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MODELING THE VALUE OF HOUSEHOLD PRODUCTION AND
LEISURE TIME: AN HISTORICAL DEVELOPMENT

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INTRODUCTION

Over the last century, interest in estimating the value of time spent outside of the labor force has grown as the uses of that information have increased. This time is variously referred to as non-market time, leisure time or household production time, i.e., the time household members spend producing goods and services for their own consumption.

This paper starts with a brief overview of how the value of non-market time has proved useful for various economic analyses. The definition of household production, its relationship to the value of time, and how household time has been variously valued is reviewed next. Then, methods for estimating the opportunity cost of time in agricultural household models is discussed followed by applications of household economics models for studying the value of travel time and recreational facilities. A brief discussion of the research frontiers for valuing household time and for incorporating it into other economic analyses conclude the paper.

An early, major impetus for estimating the value of time spent producing goods and services in the household came from efforts to document how much household production increases the welfare of individuals beyond that indicated by their incomes and, of nations, beyond that indicated by their gross national product (GNP). Adding the value of household production to the value of market goods was found to alter the measured distribution of welfare among households and among nations. Interhousehold and international comparisons of "living standards" fostered interest in studies of household time allocation which date back to at least 1915 (Bailey, 1915). In that same era, economists at the National Bureau of Economic Research (NBER) began estimating the value of household production time in order to determine how much it would increase the nation's gross national product (GNP) (Murphy, 1980; Mitchell, 1921, 1922). Similar studies continue to be done around the world (Murphy, 1980; Chadeau, 1985).

Determining the value of nonlabor force time has subsequently proven useful for analyzing its impact on the demand for market goods, the supply of labor, and investments in human capital. Estimating the value of services lost by disabled or deceased household members has been essential for insurance settlements and other litigation. The value of productive services in and out of the labor market has also been used in valuing human lives for various types of benefit cost analyses. The value of household production is generally measured by the value of the producer's time, a synonym for the value of the labor input. Whether one is interested in the total value of household production, or the value added by household labor, or how the value of time affects its allocation and the subsequent demand for purchased inputs, determines how the value of time is most appropriately measured as well as the data requirements. Four general methods for valuing household production time have been used: (1) the value added approach, (2) the market cost of replacing the household member's time with a general domestic worker, (3) the market cost of hiring a specialist to perform each of the household functions for the same length of time it would have been performed by household members, and (4) the opportunity cost of foregone activities.

Critiques of each approach are found in Murphy (1980, 1982); Hawrylyshyn (1976); Chadeau (1985); Zick and Bryant (1983); and Goldschmid-Clermont (1983a, 1983b). Goldschmid-Clermont (1983b) and Murphy (1980) both include extensive reference lists and review studies measuring the value of household time. All of the above four methods have been widely used, but economic and econometric models for estimating the opportunity cost of time as a function of the value of marginal productivity in the labor market were not formalized until the 1960s. Mincer (1963) and Becker (1965) brought consideration of the value of time into the mainstream of economic thought and analysis. Variations of the Becker (1965) model have been applied to studying everything from the domestic food demand to the impact of agricultural policies in developing countries. A large branch of the literature focuses on the supply of (female) labor (Smith, 1980). Numerous studies have analyzed the impacts of various socio-demographic characteristics on the value and allocation of time (T.W. Schultz, 1974; Binswanger et al., 1980). Others have estimated the demand for investments in human capital (Rosenzweig, 1976, 1977; Rosenzweig and Schultz, 1982; DeTray, 1974; Michael, 1974; T.P. Schultz, 1980b). These applied studies have rarely pioneered new methods for valuing time and will not, therefore, be systematically reviewed here.

The literature on the value of time and its relationship to household production is vast, scattered, and ranges from highly technical articles to heuristic arguments. That which is reviewed in this paper is representative, not comprehensive. Extensive reference lists which appear in other works are identified but not reproduced.

HOUSEHOLD PRODUCTION

Although attempts to define household production can be found in the literature prior to 1934 (Andrews, 1923:393; Richards, 1917:25), Margaret G. Reid's discussions and definitions have proved to be widely useful (Reid, 1934). Early definitions of production that required a person to labor on a material good and somehow change its form were inadequate for households since they clearly produced both material goods and services. Yet, production defined as the creation of utility proved equally inadequate and hopelessly general in application. Thus, Reid posited the definition of household production as:

> "... those unpaid activities which are carried on by and for the members, which activities might be replaced by market goods or paid services, if circumstances such as income, market conditions, and personal inclinations permit the service being delegated to someone outside the household group" (Reid, 1934:11).

This omitted from household production: (1) those activities where the experience or the process increases utility directly and (2) those activities deemed to be personal. Both personal and experience activities are ones that must be performed by oneself or with a particular other person in order to yield utility. For example, playing with one's own child may yield direct utility while playing with other children may be viewed as producing a service.

It is important to distinguish between the value of household production and the value of time. The full value of household production is the monetary value of the utility received from the commodity produced. It includes not only the value of labor time plus the cost of purchased goods but consumer surplus realized in consumption. When household members produce commodities for their own consumption, the commodity's value equals the households' willingness to pay for it including the value of their time. As in evaluating the demand for market goods, this willingness to pay can be measured by the total area under the demand curve up to the quantity consumed. Assuming household commodities are normal goods with downward sloping demand curves, the total value of commodities produced in the household (labeled Z) can be identified as area oabc in Figure 1.

If Z were purchased in the market at price p* the area dab would represent consumer surplus, or the value of utility received over and above the money expenditure. If Z is produced and consumed in the same home, p* represents the "shadow price" of production which is the value of the time plus the cost of goods that were not used to produce alternative commodities

(Fetter, 1912). The "shadow expenditure" for quantity Q* of Z is area odbc; the total (utility) value still exceeds the expenditure by area dab.[1]

In practice, the full value of household produced and consumed commodities to the user (area oabc in Figure 1) is not measured; rarely is the full shadow expenditure measured. Among the reasons for this is the difficulty of identifying the separate household produced commodities and, therefore, an inability to estimate their demand or supply. Also, allocating the same period of time to the production of more than one commodity leads to joint production. This makes determining the separate costs of inputs into each commodity very difficult to estimate. What is left, is measuring the value of the time used to produce and consume composite household commodities. This will be some portion of area odbc and can generally be expected to underestimate the value of household production. How its value has been variously measured and modeled is discussed next.

