KHT

subfaculteit der econometrie

RESEARCH MEMORANDUM

[redacted]

TILBURG UNIVERSITY
DEPARTMENT OF ECONOMICS
Postbus 90153 - 5000 LE Tilburg
Netherlands

[redacted]

FEW
153

A disaggregated analysis of the allocation of time within the household.

Peter Kooreman
Arie Kapteyn

September 1984

Department of Econometrics
Tilburg University
P.O. Box 90153
5000 LE Tilburg
The Netherlands

Table of contents

Abstract

In this paper a model of the allocation of time within the household is estimated, using data that allows to distinguish between a large number of time uses. The model is explicitly derived within a utility maximization framework, allows for random preference variation, and can be estimated using a relatively simple two step estimation procedure. The empirical results show strong responses of time use to variations in economic and demographic variables. The responses tend to cancel each other out, in such a way that most of it becomes invisible if one only observes aggregate time use categories.

1. Introduction

The classical paper by Becker (1965) has greatly enhanced economists' interest in the analysis of the allocation of time. In Becker's household production theory the household is assumed to behave as if it maximizes a utility function defined over commodities, where these commodities are produced by the household using market goods and time as inputs. By maximizing the utility function subject to the technology, the time and the income constraints, the demand for market goods, the allocation of non-market time and the household labor supply are determined simultaneously.

However valuable the household production framework may be from a theoretical viewpoint, its empirical applicability is rather limited. The main reason for this fact is that without having data on the commodities produced by the household, which is usually the case[1)], it is generally impossible to disentangle the effects of tastes and technology on observed behavior (cf. Pollak and Wachter, 1975). Therefore, models of goods and leisure demand (or equivalently labor supply) usually start from a utility function with goods and leisure as arguments.

During the last few years a number of empirical studies have been published on labor supply and the joint determination of labor supply and demands for goods. However, there are only a few empirical studies which focus on the allocation of time among different activities and even fewer that do so within a neoclassical household utility maximization framework. Where the lack of data might have been an explanation for this fact ten years ago, there are now a number of micro-economic data sets available containing detailed information on how people use their time as well as information on income, wages etc. One of these data sets, the Michigan Survey "Time use in economic and social accounts", conducted in 1975-6, will be used in this paper.

To the extent that time not spent on market work has been disaggregated within a neoclassical frame work, only two categories are usually distinguished, time spent on housework and "pure" leisure. Exam-

1) An exception is the paper by Rosenzweig and Schultz (1983) who use birth weight as an indicator of the output of the household health production function.

ples are the papers by Gronau (1977, 1980) and Graham and Green (1984). In these studies the household production process has only one output, viz. an aggregate of goods. This aggregate can also be bought on the market. Having thus made the output of the household production process observable, tastes and technology can be separated. As a matter of fact, tastes hardly play a role in these papers, because the perfect substitutability of the household production output with a market good generates an efficiency condition that relates the number of hours spent on housework by each spouse to their market wages, at least if they work non-zero hours in a paid job. Gronau assumes the absence of joint production, whereas Graham and Green allow for joint production, meaning that the spouses are allowed to enjoy housework and hence to count part of the time spent on it as leisure. In none of the papers, an attempt is made to correct for the selection bias that may result from exclusion of households with non-working spouses.

Wales and Woodland (1977) distinguish the same time use categories, and consider a sequence of models that differ from the framework developed by Gronau, but again output of household production is observable, namely total consumption. No correction for selection bias takes place when estimating their models.

The assumptions that the output of the household production process can be reasonably approximated by total consumption (Wales and Woodland) or that the output could also be bought on the market (Gronau, Graham and Green) facilitate the empirical analysis substantially.

Still they are hard to accept at face value. "Home made" is by definition not available on the market, even though advertisers would like us to believe differently.

In this paper we model the demand for goods and the allocation of time by assuming that households maximize a utility function with goods and time spent on various activities as arguments. As is obvious from the analysis of Pollak and Wachter (1975), the utility function thus defined is a reduced form that represents the influence of both preferences and technology. As a result, we may have even less intuition than usual about the form of the utility function. Hence a flexible specification, the translog, has been adapted. Since, in principle, our framework is less restrictive than the models of Gronau and Graham and Green, we should be able to see whether these models are compatible with our results. We pay attention to this when discussing the empirical outcomes of our model.

