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SIMULTANEOUS USES OF TIME IN HOUSEHOLD PRODUCTION

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A household production function is developed which allows for persons to be engaged in more than one activity at a point in time. Labour inputs are scaled back when two activities are being undertaken. Data from the 1987 Australian Time Use Survey is used to estimate equations explaining input hours into home production by adult members of the household. One implication of the empirical results is that when two activities are being undertaken simultaneously input hours on the activity coded as "primary" and the input hours on the activity coded as "secondary" should each have a weight of one-half.

I. INTRODUCTION

Activities within the home are often undertaken simultaneously. In recognition of this, Time Use Surveys frequently collect information on both primary and secondary activities undertaken in each recorded time period. This joint use of time has been relatively neglected in household production and time allocation models. Instead, emphasis has been placed on the more metaphysical concept of regarding home activities as having both a production and consumption component [Pollock and Wachter (1975), Graham and Green (1984)]. To ignore data on simultaneous uses of time means that labour inputs into home activities are measured inaccurately. Input hours need to be adjusted for intensity of input. Home renovations as a sole activity is not the same as home renovations attempted while child-minding.

While simultaneous uses of time clearly have implications for valuing household production, our focus is on modelling the household production process.[1] We adopt Pyatt's (1990) broad division of household activities into tradeable and nontradeable. Tradeable activities are those which the household may either undertake itself or pay others to undertake. Examples are meal preparation and child-minding. Nontradeable activities are those which must be undertaken by the individual who benefits from them, e.g. education, attending a concert.

The specific aims of this paper are to allow for simultaneous uses of time in (i) the estimation of a household production function and (ii) explaining time spent by adult members of the household in the home production of tradeable commodities. The model of household production is outlined in section II. The characteristics of the data set are discussed in section III and the empirical estimates in section IV.

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[1]The literature on valuing household production is summarized in Juster and Stafford (1991).

TABLE 1

HOUSEHOLD PRODUCTION MODEL VARIABLES

G_s	= market purchases consumed as final goods
G_h	= home produced commodities
G_g	= market purchases used as inputs into home production
G	$= G_s + G_h$ = household consumption
H_f	= hours spent in home production (females)
H_m	= hours spent in home production (males)
K	= household stock of capital
P_s	= price of final use market goods, G_s
P_g	= price of market goods, G_g, used as inputs
W_f	= wage rate (female)
W_m	= wage rate (male)
Z	= characteristics of household

II. A NEOCLASSICAL MODEL OF HOUSEHOLD ACTIVITY

Graham and Green (1984) embedded a household production function within a six-equation model of household activity. A key assumption of this model and that of Gronau (1977) is that the home produced commodity is a perfect substitute for the market produced one. As shown by Kooreman and Kapteyn (1987) this means that production is separable from consumption and "the choice between home production or buying at the market is purely a matter of opportunity cost" (p. 246). It also follows, as pointed out by Gronau (1977), that time spent in home production is independent of non-labour income.

In this paper we retain the assumption that goods are perfect substitutes and also follow Graham and Green in using a Cobb–Douglas production function. Our new contribution is to use information on simultaneous uses of time to redefine input hours. The model is a tightly specified one, but this is forced upon us by the limited nature of our data.[2]

The production of household goods is a function of inputs purchased in the market, weighted hours of labour inputs, the household capital stock and characteristics of the household and its members. Owing to separability, labour inputs into the home production of tradeable goods are obtained from the marginal productivity conditions on the production function or, equivalently, from minimizing the cost of supplying a given volume of total consumption, G.

The cost of home produced goods is the sum of purchases of material inputs and the opportunity cost of labour. Using notation as set out in Table 1, the cost of providing a given level of consumption is

$$P_s G_s + P_g G_g + W_f H_f + W_m H_m. \tag{1}$$

This is minimized subject to given total consumption and the home production function i.e.

$$G_h + G_s = G \tag{2}$$

$$G_h = f(G_g, H_f, H_m: K). \tag{3}$$

[2]Both Kooreman and Kapteyn (1987) and Solberg and Wong (1992) estimate more general household production functions. These are embedded in a disaggregated model of household time allocation. Simultaneous uses of time are excluded.