MEASURING THE VALUE OF TIME

Value Added

The value added method is conceptually consistent with adding the value of household production to the GNP since the value of most market (purchased) goods is already counted in the national income accounts. This method involves identifying the price of the home produced commodity if it were purchased in the commercial market (P_Z), subtracting the cost of purchased inputs ($\sum_{i=1}^{n} r_i x_i$) leaving the value of the household services (VHS) in

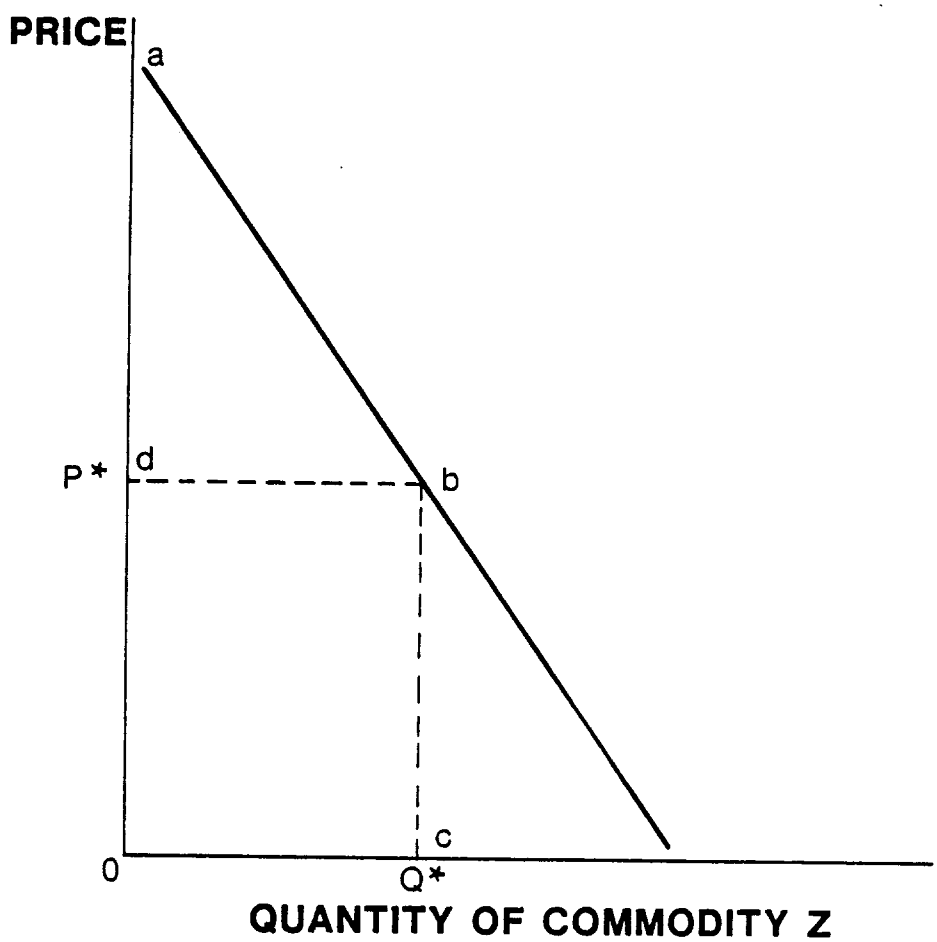

FIGURE 1. DEMAND FOR HOUSEHOLD COMMODITIES

the production of commodity z.

$$VHS_z = P_z - \sum_{i=1}^{n} r_i x_i \qquad (1)$$

where r_i is the price per unit of input x_i used to produce one unit of commodity z. To determine the wage rate, VHS_z is summed over all commodities and is divided by the number of hours spent producing those commodities ($\sum_{z=1}^{m} t_z$) in a specified time period.

$$W = \sum_{z=1}^{m} VHS_z \Big/ \sum_{z=1}^{m} t_z \qquad (2)$$

The value added method was used in an early study of Iowa farm households to measure the value of producing food for home consumption. The value of time was determined by valuing the food products at their retail price, subtracting direct production expenses, and dividing the net value added by the number of hours spent producing the food (Reid, 1943:124). The value of this time was found to average 63 cents per hour in agricultural households in the early 1940s. Volker and Bivens (1983), using the value added method, found the value of time spent in preparing purchased food for home consumption to be $2.17 per hour in urban households in the late 1970s. This implies a real increase in the value of food preparation time of about $.24 or 12 percent since the 1940s. Volker and Bivens valued home produced meals at the average cost of meals eaten away from home. Subtracting the dollar cost of the purchased food left the value added by capital goods, intermediate goods (e.g. energy) and labor and management. In that study, regression analysis was used to determine the proportion of the value added by each of the three inputs with time representing the labor and management input. Hill (1985) discusses this method and measures the value added in several home improvement projects using data collected in the Panel Study of Income Dynamics by the Survey Research Center at the University of Michigan.

The value added method is the least used method of valuing time partly because it requires large amounts of micro-data on the inputs and outputs of household production activities and their equivalent market prices. Sanik and Stafford (1983) argue these prices are no more difficult to find than various alternative wage rates needed for other methods. In addition, massive time use surveys provide much of the needed input and output data (Walker and Woods, 1976; Family Time Use, 1981; Szalai, 1972). Goldschmid-Clermont (1983a) argue that the value added method is one way to price the outputs of household production as opposed to just the value of time -- one of the inputs. Nevertheless, the enormous detail involved has left this method inoperative. Studies designed to estimate the value of household services as a portion of GNP rarely, if ever, use this method even though it is conceptually correct (Murphy, 1980:176).

Peskin (1982) discusses the market and opportunity cost methods of valuing household work as a portion of GNP. She found that in the United States in 1976 general domestics' wages valued household time 28 percent less than specialists' wages. Specialists' wages yielded about the same valuation as the opportunity cost measured as net compensation (after tax income minus work related costs).

On average the total value of household work was found by Peskin to equal 44 percent of the 1976 U.S. GNP. This compares favorably to estimates by Murphy (1982) and Nordhaus and Tobin (1965) who each found 47 percent. Earlier studies (Mitchell, 1921; Reid, 1947) found the value of household work equivalent to 25-31 and 20-22 percent, respectively, of U.S. GNP. These are consistent with studies in European countries. Adler and Hawrylyshyn (1978) found the value of housework to be 40 percent of Canada's GNP. They also found no trend in this ratio over time and that adding the value of housework to GNP did not affect the general pattern of economic growth in Canada. The contribution of household production to GNP is generally expected to be higher in the developing world. Kusnic and DaVanzo (1980) found, however, that the value of household activities increased Malaysian household's money income by only 33 percent.