In section 2 we present the model. In section 3 the estimation method is discussed which consists of a rather simple two step procedure that corrects for selection bias and allows for the incorporation of demographic variables in an elaborate way. The simplicity of the estimation procedure makes it possible to distinguish a large number of activities. Sections 4 and 5 present the data and the results. Although time use is disaggregated, consumption of goods is not, due to lack of data. Given that we use cross-section data in which all households can be assumed to face the same prices of consumption goods, it follows from Hick's composite commodity theorem that the aggregation of consumption does not cause any less of information regarding the determinants of time use. Section 6 concludes.

2. The model

We only consider households with both a male and a female partner present. Each household is supposed to behave if it maximizes a well-behaved utility function $U(\ell_{m1},\ldots,\ell_{mK};\ell_{f1},\ldots,\ell_{fK};y)$, where ℓ_{mi} $(i=1,\ldots,K)$ is the time spent on the i-th activity by the male partner, $\ell_{fi}(i=1,\ldots,K)$ is the time spent on the i-th activity by the female partner, and y is total household consumption[1)].

Maximization of the household utility function takes place subject to:

$$py \leqslant w_m(T - \sum_{i=1}^{K} \ell_{mi}) + w_f(T - \sum_{i=1}^{K} \ell_{mi}) + \mu \tag{2.1}$$

$$\sum_{i=1}^{K} \ell_{mi} \leqslant T \tag{2.2}$$

$$\sum_{i=1}^{K} \ell_{fi} \leqslant T \tag{2.3}$$

$$0 \leqslant \ell_{mi} \qquad i = 1,\ldots,K \tag{2.4}$$

$$0 \leqslant \ell_{fi} \qquad i = 1,\ldots,K \tag{2.5}$$

$$0 \leqslant y \tag{2.6}$$

where p is the price of consumption and w_m and w_f are the male and female wage rate, respectively, T is the totale number of hours available per period of time and μ is non-labor family income[2)] (e.g. property income or welfare benefits).

Inequality (2.1) can be written as:

$$py + w_m \sum_{i=1}^{K} \ell_{mi} + w_f \sum_{i=1}^{K} \ell_{fi} \leqslant Y \equiv w_mT + w_fT + \mu \tag{2.7}$$

1) The data do not allow for a desaggregation of totale household consumption. Of course, it would be preferable to have data that allow for a desaggregation of both time use and consumption.

2) The wage rates and non-labor income are all measured after taxes.

where Y denotes full income. Notice that (2.7) is a conventional budget constraint where all male activities have price w_m and all female activities have price w_f.
As a specification of our model we choose the indirect translog utility function; see Christensen, Jorgenson and Lau (1975):

$$\psi(v;\theta,\varepsilon) = \sum_{i=1}^{2K+1} (\alpha_i+\varepsilon_i)\ln v_i + \tfrac{1}{2} \sum_{i=1}^{2K+1} \sum_{i=1}^{2K+1} \beta_{ij} \ln v_i \ln v_j \quad (2.8)$$

where

$$\begin{aligned} v_i &= w_m/Y & i &= 1,\ldots,K \\ v_i &= w_f/Y & i &= K+1,\ldots,2K \\ v_i &= p/Y & i &= 2K+1 \end{aligned} \quad (2.9)$$

and ε is a (2K+1)-dimensional vector of $N(0,\Sigma)$ distributed random variables.

For normalization, we set $\sum_{i=1}^{2K+1} \alpha_i = -1$ and $\sum_{i=1}^{2K+1} \varepsilon_i = 0$. The random variable ε_i is introduced to represent individual variation in preferences. The share equations derived from (2.8) using Roy's identity, $v_i q_i = v_i(\partial\psi/\partial v_i)/\{\sum_j v_j(\partial\psi/\partial v_j)\}$, are

$$v_i q_i = (\alpha_i+\varepsilon_i+\sum_{j=1}^{2K+1} \beta_{ij} \ln v_j)/D \qquad i = 1,\ldots,2K+1 \quad (2.10)$$

where $(q_1,\ldots,q_K) = (\ell_{m1},\ldots,\ell_{mK})$.

$$(q_{K+1},\ldots,q_{2K}) = (\ell_{f1},\ldots,\ell_{fK}),$$

$$q_{2K+1} = y$$

and $$D = -1 + \sum_{i=1}^{2K+1} \sum_{j=1}^{2K+1} \beta_{ij} \ln v_j. \tag{2.11}$$

Although the ε_i have been introduced to represent random preference variation, it is clear from (2.10) that these can also comprise other sources of random variation in $v_i q_i$, like measurement errors, optimization errors by the household, etc.

