14	17	0	1	37	0	4543
10228	1	0	14	50	14	18	1	1	38	2	26716
10239	1	0	6	40	12	15	1	1	33	2	20021
10245	1	0	25	30	16	20	1	1	42	2	43371
10271	1	0	4	15	14	25	0	1	45	2	44185
10288	0	0	13	40	12	13	1	1	31	0	150
10313	0	0	14	50	9	10	0	1	25	3	7403
10333	1	0	5	65	9	9	0	1	24	0	-5661
10352	0	0	16	40	12	26	0	1	44	1	5262
10356	1	0	25	9	12	5	1	0	23	1	20000
10358	1	0	6	50	12	33	1	1	51	2	2021
10408	1	0	50	50	16	13	0	1	35	1	-49990
10445	1	0	9	20	9	38	1	1	53	0	35481
10477	1	0	15	44	12	14	0	1	32	0	2496
10507	0	1	23	53	14	34	0	1	54	1	16617
10536	0	0	18	45	14	23	0	1	43	2	6553
10586	0	1	22	45	14	26	0	1	46	0	28009
10587	0	1	13	40	18	12	1	1	36	4	25899
10588	1	0	10	45	14	9	0	1	29	0	4102
10628	0	0	6	20	14	39	0	1	59	0	31260
10631	1	0	17	48	12	8	0	0	26	1	4647
10667	0	0	8	48	14	0	0	1	20	0	2534
10681	1	0	18	50	16	28	0	1	50	0	7004
10700	1	0	7	40	14	0	0	1	20	0	33981
10761	0	1	12	50	12	19	0	1	37	3	16702

CASEID	I	Y	WAGE	HOURS	EDUCATE	EXPER	GENDER	METROPOL	AGE	KIDS18	VINCOME
10777	0	1	11	65	12	6	0	1	24	0	10323
10981	1	0	35	60	12	25	0	1	43	2	2500
20013	0	0	6	43	12	12	1	1	30	2	-624
20036	1	0	10	40	12	40	1	0	58	0	20911
20041	0	0	4	40	12	2	0	0	20	1	8453
20065	1	0	15	41	16	33	1	0	55	0	-13698
20069	1	0	12	48	12	4	0	0	22	0	12550
20076	1	0	7	32	14	2	1	0	22	0	1269
20077	0	0	7	30	12	33	1	0	51	0	53691
20081	0	1	12	40	12	16	0	0	34	1	12022
20082	0	1	7	35	14	32	1	0	52	0	52716
20107	1	0	5	30	9	4	1	0	19	2	5800
20151	1	0	20	40	16	21	0	0	43	2	-2500
20161	1	0	18	60	9	20	0	0	35	1	-10898
20162	0	1	20	40	12	25	0	0	43	2	30336
20189	1	0	15	43	12	17	0	0	35	3	20202
20214	1	0	10	36	14	5	1	1	25	0	23051
20229	1	0	13	65	16	21	0	0	43	2	15300
20231	1	0	18	40	12	21	0	0	39	3	11103
20233	0	0	12	16	16	14	1	0	36	3	70017
20263	0	1	6	30	12	13	1	0	31	1	17829
20270	0	0	8	35	12	17	1	0	35	3	28851
20286	1	0	19	40	12	22	0	0	40	1	40483
20287	0	1	13	42	12	24	0	0	42	2	14110
20305	0	0	5	53	14	30	1	0	50	0	17856
20338	1	0	10	35	16	6	1	1	28	2	40000
20373	1	0	5	51	12	22	1	0	40	0	29241
20376	1	0	17	45	14	18	0	0	38	1	17500
20382	0	0	10	42	12	22	0	0	40	5	4679
20385	1	0	4	28	9	24	1	0	39	0	31312
20414	0	0	11	40	12	22	0	1	40	2	14143
20440	1	0	10	32	9	17	1	0	32	2	21352
20470	0	0	12	40	12	10	0	0	28	3	7542
20475	1	0	5	43	12	0	0	0	18	1	9500
20506	1	0	12	48	16	23	0	0	45	2	50150
20511	1	0	4	32	14	16	1	0	36	4	15429
20520	1	0	5	34	12	16	1	0	34	4	4545
20533	1	0	3	40	16	2	1	0	24	0	16260
20535	0	0	11	45	9	35	0	0	50	1	12932
20570	1	0	8	30	12	19	1	0	37	3	2500
20584	1	0	20	60	9	54	0	0	69	0	2500
20600	1	0	10	50	12	8	0	0	26	0	11901