Market Cost

The two market cost methods of valuing household production time use the cost of substituting hired labor for household labor. There are two primary methods of determining the costs of hired household labor. One is to use the wage rate of a general housekeeper who performs a variety of household tasks for the same number of hours required by household members. This may be written as the (annual) value of a household's services (VHS) equalling the total number of hours spent (per week) producing household goods or services that could be purchased in the market ($\sum_{z=1}^{m} t_z$) times the wage rate of general domestic labor (W^d) times 52.

$$VHS = 52 \left(\sum_{z=1}^{m} t_z \right) W^d \qquad (3)$$

The primary advantages of this method are its simplicity and its approximation to reality. Little data on inputs and outputs is needed and the experience of hiring a single person to perform a plethora of household tasks is quite common. Although it underestimates the value of managerial skills, it avoids the problems of non-joint production and double counting involved in the market cost method using specialists' wages. It generally yields the lowest overall value of household services among the latter three methods, mainly because the wage rates for unskilled domestic workers are relatively low.

The second market cost method requires determining how many hours household members spend on various productive activities and substituting the market wage rate of a specialist in that activity for the same number of hours. This may be written as the annual value of a household's services being equal to the sum of the weekly hours spent in each activity (t_z) times the wage rate for a specialist in that activity ($W^s{}_z$) times 52.

$$VHS = 52 \sum_{z=1}^{m} t_z W_z^s \qquad (4)$$

An obvious upward bias exists if the productivity of hired specialists is greater than that of household members. Also, the specialist approach does not allow for the possibilities of joint production which can be accomplished by the generalist or the household member. For example, the generalist might produce clean windows and clean clothes in the same hour whereas a specialist in laundry would probably not wash windows.

Opportunity Cost

The third major approach to valuing household production time is by its opportunity cost -- the actual or potential labor market earnings foregone while working in the household. Murphy (1982) argues that the theoretically correct valuation of the opportunity cost is the average net wage. After tax compensation minus work related costs comes close to this net wage. In practice, total earned income (gross or net) is simply divided by the number of hours worked to determine the opportunity cost for those who are in the labor force. Empirical problems with this method arise when people misreport their income and/or report the standard work week as the number of hours worked rather than the actual hours worked. Nevertheless, it is fairly standard procedure. For those who are not in the labor force a wage rate must be imputed. Techniques for doing this are provided by economic household production models, discussed in a later section.

The opportunity cost method assigns a single wage rate to all activities. A single wage rate is theoretically justified by assuming every individual is able to freely allocate all their time between working in the labor force, working at home, or taking leisure. With no constraints on how time is used or the sequencing of activities, the rational person will allocate it so that the marginal utility from the last units of time are equal in all activities and, therefore, equal to a single wage rate. Reid (1943) pointed out that equal amounts of hourly labor may have quite different opportunity costs. Tasks that can be done in slack periods or are flexible as to the time of the month, week, or day, are likely to involve lower costs than tasks which must be performed at or for a fixed time. Winston (1982) specifically modeled the timing of household activities within a household production framework. Both the optimal duration and sequencing of activities can be determined by his model, but they still depend on an exogenous, single wage rate. Attempts to find various wage rates include the work of Hanoch (1980) who proposed a utility function with two kinds of leisure time, one for weekdays and one for weekends. Other models that define various opportunity costs are generally variations of the work by DeSerpa (1971).

Since individuals certainly do not value each and every unit of their time equally, serious errors are probably made when the imputed (or even the actual) market wage rate is interpreted as the individual's subjective value of time in all activities. Other problems arise when the opportunity cost of an individual's time (i.e., their wage rate) is interpreted as the value of household production. The value of commodities produced will be greater for persons with higher market wages than for those with lower market wages even though the latter may be more efficient (Hill, 1985:206-208). The market wage rate generally under-estimates the marginal productivity of household time unless one assumes constant returns in the production of household commodities. On the other hand, Graham and Green (1984) argue that the market wage overestimates the value of household production, primarily because of significant joint production in the household. Deacon and Sonstelie (1985) provide some insight into how individuals subjectively value their time, at least, while waiting in lines. They found the subjective value of time was about equal to the after-tax wage rate except for very low income persons in which case the subjective value of time was higher than the wage rate.

Time Surveys

Household time allocation surveys have not focused primarily on determining the value of household time, but they have collected invaluable data that allows that value to be estimated. Among these studies is one by Vaneck (1974) in the United States and an international comparison by Szalai (1975). Walker and Woods (1976) provide a tome of information about household time allocation, including a comprehensive reference list of U.S. household time studies done between 1915 and 1975. A major regional project undertaken in 1977 by 11 of the U.S. agricultural experiment stations established a data bank of urban and rural families' use of time (Family Time Use, 1981). Out of over 150 manuscripts resulting thus far from that regional project, seven of them indicate by their title that the data was used to estimate a value of time. Four of these are authored or coauthored by Bryant (Zick and Bryant, 1983; Bryant and Zick, 1984a,1984b; Bryant, 1982-83). The others are by Gauger and Walker (1980), Goldschmidt-Clermont (1983a) and Simmons (1984).[2]

The methods for valuing time in the studies mentioned above vary. Gauger and Walker (1980) used the market wages of specialists, Zick and Bryant (1983) estimated the opportunity cost, and Goldschmidt-Clermont (1983a) used the value added method to value household output. Zick and Bryant (1983) compared their estimated opportunity cost to the wage rate obtained by Gauger and Walker (1980) for the same set of households. They found that the opportunity cost is generally higher than the market costs of specialists. For example, the market method found an hourly wage for unemployed New York wives with their youngest child age one to be $2.99 compared to an opportunity cost of $3.94. In all cases, the opportunity cost (estimated as the reservation wage) was lower for employed wives than for unemployed wives, supporting the theoretical prediction that the market wage understates the value of the inframarginal units of time spent in household production.

ECONOMIC HOUSEHOLD PRODUCTION MODELS

Studies which employ the opportunity cost of valuing time, generally have their theoretical roots in economic household production models based on "A Theory of the Allocation of Time" by Gary Becker (1965). This theoretical framework was dubbed the "new home economics" by Nerlove (1974). It is also known as the "new household economics." It has spawned numerous household production models.