Equations (2.10) only apply to households for which the constraints (2.2) - (2.6) are non-binding. Although the theory of rationing developed by Neary and Roberts (1980) provides an appropriate framework for the analysis of corner solutions, only restrictive functional specifications allow for a closed form for the utility maximizing demands in such cases. Therefore, in the estimation of the model we will only use observations on households where both male and female partner have a paid job, i.e. households for which (2.2) and (2.3) are non-binding. We will ignore the constraints (2.4) - (2.6) which are binding for only a limited number of observations.

3. Estimation method

In view of the large number of parameters that have to be estimated maximum likelihood estimation of the complete model must be considered to be infeasible. Therefore, the model will be estimated using a two step estimation procedure which yields consistent estimates and is considerably easier computationally than the maximum likelihood estimator. In the first step we aggregate the ℓ_{mi} and ℓ_{fi} to total male leisure ℓ_m and female leisure ℓ_f respectively and estimate the resulting model by maximum likelihood. The ML-estimates are used to correct for selection bias in the second step in which the complete disaggregate model is estimated. As always the budget constraint (in this case the full income constraint (2.1)) allows us to drop one equation. We have chosen to omit the demand for total consumption equation.

Thus we define: $\ell_m \equiv \sum_{i=1}^{K} q_i = \sum_{i=1}^{K} \ell_{mi}$ and $\ell_f \equiv \sum_{i=K+1}^{2K} q_i = \sum_{i=1}^{K} \ell_{fi}$

and we rewrite (2.10):

$$v_i q_i = \{\alpha_i + \varepsilon_i + \sum_{j=1}^{K} \beta_{ij}\, \ell n(w_m/Y) + \sum_{j=K+1}^{2K} \beta_{ij} \ell n(w_f/_Y) + $$

$$+ \beta_{i,2K+1} \ell n(p/_Y)\}/D \tag{3.1a}$$

and $$D = -1 + (\beta_{mm}+\beta_{fm}+\beta_{ym})\ell n(w_m/Y) +$$

$$(\beta_{mf}+\beta_{ff}+\beta_{yf})\ell n(w_f/Y) + (\beta_{my}+\beta_{fy}+\beta_{yy})\ell n(p/_Y) \tag{3.1b}$$

with $$\beta_{mm} = \sum_{i=1}^{K}\sum_{j=1}^{K} \beta_{ij} \qquad \beta_{mf} = \sum_{i=1}^{K}\sum_{j=K+1}^{2K} \beta_{ij} \qquad \beta_{my} = \sum_{i=1}^{K} \beta_{i,2K+1}$$

$$\beta_{fm} = \sum_{i=K+1}^{2K}\sum_{j=1}^{K} \beta_{ij} \qquad \beta_{ff} = \sum_{i=K+1}^{2K}\sum_{j=K+1}^{2K} \beta_{ij} \qquad \beta_{fy} = \sum_{i=K+1}^{2K} \beta_{i,\ 2K+1}$$

$$\beta_{ym} = \sum_{j=1}^{K} \beta_{2K+1,j} \qquad \beta_{yf} = \sum_{j=k+1}^{2K} \beta_{2K+1,j} \qquad \beta_{yy} = \beta_{2K+1,2K+1}$$

From (3.1) it follows that

$$s_m \equiv \sum_{i=1}^{K} v_i q_i = \frac{w_m \ell_m}{Y} =$$

$$\{\alpha_m + \varepsilon_m + \beta_{mm}\, \ell n(w_m/Y) + \beta_{mf}\, \ell n(w_f/Y) + \beta_{my}\, \ell n(p/Y)\}/D \qquad (3.2)$$

and

$$s_f \equiv \sum_{i=K+1}^{2K} v_i q_i = \frac{w_f \ell_f}{Y} =$$

$$= \{\alpha_f + \varepsilon_f + \beta_{fm}\, \ell n(w_m/Y) + \beta_{ff}\, \ell n(w_f/Y) + \beta_{fy}\, \ell n(p/_Y)\}/D \qquad (3.3)$$

where

$$\alpha_m = \sum_{i=1}^{K} \alpha_i \;,\; \alpha_f = \sum_{i=K+1}^{2K} \alpha_i$$

$$(3.4)$$

$$\varepsilon_m = \sum_{i=1}^{K} \varepsilon_i \;,\; \varepsilon_f = \sum_{i=K+1}^{2K} \varepsilon_i$$

and s_m and s_f are the shares of male and female leisure in full household income.