We assume an interior solution and choose our data accordingly. Choosing a Cobb–Douglas form for the household production function

(4) $$G_h = f(Z) G_g^{\beta} H_f^{\gamma_f} H_m^{\gamma_m} K^{\gamma_k}, \qquad \text{where } f(Z) = \alpha\, e^{\eta Z}$$

and assuming the capital stock is fixed the restricted minimization gives three equations in the endogenous variables H_f, H_m and G_g:

(5) $$W_f H_f = \gamma_f P_s G_h, \qquad W_m H_m = \gamma_m P_s G_h \quad \text{and} \quad P_g G_g = \beta P_s G_h.$$

Substituting for G_h using (4) and solving for the two endogenous variables for which we have data yields:

(6) $$\log H_f = a_1 + b_1 \log W_f + c_1 \log W_m + dZ + e \log P_g + k \log K$$

(7) $$\log H_m = a_2 + b_2 \log W_f + c_2 \log W_m + dZ + e \log P_g + k \log K$$

where:

$$b_1 = -(1-\beta-\gamma_m)/\delta,\ c_1 = -\gamma_m/\delta,\ b_2 = -\gamma_f/\delta,\ c_2 = -(1-\beta-\gamma_f)/\delta,$$

$$\delta = (1-\beta-\gamma_f-\gamma_m),\ d = \eta/\delta,\ e = -\beta/\delta \quad \text{and} \quad k = \gamma_k/\delta.$$

The wage variables and the price of input goods are now expressed in real terms relative to the price of final use purchases. The parameter δ measures "economies of scale." The restrictions

(8) $$b_2 - b_1 = 1 \quad \text{and} \quad c_1 - c_2 = 1$$

arise from the use of the Cobb–Douglas production function which assumes an elasticity of substitution between H_f and H_m of unity. This is seen most clearly by subtracting equation (7) from equation (6):

(9) $$\log (H_f/H_m) = \log (\gamma_f/\gamma_m) + \log (W_m/W_f).$$

Due to the restrictions on the coefficients of equations (6)–(7), the underlying parameters are not identified. It is possible only to estimate the ratio γ_m/γ_f (as the ratio c_1/b_2). With cross-section data there is no variability in P_g and this term is absorbed into the intercept. In the absence of data on capital stock this variable must be omitted.

The input hours variables are a weighted average of primary and secondary time use. The weights may be estimated directly as follows. Define

h_1 = time spent in unpaid work as primary activity with no secondary activity
h_2 = time spent in unpaid work as secondary activity
h_3 = time spent in unpaid work as primary activity when there is a secondary activity (of any kind)
$h_4 = h_1 + h_3$ = time spent on unpaid work if all secondary activities are ignored.

Let θ be the weight given to unpaid work as a secondary activity, and $(1-\theta)$ be the weight given to unpaid work as a primary activity when there is also a secondary activity. Then weighted time, H, in unpaid work is given by

(10) $$H = h_1 + \theta h_2 + (1 - \theta) h_3.$$

Since a secondary activity by definition is less important than a primary activity we expect $0 < \theta < 0.5$. Note that when the primary and secondary activities are both unpaid work the time spent enters with full weight.

Equation (10) can be rewritten as

(11) $$H = h_4 - \theta(h_3 - h_2)$$

where the term $(h_3 - h_2)$ is non-zero only when there is both a primary and secondary activity and one of these activities, but only one, is unpaid work in the home. The term h_4 is the usual definition of time spent on work in the home, that is, when secondary activities are ignored. The issue in this paper is the extent to which the term $(h_3 - h_2)$ matters. Substitution of equation (11) into equations (6) and (7) permits direct estimates of the weighting parameter, θ, to be obtained.

A full treatment of unpaid work would involve including inputs of different intensities as separate arguments in the production function. Such a treatment would however increase the complexity of the model considerably through a substantial increase in the number of coefficients and by necessitating the use of a more flexible form for the production function to allow for zero inputs.

III. Data

The data source is the 1987 Time Use Pilot Survey undertaken by the Australian Bureau of Statistics. Details are contained in ABS (1988) and Bitman (1991). The survey covered about 1,000 households in Sydney. All adults (defined as persons aged 15 years or over) in the selected households were surveyed. The survey yielded 3,181 diary days of information on 1,611 adults. In estimation we confine the sample to households of exactly two adults of opposite sex, with or without children, where both adults were in the paid workforce.[3] At any point in time both primary and secondary activities were recorded. We define home production of tradeable commodities as domestic activities (housework and other), child-care and time spent in purchasing goods and services.

We calculate hourly wage rates from two questions asked of respondents separately from the time use questions. These questions relate to gross annual income and number of hours worked in the preceding week. Both the income and hours worked data were collected only in grouped form and mid-points were used in calculation.