In these models, time is treated as an argument in the utility function, as a constraint on utility maximization, and as the labor input into the production of household commodities. Borrowing from neoclassical labor economics, it is generally assumed that utility increases with "leisure time" and does not increase with work time.[3]

The fundamental properties of this approach can be illustrated formally as follows. Utility is a function (5) of commodities produced by the household (Z_i). Each commodity has a production function (6) that depends on a vector of purchased inputs (X_{ij}) and time (t_i).

$$U = u(Z_1 \ldots Z_n) \tag{5}$$

$$Z_i = f_i(X_{ij}, t_i) \tag{6}$$

where X_{ij} is the j^{th} purchased input used to produce the $Z_i{}^{th}$ commodity, i=1-n commodities and j=1-m purchased inputs. Substituting (6) into (5) results in restating utility as a function of the production technology (7).

$$U = v(f_1 \ldots f_n) \equiv v(X_{1j} \ldots X_{nj}, t1 \ldots t_n) \tag{7}$$

In Becker's original model utility is maximized subject to a full income constraint which is the sum of expenditures on goods and services used to produce the $Z_i{}^{th}$ commodity plus the value of all nonlabor force time (t_i) measured as the number of non-labor force hours times a constant wage rate (W).

$$I = \sum_{j=1}^{m} \sum_{i=1}^{n} P_j X_{ij} + \sum_{i=1}^{n} t_i W \tag{8}$$

Since expenditures require money which is presumably earned via labor time, $\sum_{j=1}^{m} \sum_{i=1}^{n} P_j X_{ij}$ equals the value of time in the labor force or $t_w W$ plus any unearned income (A). An alternative way to write equation (8) is

$$I = A + t_w W + \sum_{i=1}^{n} t_i W \quad i \neq w \tag{9}$$

This assumes that total time (T) is divided between the labor force (t_w) and the production of household commodities (t_i) one of which is "leisure time," more appropriately called "rest and recreation". Therefore, the full income constraint equals the number of hours in a day times the wage rate (TW) plus asset income. If one chooses to spend some time not working for wages, the money income forfeited measures the opportunity cost of obtaining utility from alternative activities. The time spent not working for wages increases utility because: (a) it is used to produce commodities in the household for members' own consumption, or (b) it is experience or personal time according to Reid's classic definition (Reid, 1934).

In most of the empirical work utilizing household production models, leisure time has not been explicitly valued or included in the full income constraint but it generally appears as an argument in the utility function. This allows the construction of an indifference curve representing preferences between leisure time and commodities which further allows the optimum allocation of time to be determined, given the production possibility set. Time spent producing household commodities is then valued at a market (or imputed) wage rate equal to the marginal utility of the last unit of productive household time. Sometimes household production time has been lumped together with leisure, as in neoclassical theory, and excluded from full income. At any rate, something less than Becker's full income constraint appears in most empirical applications of the theory.

Agricultural Household Models

Applications of the new household economics models have proliferated among agricultural and development economists. This is due, in part, to the appropriateness of these models for explaining the production activities of households which engage in their own small business or farming enterprise. Several models have been developed to analyze the behavior of subsistence farmers in developing countries. In these models, the commodities produced by the households are defined as the agricultural commodities (usually crops), some of which are sold on the market for money and some of which are consumed at home. In most of these models, nonagricultural commodities produced by the household, such as home cooked meals or clean clothes, are not considered at all and the time spent producing them is treated as if it were leisure. To those who are interested in the value of commodities produced in the household or in how time is allocated among various household activities this may seem unfortunate. However, research studies that did not require knowledge about household production activities themselves have proved very useful for studying important human nutrition and agricultural policy questions in developing countries.

The earliest of these agricultural household production models focused on farm households without an outside labor market (Nakajima, 1969; Mellor, 1963; Sen, 1966). With these models, raising the market price of agricultural commodities was often found to lead to a decrease in farmers' production. This seemingly perverse result occurs because increased output prices increased farmers' income which apparently increased their demand for household or leisure time. In a model where family labor (time) is the only variable input to production and an increase in income decreases its supply, agricultural production will likely decrease.

About the same time, models were developed which included a labor market. Farmers could allocate time to off-farm work or hire farm labor or both. In these cases, a rise in the market price of farm products generally increased the demand for farm labor and that tended to increase production. Such models were discussed by Nakajima (1969) and used by Jorgenson and Lau (1969). They formed the basis of most of the empirical work that followed. Household production and consumption decisions were generally estimated separately, a convenience allowed by assuming a two-stage decision process. (1) The decision to maximize farm revenue (or profits) subject to the production function, and (2) the consumption decision consistent with utility maximization subject to money income generated by the production process.

Some of the first empirical estimates of agricultural household models of this type (Yotopoulos and Lau, 1974) were used to study households in Taiwan (Yotopoulos, Lau, and Lin, 1976; Lau, Lin, and Yotopoulos, 1978), Japan (Kuroda and Yotopoulos, 1978, 1980), and Malaysia (Barnum and Squire, 1978, 1979a, 1979b). All of these studies estimated households' demand for input (non-farm produced) goods, as well as the quantity of farm products sold on the market and the amount retained for own consumption. Family labor supplied to the farm and total farm labor demanded were also estimated as a function of changes in output prices, wage rates, and some family characteristics. In general, these studies showed that for farm households that produced food in excess of their cnosumption needs, an increase in the output price resulted in an income effect that outweighed the price effect. Consequently, while production increased, own consumption increased more and the amount sold on the market declined. The income effect also resulted in household members increasing their leisure and hiring more outside farm labor. For those households that produced little or none of their own food (landless poor), an increase in the output price generally led to less leisure and less food consumption, diminishing their welfare. These results contrast with those obtained from models where the allocation and value of time are not accounted for and where farm profits are not allowed to vary as price changes induce reallocations of labor (time). These results are important to policymakers in developing countries who typically want to induce farmers to produce and sell more farm products for urban consumers or for export. Singh, Squire, and Strauss (forthcoming) provide a review of studies from around the world which shows that the use of household production models yield different and more realistic results than models which ignore the value of time and full income effects.