The likelihood function of the aggregated model (3.2) - (3.3) for a sample of two earner families only is given by:[1)]

$$L = \prod_{h=1}^{N} \{f_1(s_{mh};\, s_{fh}) / \int_{-\infty}^{\tilde{T}_h} f_2(s_{fh}) ds_{fh}\} \qquad (3.5)$$

where f_1 is the joint density of s_{mh} and s_{fh} (h denotes the observation), f_2 is the marginal density of s_{fh}, N is the number of obser-

1) We only take into account the most stringent selection rule of excluding non-participating females.

vations, and $\tilde{T}_h$ is defined by $\tilde{T}_h = {}^{w}fh^{T}/Y_h$. This first estimation step yields consistent of α_m, α_f, β_{mm}, β_{mf}, β_{my}, β_{fm}, β_{ff}, β_{fy}, β_{ym}, β_{yf} and β_{yy}. After substituting the estimates of the β's into (3.16) we obtain consistent estimates of D_h, for all observations.

In the second step the estimates of D_h are inserted into (3.1a), so that we are left with 2K linear equations, which can be estimated equation by equation using weighted least squares (WLS).

In this second estimation step, the selection bias that arises from using two earner families exclusively is accounted for by adding the estimated inverse of Mill's ratio a a regressor to the linear equations (cf.,e.g., Heckman, 1979). The estimated inverse of Mill's ratio in this case is given by

$$\hat{\lambda}_h = \phi(\hat{Z}_h/\hat{\sigma}_{\varepsilon_f}) \Big/ \int_{-\infty}^{\tilde{T}_h} f_2(s_{fh})ds_{fh} \tag{3.6}$$

where ϕ is the standard normal density, $\hat{\sigma}_{\varepsilon_f}$ is the estimated standard error of ε_f and

$$\hat{Z}_h = \tilde{T}_h\hat{D}_h - \left\{\hat{\alpha}_f + \hat{\beta}_{fm}\ \ell n({}^{w}mh/Y_h) + \hat{\beta}_{ff}\ \ell n({}^{w}fh/Y_h) + \hat{\beta}_{fy}\ \ell n(p/_{Y_h})\right\} \tag{3.7}$$

Notice that $\hat{\lambda}$ can be calculated directly using the results from the first estimation step. Although the selection rule differs from the standard case, as it depends on the behavior of a sum of endogenous variables, this complication disappears in practice. Due to the equality of prices within groups of commodities, perfect aggregation is possible within the commodity groups, so that the behavior of the sum of endogenous variables can be discribed solely in terms of the aggregate model.

In order to allow for the effects of household characteristics on the allocation of time, the parameters α_i will assumed to be linear functions of these demographic characteristics. By using this specification the possibility to apply WLS in the second step is retained. In the first step symmetry and adding-up will be imposed (homogeneity is satisfied automatically). It is not possible however to impose symmetry and adding-up in the second step, without greatly complicating the computations.

4. The data

The model has been estimated using data from the Michigan survey "Time use in economic and social accounts", 1975-6. The sample has been drawn randomly from the population of all U.S. households; it contains 975 households. In addition to detailed diary information on time use of the respondents, the sample contains information on the employment status of the respondent and spouse, earnings and other income and demographic variables.

From the sample we took the subsample of households containing at least two adults of different sex, where both the male and female partner are employed wage earners. Thus, we excluded the self-employed, the households with only one adult, the households where the male or female partner is unemployed, retired, going to school, disabled, etc. After excluding the observations with incomplete data, we have a sample of 114 households.

In the estimation of the model, seven types of leisure activities will be distinguished:

I Household activities

II Child care

III Obtaining goods and services

IV Personal needs and care (including sleeping)

V Organizational activities, hobbies and active sports

VI Entertainment, Social activities

VII Radio, TV, reading books etc.