Wage rates calculated from the survey in the manner outlined above will contain measurement error. In recognition of this we use predicted wage rates, which can be interpreted as instrumental variable estimates, rather than actual wages. Predicted wages were obtained by regressing the logarithm of actual wages, for females and males separately, on age and its square, dummy variables for education, occupation, place of birth, and cross-products between age and education level. Significant selection bias may arise in using only working adults in the wages equations. To check for this we carried out the usual two-stage procedure

[3]Persons aged between 15 and 19 who were full-time students were reclassified as children.

[see Killingsworth (1983) and Biddle and Hamermesh (1990)]. First a probit was estimated over a sample which included non-working adults relating the probability of working to the following variables: age and its square, education level, birthplace, and the presence of young children. The inverse of the Mills ratio was then added to the equation describing the logarithm of wages. This additional term turned out to be insignificant and was subsequently dropped.

Although we confine the sample to households where both adults are in the workforce, one or neither may not be engaged in paid work on the diary day. Implicitly, models of labour-leisure choice and time-use assume that decisions relate to at least an annual period. If H^a is time spent on unpaid work in the home over an annual period then the time spent on unpaid work in a given day, H^d, may be written as

$$H^d = k(D)H^a, \tag{12}$$

where $k(D)$ depends on factors such as the institutional arrangements relating to the employment of both the adults in the household, and irregular factors such as illness of household members and the weather. We treat the factors influencing $k(D)$ as exogenous and model them solely in terms of dummy variables defined as follows:

$D1 = 1$ if neither adult is working on that day; 0 otherwise,
$D2 = 1$ if female is not working on the day but male is working; 0 otherwise,
$D3 = 1$ if male is not working on the day but female is working; 0 otherwise.

Finally, the demographic variables we use are:

$Z1 = 1$ if household has children aged 0–4 years; 0 otherwise,
$Z2 = 1$ if household has children aged 5–9 years; 0 otherwise,
$Z3 = 1$ if household has children aged 10 years or over; 0 otherwise,
$Z4 = 1$ if household has children aged 5 or more but none aged less than 5 years; 0 otherwise.

IV. Estimates of Household Production Parameters

The model given by equations (6)–(7) is estimated using as the dependent variable (i) primary time only and (ii) weighted primary and secondary time as defined in equation (11). Dummy variables (D) are added to allow for the fact that both adults may not be working on the diary day. (Recall also that P_g is constant and K must be omitted owing to the lack of data.)

Two data samples are used. In the first, the sample is restricted to households where both adults were engaged in paid work on the diary day. In the second, all households where both adults were in the paid workforce are included, whether they worked on the diary day or not. The first data set is a subset of the second. Characteristics of the sample data on hours of unpaid work are given in Table 2. The wage variable, W, used is after-tax predicted wage rates as described in section III. After-tax actual rates were also used but these give inferior results.

As the results for the two samples were similar, we confine presentation to those obtained using the larger sample. Maximum likelihood estimates are given

TABLE 2

MINUTES OF UNPAID WORK DURING THE DIARY DAY: SAMPLES USED IN ESTIMATION

	Adults in Paid Work		Adults in Paid Workforce	
	Female	Male	Female	Male
# Sample days	91	91	165	165
Primary time (mean)	218.6	115.3	295.1	135.2
Primary time (st. dev)	130.7	103.7	178.6	128.3
Secondary time (mean)	33.5	11.8	41.9	13.8
Secondary time (st. dev)	48.5	26.3	68.6	26.9

in Table 3.[4] The restriction on the coefficients implied by the model (equations (8)) are satisfied when primary time only is considered and when both primary and secondary time are allowed for.[5] We therefore present only the restricted estimates. When secondary time was included the θ parameter of equation (11) was not significantly different for females and males. It is therefore constrained to be the same in the presented results. We present the heteroskedastic-consistent estimates of the standard errors although they are very close to the unadjusted estimates.

The estimated value of θ is 0.55. It is significantly different from zero but not significantly different from 0.5 (at the 5 percent level). This implies that primary and secondary time should be treated equally and each given a weight of one-half when defining time spent on unpaid work. The estimates of the coefficients of the Cobb–Douglas production function are, however, relatively insensitive to whether secondary time is included or not.[6]

The only insignificant wage effect is that of female wage rates on time spent by males in unpaid work. The elasticities of unpaid work time with respect to wages are always less than one in absolute magnitude. The "own-wage" elasticities are negative and the "cross-wage" elasticities are positive. Using the notation of equations (6) and (7), these point estimates imply that $(\beta + \gamma_f)$ and $(\beta + \gamma_m)$ each exceed unity and economies of scale exist.

The demographic variables turn out to be more important than the wage variables. The presence of pre-school children ($Z1$) raises the time spent on unpaid work, principally child-care, by nearly 150 percent. The other significant demographic variable is the presence of older children ($Z4$).