Formally, the agricultural household model assumes that utility is a function of purchased and/or home produced commodities (X_i's) and leisure time. This is like equation (7) with all t's left out except those used in leisure time activities. Recall that leisure activities now include household production that is not directly related to producing farm products.

$$\text{Max } U = u(X_0, X_1, \ldots, X_n) \text{ where} \tag{10}$$

X_0 is leisure time and $(X_1, \ldots, X_n)$ are commodities consumed by the household. Utility is maximized subject to the full income constraint (11) where P_i represents the shadow price of the i^{th} commodity.

$$Y = \sum_{i=0}^{n} P_i X_i \tag{11}$$

The full income constraint for an agricultural household is written as (12) where W is the wage rate and T is the total time endowment of family members. $T \cdot W$ is the potential earnings if all time was spent working off the farm and $t_w W$ is the value of the time spent working on the farm by family members.

$$Y = T \cdot W - t_w W + \sum_{j=1}^{m} P_j Q_j + A \tag{12}$$

As in equation (9), A is unearned, exogenous income. Net revenue from farm production is represented by $\sum_{j=1}^{m} P_j Q_j$ where Q_j is positive if an output and negative if a variable input including hired labor; P_j is the respective output price or input cost. With no off-farm labor, $W(T-t_w)$ is the value of household and leisure time. The implicit production function (13) includes own farm labor (t_w), other variable inputs ($-Q_j$), outputs (Q_i), and fixed inputs (K_j), i=1...n, j=n+1...M.

$$G(t_w,\ Q_1 \ldots Q_i,\ -Q_j \ldots -Q_M,\ K_1 \ldots K_n) = 0 \qquad (13)$$

As long as wages and all prices are exogenous, maximizing utility (10) subject to full income (12), and production technology (13) can be estimated as a separable model. The household behaves as if it maximizes profits subject to production first and then maximizes utility subject to income.

Household and leisure time, as such, increase utility in this model and the first order conditions from utility maximization show that the price of time equals the ratio of the marginal utility of labor (time) in household production to the marginal utility of full income times the marginal productivity of household labor. If the marginal utility of household labor time is assumed to be negative, then (W) is negative and the shadow price of time becomes an (opportunity) cost. Relating this to equation (12), the first two terms on the right-hand side, $W(T-t_w)$, represent the opportunity cost of not participating in the labor market for a wage (Singh, Squire, and Strauss, forthcoming).

<u>Household production functions</u>. There have been a few attempts to model and directly estimate household production functions for commodities not traded in a commercial market. One of the first was by Hymer and Resnick (1969) who referred to (Z) commodities as nonagricultural, non-leisure activities, such as home care, food preparation, or child care. They assumed labor and leisure were not choice variables and, therefore, specified

no value of time in their model. By relaxing the assumption that labor and leisure are exogenous, Gronau (1973, 1974, 1977) used similar models to estimate the implicit price of time and subsequently the value of household commodities (Gronau, 1980). He was one of the first to differentiate household production time from leisure time.

A few studies have estimated household production functions for specific household commodities. Bryant et al. (1983) and Stafford and Sanick (1983) estimated production functions for home laundry and food preparation, respectively. Huffman (1976) and Lange and Huffman (1982) estimated farm household production in order to determine its impact on wives' labor force participation and the marginal productivity of their time on the farm. Gronau (1980) proposed a model to estimate household production by estimating the marginal productivity of housewives. This was actually accomplished by estimating the number of hours spent in household activities which is reasonable as long as the wage rate equals the value of the marginal household product. Pollack and Wachter (1975) point out that the prevalence of joint production in the household renders invalid the estimation of household production functions that assume no joint production. Hawrylyshyn (1977) proposed a household production model to solve the joint production problem but did not attempt to estimate it.

Estimated wage rates. Household production models are used extensively to predict how labor supplied to the household and to the work force changes with changes in the wage rate. In cases where labor is not bought or sold in the market various estimates of the implicit price of time, called the "shadow" wage or the "potential" wage, have been made. Such estimates occupy much of the applied economics literature using the household production theory.

The shadow wage rate at which a household member would be indifferent between working in the household or in the labor force is called the "reservation" wage. It is the minimum wage that would draw a person out of household production and into the labor market. This is most relevant for housewives (or farmers) whose value of marginal product is initially greater in the household (on the farm) than in the labor market. The potential wage that one could expect to earn in the labor market given their location, education, and other personal characteristics is often estimated and interpreted as their (constant) value of time. The estimated potential wage may be more or less than the reservation wage but if it is more, they should (rationally) be in the labor market. Figure 2 illustrates the differences.

Curve de on Figure 2 represents the household's production function where Z is the output and time is the only variable input. Distance oe represents the total number of hours available for work per day (or week or month). At point (a) the household member is indifferent between working in the home and in the labor force. The reservation wage rate equals the marginal productivity of time in producing household commodities (slope of the production possibility curve de) at the point where it is also equal to the marginal rate of substitution between