(For an extensive description the reader is referred to Juster et al. (1978)). In tables 4.1 and 4.2 a number of sample statistics are presented.

Table 4.1 Average time use (hours per week)

	Husband	Wife
Household act.	7.9	18.8
Child care	1.5	4.4
Obtaining goods/serv.	3.8	5.8
Personal needs/care	73.2	74.8
Org. act./hobbies/sports	7.7	7.3
Entertainment	6.1	8.1
Radio/TV/reading	18.8	17.6
Market work	49.0	31.2

Table 4.2. Average values exogenous variables

Husband's net wage a) (w_m)	5.3
Wife's net wage a) (w_f)	4.4
Husband's age (AGE_m)	36.5
Wife's age (AGE_f)	34.1
Husband's education index ($EDUC_m$)	3.6
Wife's education index ($EDUC_f$)	3.4
Number of children 0-5 (C_1)	0.3
Number of children 6-12 (C_2)	0.3
Number of children 12-18 (C_3)	0.5
Number of children $\geq$ 18 (C_4)	0.6
White (0) - non-white (1) (NON-WHITE)	0.05
Unearned income b) (μ)	14.2

a) \$ per hour

b) \$ per week

5. Estimation results

In this section the results of the two step estimation procedure outlined in section 3 will be presented and discussed.
The parameters α_i are specified as follows:

$$\alpha_{ji} = \gamma^0_{ji} + \gamma^1_{ji}\,AGE_j + \gamma^2_{ji}\,AGE^2_j + \gamma^3_{ji}\,EDUC_m$$
$$+ \gamma^4_{ji}\,EDUC_f + \gamma^5_{ji}\,\text{NON-WHITE} +$$
$$+ \gamma^6_{ji}C1 + \gamma^7_{ji}C2 + \gamma^8_{ji}C3 + \gamma^9_{ji}C4,\ j = m,f;\ i = 1,\dots,K. \quad (5.1)$$

with $\alpha_{mi} = \alpha_i$ and $\alpha_{fi} = \alpha_{i+K}$ $(i=1,\dots,K)$.
From (3.4) and (5.1) it follows that α_m and α_f have the same form as (5.1) with γ^k_{mi} and γ^k_{fi} replaced by $\gamma^k_m \equiv \sum_{i=1}^{K} \gamma^k_{mi}$ and $\gamma^k_f \equiv \sum_{i=1}^{K} \gamma^k_{fi}$ $(k = 0,\dots,9)$, respectively.
First, we compare the second step estimation results with the corresponding first step results. With respect to α_m and α_f we observe that in both steps none of these parameters differ significantly from zero. With respect to the β's we observe that for all of them the estimates from both steps have the same sign and do not show large differences (see table 5.1)[1)]

Table 5.1[2)]

	$\hat\beta_{mm}$	$\hat\beta_{mf}$	$\hat\beta_{my}$	$\hat\beta_{fm}$	$\hat\beta_{ff}$	$\hat\beta_{fy}$
First step	-0.03	0.16	0.01	0.16	-0.02	-0.01
	(-0.4)	(0.8)	(0.4)	(0.8)	(-0.2)	(-0.2)
Second step	-0.05	0.11	0.00	0.12	-0.12	-0.03
	(-1.5)	(1.0)	(0.1)	(2.7)	(-1.0)	(-0.4)

Finally, we observe that $\hat\beta_{mf}$ is very close to $\hat\beta_{fm}$ in the second step.

1) Since the estimation of the aggregate model is not our primary aim, we do not present the results of the first estimation step in full detail.

2) The t-values from the second step are conditional on the values of D_h and h.

Table 5.2a Estimation results for the disaggregate model; husband [1,2)]