CASEID	I	Y	WAGE	HOURS	EDUCATE	EXPER	GENDER	METROPOL	AGE	KIDS18	VINCOME
20603	0	0	4	15	12	25	1	0	43	0	50014
20611	1	0	15	45	18	24	1	0	48	0	11500
20670	0	1	7	40	12	34	1	0	52	1	7213
20687	1	0	25	50	16	16	0	0	38	3	-500
20689	0	0	12	40	14	25	0	0	45	1	14249
20712	1	0	5	35	14	10	1	0	30	1	24540
20761	0	0	12	43	14	22	0	0	42	1	25670
20801	1	0	11	40	12	9	0	0	27	1	-2059
20808	0	0	9	50	9	15	0	0	30	6	17768
20817	1	0	13	35	14	19	1	1	39	3	88842
20867	0	0	6	40	16	30	1	0	52	1	16061
20873	0	0	7	40	12	24	0	0	42	3	21581
20921	0	0	10	40	14	9	1	0	29	1	2104
20922	1	0	10	45	12	14	0	1	32	1	12500
30003	1	0	15	50	12	10	0	1	28	2	-4157
30011	0	1	11	70	12	15	0	1	33	1	38314
30021	0	0	18	37	16	2	0	1	24	0	3352
30076	0	1	12	50	12	10	0	1	28	1	22602
30093	1	0	22	50	14	29	0	1	49	0	22804
30111	1	0	10	40	12	17	0	1	35	0	11700
30115	0	0	6	40	12	19	1	1	37	4	5021
30157	1	0	15	40	14	25	1	1	45	0	48802
30193	1	0	7	35	14	-1	0	1	19	2	35034
30202	0	0	18	40	12	18	0	1	36	2	14422
30211	1	0	15	40	12	14	1	1	32	2	56207
30326	1	0	6	57	14	19	1	1	39	0	-6054
30329	1	0	17	40	12	35	0	1	53	0	12143
30336	0	0	8	40	12	1	0	1	19	0	10861
30341	1	0	9	30	12	17	1	1	35	3	33695
30392	1	0	40	35	16	23	0	1	45	1	80652
30414	0	0	14	36	12	33	1	1	51	0	10527
30424	1	0	19	40	14	20	0	1	40	0	18773
30478	0	1	13	60	14	5	0	1	25	0	47723
30509	0	0	11	50	14	18	0	1	38	5	4942
30522	1	0	8	30	12	14	1	1	32	1	21
30529	1	0	27	24	16	17	1	1	39	3	56202
30547	1	0	4	30	14	-1	1	1	19	0	15637
30586	1	0	40	30	18	31	0	1	55	1	-120000
30590	0	0	20	40	14	32	0	1	52	2	38403
30622	1	0	12	40	9	18	0	1	33	1	12001
30641	1	0	13	38	14	34	1	1	54	0	12010
30662	1	0	8	50	16	23	1	1	45	0	37751

CASEID	I	Y	WAGE	HOURS	EDUCATE	EXPER	GENDER	METROPOL	AGE	KIDS18	VINCOME
30673	0	0	17	40	14	14	0	1	34	2	2143
30780	0	0	7	45	12	2	0	1	20	1	26121
30888	1	0	10	40	14	10	1	1	30	3	1951
30893	0	1	12	50	9	26	0	1	41	3	11302

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