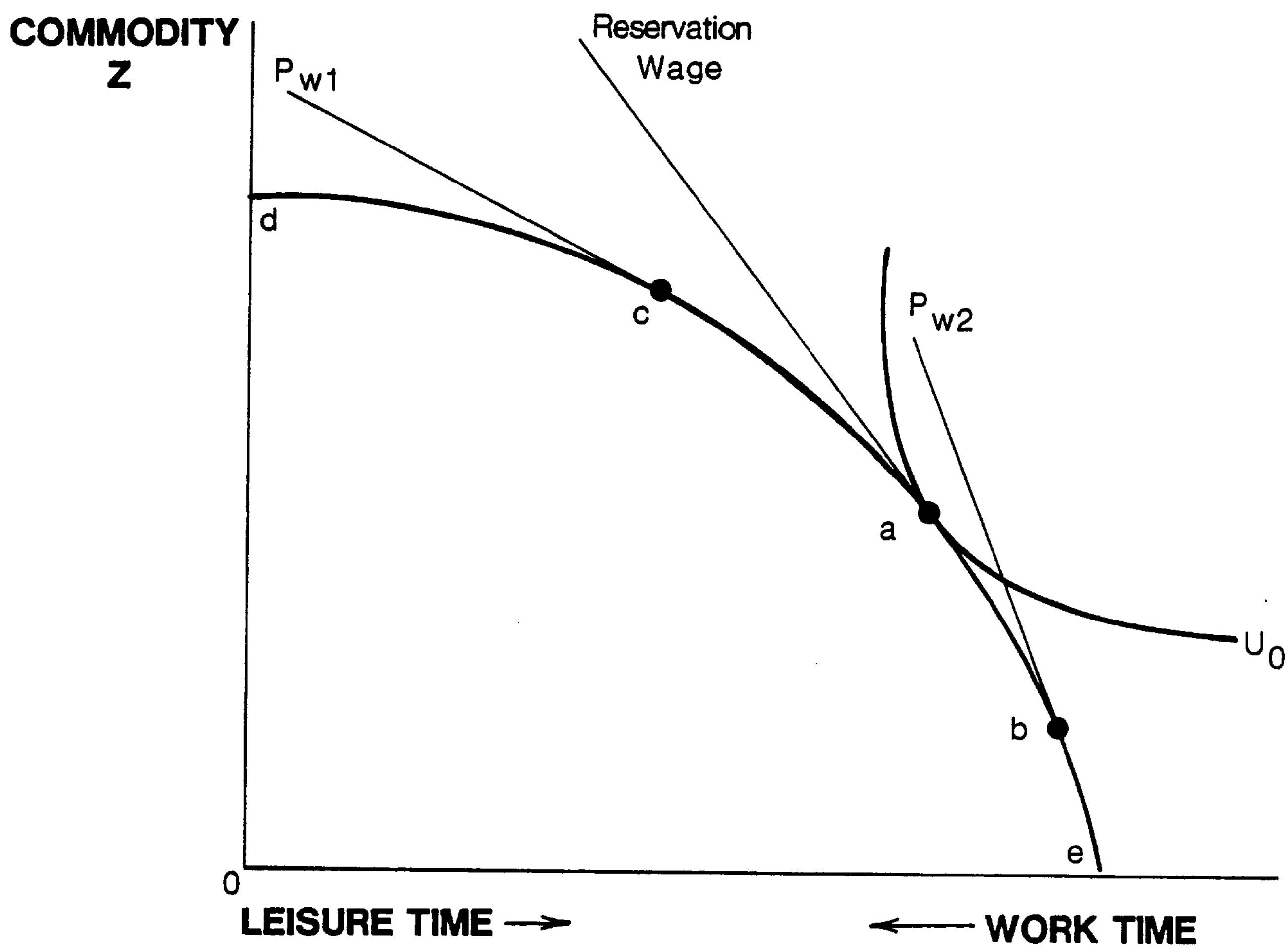

FIGURE 2. HOUSEHOLD PRODUCTION POSSIBILITIES AND WAGE RATES

commodities and leisure time (slope of the indifference curve U_o). A household member with indifference curve U_o would not enter the labor force at expected wage P_{w1} which is lower than their reservation wage. This would result in a lowering of utility. They would enter the labor market at potential wage P_{w2} because this would put them on a higher indifference curve.

Pioneering work by Mincer (1963) and Heckman (1976, 1979) developed what have become standard procedures for estimating potential and reservation wages. Econometrically, the first three steps are similar. First, using probit analysis, the probability of being in the paid labor force is estimated over the entire sample which includes those who are in the labor force and those who are not. The results of this probit estimate include an inverse probability ratio known as the "inverse Mills ratio," which is used as an explanatory variable in a second equation that estimates the parameters of a wage equation for those in the labor force. (Wages are regressed on various labor market and personal characteristics, plus the inverse Mills ratio). The parameters from this second equation can then be used to predict the potential wage rate of individuals (or homogeneous groups) by substituting their particular labor market and personal characteristics into the wage equation. In the literature this estimated potential wage has been interpreted as the "implicit value of time" and used as the wage rate by which household production and/or leisure time is valued (Senauer et al., 1984; Peck, 1983; McCracken and Brandt, 1986).

Note that the estimated potential wage could be higher or lower than the actual wage for those in the labor force and it is most certainly lower than the reservation wage for those who are not in the labor force. The model assumes that given the preferences of those not in the labor force, the value of their marginal productivity in household activities exceeds the wage rate they could capture in the labor market or they would not have rejected it. Again, Figure 2 is illustrative. For those who are not in the labor force, their estimated potential wage must be tangent to the production function curve (de) to the left of (a). Recall that the wage rate that is just tangent at (a) represents the reservation wage.

The reservation wage can be estimated by a three stage procedure similar to the one described above. The first three estimating equations (the probit, the wage equation, and the predicted potential wage) are the same. The results are used to estimate a labor supply equation which predicts the number of hours one would be in the labor force given their potential wage. This labor supply function is estimated over the entire sample using tobit analysis by regressing hours in the labor force on the predicted wage (from the third equation of the Heckman procedure), household income, and other characteristics. The reservation wage is then calculated from the estimated coefficients[4] (T.P. Schultz, 1980b; Gibney, 1983:76; Heckman, 1980). Gibney (1983) found reservation wages for non-labor force participants were greater than the estimated potential wage for both men and women. Her findings along with those of Zick and

Bryant (1983) are consistent with theoretical predictions of the household production model.

Two other methods of estimating a shadow wage are one developed by Olson (1980) and an earlier maximum likelihood method by Heckman (1974). The latter is generally too expensive to calculate but was presented in McCracken and Brandt (1986). The Olson procedure, which requires only linear regressions has produced results very similar to Heckman's three stage procedure described above. Lange and Huffman (1982b) employed the Olson procedure to estimate the potential wage for men and women in a study of farm and off-farm labor force participation in Iowa. Their model of an agricultural household included the joint production of farm and household commodities.

The implications of the changing value of time on the demand for commodities produced in the household, their market substitutes, and the form of the production inputs are vast. Senauer et al. (1985) were able to show that increasing the value of time in Sri Lankan households led to an increased demand for more convenient foods, i.e., baked bread vs. flour. McCracken and Brandt (1986) in a United States study found that higher estimated potential wages lead to increased demand for the number of meals eaten away from home and increased expenditures at fast food facilities. Expenditures at restaurants were not affected. An earlier study by Prochaska and Shrimper (1973) and a recent one by Hull, Capps, and Havlicek (1983) also showed that increasing the value of household time increased the demand for food away from home and more convenient food, respectively.

These studies point out the potential usefulness of incorporating the value of time into the analysis of demand for goods and services. Household production models have already been used extensively to analyze the demand for children (Gronau, 1977; Banskota and Evenson, 1975; DeTray, 1974, 1980; T.P. Schultz, 1980a; Michael, 1974; Ben-Porath, 1974; Hashimoto, 1974; Rosenzweig, 1977), health care (Pitt and Rosenzweig, 1983), and education (Rosenzweig and Schultz, 1982).[5]

For all of its mathematical rigor and numerous useful applications, estimating the value of household time with new household economics models is limited because of the need for detailed micro data and because a constant wage rate is assigned to all activities. This wage rate represents the opportunity cost of not working in the labor force, if there are no exogenous time constraints on individual activities.