The "who's at home" dummy variables (D) are significant (at the 5 percent level) in nearly all cases and the coefficients are large. Compared to the control situation of both adults engaging in paid work during the diary day, the estimates

[4]In estimating the model with secondary time, the implicit functions were estimated using the LSQ option on TSP. They are effectively minimum distance estimates. The point estimates obtained for the parameters of equations (6) and (7) are the same as would be obtained from explicit equations with dependent variable defined as (11) and θ put equal to its minimum distance value. When θ is estimated (right-hand panel in Table 3), the residual sum of squares is reduced, but the R^2 is slightly lower due to the lower variance of the dependent variable.

[5]Estimates of the ratio equation (9) are not inconsistent with a Cobb–Douglas production function although the coefficient on the relative wages term is ill-determined. When primary time only is considered the coefficient is 0.450 with a standard error of 0.508.

[6]In particular, the coefficients obtained when $\theta = 0.5$ are virtually the same as those reported in the right-hand panel of Table 3.

TABLE 3

TIME SPENT ON UNPAID WORK: ADULTS IN PAID WORKFORCE

Explanatory Variable	Primary Time Only		Weighted Primary and Secondary	
	log H_f	log H_m	log H_f	log H_m
Constant	4.516**	3.528**	4.524**	3.512**
	(0.733)	(0.767)	(0.762)	(0.793)
Log W_f	−0.400*	0.600**	−0.350**	0.650**
	(0.188)	(0.188)	(0.179)	(0.179)
Log W_m	0.425	−0.575*	0.387	−0.613**
	(0.306)	(0.306)	(0.312)	(0.312)
Z1	0.896**	0.896**	0.893**	0.893**
	(0.129)	(0.129)	(0.125)	(0.125)
Z4	0.656**	0.656**	0.620**	0.620**
	(0.129)	(0.129)	(0.130)	(0.130)
D1	0.627**	1.203**	0.583**	1.202**
	(0.160)	(0.289)	(0.161)	(0.283)
D2	0.781**	−0.747**	0.769**	−0.541
	(0.105)	(0.353)	(0.104)	(0.333)
D3	−0.599**	1.572**	−0.530*	1.564**
	(0.290)	(0.594)	(0.317)	(0.592)
θ	0	0	0.551**	0.551**
			(0.189)	(0.189)
R^2	0.393	0.159	0.384	0.153
s	0.683	1.679	0.681	1.620
Log L	−491.062		−484.402	

Notes: Asymptotically consistent standard errors in parentheses; sample size is 165 households. *Denotes significance at 10 percent level; **denotes significance at 5 percent level.

Likelihood ratio test for restrictions as set out in equations (6)–(7) yield χ^2 values of 6.98 (primary time) and 7.09 (primary and secondary time); the critical values at the 5 percent level are 9.49 and 11.07, respectively. The restrictions are individually satisfield using Wald tests.

for the model with secondary time included imply the following: if both adults "stay home" time spent on unpaid work increases by 79 percent for females and 233 percent for males; if only the female "stays home" her unpaid work increases by 116 percent while that of the male decreases by 42 percent; if only the male "stays home" his unpaid work increases by 378 percent whereas that for the female falls by 41 percent. The general result is that on days when males are not engaged in paid work the time they spend on unpaid work at home shows a larger increase. This is true whether both or only one adult does not undertake paid work on the day.

V. CONCLUDING REMARKS

Our results suggest that, in measuring household production, if two activities are being undertaken simultaneously, input hours into each should be weighted equally at one-half, despite one activity being coded as "primary" and one as "secondary." To illustrate, it does not seem necessary to distinguish between looking after children while watching television and watching television while looking after children. The implication is that it would be sufficient to record all activities taking place at a given time and weight each by the inverse of the number of simultaneous activities.

Of course this result is only as good as the model used. Although giving secondary and primary activities equal weight provides the best fit to the data, the empirical results are relatively insensitive to the treatment of secondary time. We find that the wage rates of the female and male adult members of a household significantly effect time spent on unpaid work by both adults. Own wage rates have a negative effect on time spent in unpaid work; cross wage rates have a positive effect. The estimated elasticities are all less than one in absolute value.

In order to economize on degrees of freedom for what is a relatively small sample, we have estimated within a fairly tightly constrained model of unpaid time use within the household. There was no indication that the constraints were inappropriate, but it would be desirable to estimate a more general production function using a larger sample. A major omission from this and other studies of household production is data on stocks of household durables used in home production.

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