HOUSEHOLD PRODUCTION MODELS WITH VARYING TIME VALUES

Several economists have tried to develop models that allow for differing values of time to be estimated for various household activities. Much of this work has been done by resource economists interested in the value of time as a cost of using recreational facilities. Cesario and Knetsch (1970) were among the first to recognize the importance of the opportunity cost of time in the demand for outdoor recreation. DeSerpa's (1971) theoretical model has a utility function that looks exactly like the one Becker proposed in 1965 (Equation 7 above).[6] However, DeSerpa assumes that the price of time is endogenous;

utility may be received not only from the commodities consumed but from the time allocated to the consumption activity. No specific allocation of time is assumed to yield positive or negative utility, a priori. Conceptually this is a different approach than that discussed above. In most of the agricultural household production models only leisure time increases utility; work time is assumed to decrease utility and it rarely enters the utility function. (Exceptions are found in studies by Lopez (1982) and Sussman (1985).) In the DeSerpa approach, both money income and the amount of time are fixed over the decision period. One cannot trade time for money as in the Becker model. One can only reallocate time among different production/consumption activities. Since there is no way to increase the total stock of time, DeSerpa argues that an absolute value of time has little meaning. The value of "saving time" in one activity so it can be transferred to another is more meaningful and is one of the outcomes of this model. In this approach, the data are used to determine the subjective value an individual places on time spent in different activities. This subjective opportunity cost is measured by the value of time in alternative activities that could feasibly be engaged in during a specific time period, not the value of time in the labor market, i.e., the wage rate.

Formally this approach is to maximize utility subject to a budget constraint (15), a time constraint (16), and a production function (17). Time is the only variable input.

$$\text{Max } U = u(X_1 \ldots X_n, t_1 \ldots t_n) \tag{14}$$

$$\text{s.t. } \sum_{i=1}^{n} P_i X_i = Y \tag{15}$$

$$\sum_{i=1}^{n} t_i = T \tag{16}$$

$$t_i \geq a_i X_i \tag{17}$$

where X_i denotes the quantity of the i^{th} consumption good or activity including rest and recreation and t_i denotes the amount of time allocated to producing and consuming the i^{th} good or, engaging in the i^{th} activity. In equation (14), $t_1 \ldots t_n$ may be thought of as all unallocated time that can be divided among n activities including leisure and labor. T is the finite time endowment and a_i is the technologically determined minimum amount of time required to produce and consume one unit of X_i. As in the household models discussed earlier, time is considered a resource by the second constraint (16). The third constraint (17) is new. In this contraint time is considered a commodity that may yield utility directly. Anyone who allocates more than the minimum amount of time to any activity does so because the time spent on that activity yields direct utility[7] (DeSerpa, 1971).

Maximization involves the Lagrangian (18) and first order conditions which are (19-21):

$$\text{Max } L = u(X_1 \ldots X_n, t_1 \ldots t_n) + \lambda(Y - \sum_{i=1}^{n} P_i X_i) +$$

$$\mu(T - \sum_{i=1}^{n} t_i) + \sum_{i=1}^{n} K_i(t_i - a_i X_i) \qquad (18)$$

$$\frac{\partial U}{\partial X_i} = U_{X_i} = \lambda P_i + K_i a_i \qquad (19)$$

$$\frac{\partial U}{\partial t_i} = U_{t_i} = \mu - K_i \qquad (20)$$

$$K_i(t_i - a_i X_i) = 0 \qquad (21)$$

Dividing U_{ti} by λ yields $U_{ti}/\lambda = \mu/\lambda - K_i/\lambda$. U_{ti}/λ is interpreted as the marginal rate of substitution of time for money in the consumption of good i and represents the value of time allocated to the activity of producing and consuming the i^{th} commodity. It is the value of time as a "commodity" because it is the change in utility from commodity i due to a change in the amount of time spent on it. In contrast, μ/λ represents the opportunity cost of time as a "resource" used in the production and consumption of good (i), i.e. the value of that time at its best alternative use. It is the marginal utility of time divided by the marginal utility of money and may be interpreted as the wage rate as it is in the (agricultural) household models.

Since each consumption activity requires a minimum amount of time, relaxing the i^{th} time consumption constraint is equivalent to saving time in that activity. Therefore K_i is interpreted as the marginal utility of saving time and the ratio K_i/λ is the value of saving time in activity i.

Either $t_i = a_i x_i$ (the minimum amount of time is in fact spent producing and/or consuming x_i) or $K_i = 0$ implying no marginal utility of saving time in activity i. If the time actually spent is greater than the minimum amount required ($t_i > a_i x_i$), K_i must equal zero.

More conventional economic theories with leisure-income or leisure-commodity tradeoffs ignore the third time constraint built into this model. They assume $K_i = 0$ for all commodities. If work time is not in the utility function (implying its marginal utility = 0), $\mu/\lambda = U_{ti}/\lambda$, i.e., the value of time as a resource equals the value of time as a commodity and both equal the wage rate. If the marginal utility of work time is, in fact, negative ($K_i/\lambda < 0$), $\mu/\lambda = U_{ti}/\lambda - K_i/\lambda$. This implies that the value of leisure time (as a resource $=\mu/\lambda$) is less than the wage rate. This model posits a definition of "leisure" activities as those for which the time-consumption constraint (21) is not binding and consumers spend more time on the activity than the technologically determined minimum.

Since utility cannot be measured in any meaningful way, μ/λ cannot be empirically estimated. However, K_i / λ can be obtained from observable data. It has been interpreted as the value of saving time and, thus, as the "price of time" in various activities. Incorporating this time price into demand functions results in being able to show that the time elasticity of demand for leisure activities is zero (i.e., the demand for leisure activities does not depend on the price of time in that activity). But, the models do not predict that the demand curves for time-elastic activities will slope downward. Only empirical evidence can determine the outcome. Herein lies one of the problems with this type of model. Different sets of data can yield different, but equally correct, results.

Many of the models developed for estimating different values of time for different activities was motivated by a need to estimate the demand for, and the costs and benefits of public goods such as highways or recreational facilities. Clearly it makes a difference whether time on a recreation site is valued differently from time spent in travel since one could be a cost and the other a benefit. Including time costs in the final value of recreational facilities was found to increase total consumer surplus of recreational activities by four times in a study by Bishop and Heberlein (1979). This difference was found even though time costs were valued at only half the wage rate and compared to time costs of zero. Studies by Wilman (1980) and McConnell (1975) showed that both travel and recreation time impose opportunity costs. Wilman argues that recreation is appropriately valued at the scarcity value (wage rate) and that travel time is best valued in terms of the "value of time saved", i.e. the difference between the commodity and scarcity value of time.[8] Wilman's model which assumes the number of trips and visits to a recreation site are equal resulted in recreation time (akin to leisure) being valued higher than travel time. However, dropping the assumed equality of trips and visits resulted in both types of time being valued at the wage rate. The approach used by Wilman (1980) and McConnell (1975) lets the model estimate the costs of time.

Some ad hoc techniques have been used to determine time costs such as arbitrarily selecting a constant opportunity cost like the minimum wage or assigning some proportion of the individual's wage rate (Nichols et al., 1978). McConnell and Strand (1981) argued that the opportunity cost is appropriately measured as some proportion of the wage rate and suggest a method for determining that proportion from sample data. They also suggested that opportunity costs may vary across recreational sites.

Smith et al. (1983:265) estimated wage rates for males and females using a hedonic wage model with data from a current population survey for each region of interest with the mean nominal wage rate as a dependent variable. The estimating equation was specified as a semi-log function of the local area cost of living index, characteristics of individuals, i.e. age, education, race, occupation, etc., attributes of the job and industry and characteristics of the individual's residential location. The parameters from this wage equation were then used to predict the wages of individuals in the survey sample. These proxies for individuals' actual wage rates are probably underestimated, but arguably better than more ad hoc methods discussed above. However, in estimating the demand for recreation sites, their method did not perform significantly better than allowing the opportunity cost to be a constant one-third of the wage rate (Cesario, 1976).

Smith et al. (1983) provide a review and evaluation of the proposals for valuing travel time in recreation demand models based on a household production framework. They reconfirm the importance of including the value of on-site time as well as the costs of travel in estimating the demand for recreation facilities but reject the idea of treating the opportunity cost as some fixed multiple of the individual's wage rate. A key point is that opportunity costs appear to be determined by the time constraints faced by individuals and the total leisure time they have available. The proposed model treats total time available for recreation as a constraint but on-site time as a choice. Their opportunity cost is a non-linear function of wages. This model allows opportunity costs to vary for travel and on-site time and for different types of recreational facilities.

THE FRONTIERS

Clearly a variety of methods have been used to estimate the value of time spent producing household commodities. Intensive interest in determining an appropriate value has been motivated by recognition that much of the productive activity in any economy takes place in the household and its value is unaccounted for in national income statistics. Being unable to accurately identify and value the output of household production, various models have been developed to value one of its major inputs, namely time. This is appropriate for augmenting GNP since it represents the value added to market goods. The value of time is used for predicting and explaining the supply of labor and the demand for market commodities. The value of time is also useful for explaining intrafamily decisions about children, education, investments in human capital, and the allocation of human resources. In short, how people value their time is believed to impact all economic choices. Determining the value of time enables researchers to better explain or predict human behavior.

Major conceptual breakthroughs occurred in the 1930s with work by Kyrk (1933) and Reid (1934) and in the 1960s with work by Mincer (1963) and Becker (1965). Heckman's (1976, 1977, 1980) methodologies were a major contribution. DeSerpa's (1971) model is a variation on Becker's, but resulted in new directions for empirical studies. Data collected on household time use have been an invaluable part of the overall research effort (Walker and Woods, 1976; Family Use Time, 1981).

The frontiers of future work in valuing household production time and in uses of that information lie in: (1) more extensive applications in demand analysis, and (2) better estimates of the value of time in specific activities. The first frontier involves using the new household economics approach, including the value and allocation of time and the full income constraint, for estimating the demand for market goods and services. Much of the work attempting to estimate the demand for (agricultural) production inputs has used data from developing countries. In a westernized world where demographics are changing dramatically and labor force participation patterns are changing rapidly, the value of time could also go a long way towards explaining market behavior.

The second frontier involves developing theoretical models and methodologies for assigning a shadow wage to time spent in specific activities that more closely approximates the individual's subjective value of time in that activity. The literature is rife with criticisms of a constant wage rate (actual or imputed) being used to value all uses of time; only a few have tried to deal with the problem short of going to the market cost approach. In addition, a clearer distinction needs to be made between opportunity costs associated with different activities at different times of the day, week, or year and the value of the marginal product associated with household activity. Even if the various subjective opportunity costs can be found, they may not be close approximations of the value of the marginal product for an individual producing household commodities. Marginal productivity is more difficult to define and measure because it is determined largely by effort and skill and other endowments of human resources which are difficult to quantify. Furthermore, it involves identifying individual commodities being produced and resurfaces all the problems of estimating household production functions. Information and technology alters the marginal productivity of household labor and changes the subjective value of time, over time. These factors need to be considered in models for valuing time if they are to be useful over the long run.

FOOTNOTES

1. In the household, the cost of production equals the price of consumption since once Q* has been decided upon, Q* in Figure 1 becomes the supply. P* is determined by demand if the supply (at least of labor) is perfectly inelastic (Gronau, 1973). If supply is infinitely elastic as implied by the common practice of equating marginal and average wages, Q* and the expenditure is demand driven. If, however, household time has diminishing marginal productivity, and the supply curve slopes upward, the valuing of household production by area dbco overestimates the cost by the area of producers' surplus, i.e., the value received by the household producer above the marginal shadow cost incurred.

2. Other publications associated with that regional project may have estimated a monetary value of time but their titles do not reveal it (Publications and Papers of NE-113, 1986).

3. Leisure time is an unfortunate term. "Unallocated time" better conveys the idea of a finite number of hours that can be allocated to various activities all of which contribute to one's utility directly or indirectly.

4. The reservation wage estimate involves reversing the signs of the estimated parameters and multiplying each by the reciprocal of the estimate on the own wage variable (see T.P. Schultz, 1980b:43-45).

5. A number of studies have also estimated how various stocks of human capital impact on productivity and on the value of time. R. Michael's study of educational impacts is a classic example (1972).

6. Other models by McConnell (1975) and Smith et al. (1983) have only a composite commodity and recreation in the utility function. Smith, et al.'s model utilizes the full-income constraint of the household production model.

7. Related to this point is the discussion by Dow and Juster (1985) who estimate (utility) benefits derived from the "process" of performing activities. Their "process well being" is a function of the time spent in any one activity and a subjective measure of satisfaction derived from that activity.

8. Most studies of the value of time spent in commuting also use the "value of time saved" as its appropriate value.

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