activity / parameter of	Household act.	Child care	Obtaining goods/ serv.	Personal needs/ care	Org.Act./ hobbies/ sports	Entertain-ment/Soc. act.	Radio/ TV/ reading	Total leisure
$^1/D$	-0.208	-0.290	0.163	0.514	0.513	0.104	-0.594	0.201
		(-2.1)		(1.1)	(1.6)		(-1.3)	
$^1/D * \ln(^w m/Y)$	-0.017	-0.016	0.007	-0.012	0.034	0.003	-0.051	-0.054
	(-1.0)	(-2.2)			(1.9)		(-2.1)	(-1.5)
$^1/D * \ln(^w f/Y)$	-0.025	-0.051	0.010	0.123	0.054	0.036	-0.033	0.113
		(-2.5)		(1.7)	(1.1)			(1.2)
$^1/D * \ln(^1/Y)$ [3)]	0.001	0.013	0.012	0.000	0.005	-0.016	-0.012	0.003
		(1.5)	(1.0)					
$^1/D * AGE_m$	-0.002	-0.000	0.001	0.000	0.001	-0.000	-0.001	-0.001
	(-2.0)							
$^1/D * AGE_m^2 * 0.01$	0.002	0.000	-0.001	-0.000	-0.001	0.001	0.000	0.002
	(1.9)							
$^1/D * EDUC_m$	0.003	-0.001	-0.001	-0.001	0.002	0.002	-0.004	-0.000
	(1.9)				(1.2)	(1.2)	(-1.9)	
$^1/D * EDUC_f$	-0.004	0.001	0.001	-0.001	-0.003	-0.003	0.006	-0.003
	(-1.7)				(-1.1)	(-1.2)	(1.7)	
$^1/D *$ NON-WHITE	-0.000	0.001	-0.004	0.006	-0.013	-0.002	0.013	-0.001
					(-2.3)		(1.6)	

$^{1}/D$ * C1	0.004	-0.001	-0.002	-0.004	0.001	0.001	0.003	0.001
	(1.4)		(-1.2)					
$^{1}/D$ * C2	0.002	0.000	-0.000	-0.002	0.002	0.001	-0.001	0.002
$^{1}/D$ * C3	0.002	0.001	-0.001	0.000	-0.002	-0.000	0.003	0.002
	(1.1)				(-1.1)		(1.2)	
$^{1}/D$ * C4	0.001	0.001	-0.000	-0.007	0.000		0.004	-0.001
				(-2.6)			(1.8)	
$\hat{\lambda}$	0.053	0.052	-0.013	-0.024	-0.041	0.007	0.041	0.074
	(1.1)	(2.4)						
R^2	0.68	0.43	0.56	0.99	0.60	0.51	0.85	0.99

1) t-values in parentheses if greater than 1.0 in absolute value.

2) Since D_h is negative for all observations, a positive (negative) sign implies a negative (positive) effect of the demographic variable on the time spent in activity i.

3) We set p = 1, without loss of generality.

Table 5.2b Estiomation results for the disaggregate model; wife

parameter \ activity of	Household act.	Child care	Obtaining goods/ serv.	Personal needs/ care	Org.Act./ hobbies/ sports	Entertain- ment/Soc. act.	Radio/ TV/ reading	Total leisure
$^{1}/D$	-0.130	-0.104	0.381	0.640	-0.216	-0.230	-0.764	-0.423
			(1.7)	(1.5)			(-2.1)	
$^{1}/D * \ell n(^{w}m/Y)$	0.022	-0.010	0.020	0.107	0.007	0.004	-0.034	0.118
	(1.0)	(-1.0)	(1.7)	(4.6)			(-1.7)	(2.7)
$^{1}/D * \ell n(^{w}f/Y)$	-0.058	-.025	0.031	0.101	-0.041	-0.038	-0.093	-0.124
				(1.5)			(-1.7)	(-1.0)
$^{1}/D * \ell n(^{1}/Y)$	0.009	0.015	0.018	-0.058	-0.008	0.000	-0.002	-0.026
		(1.0)	(1.0)	(-1.7)				
$^{1}/D * AGE_f$	-0.002	0.000	0.001	0.001	-0.002	0.001	-0.001	-0.001
	(-1.0)							
$^{1}/D * AGE_f^2 * 0.01$	0.003	-0.000	-0.001	-0.001	0.002	-0.000	0.001	0.003
	(1.0)							
$^{1}/D * EDUC_m$	-0.001	-0.000	0.001	-0.001	0.001	0.002	-0.003	-0.002
			(1.0)			(1.4)	(-1.9)	
$^{1}/D * EDUC_f$	0.001	0.000	0.002	-0.004	-0.006	-0.001	0.004	-0.003
			(1.3)	(-1.1)	(-1.7)		(1.1)	
$^{1}/D$ * NON-WHITE	0.006	0.005	-0.003	-0.003	0.007	0.001	-0.006	0.008
		(1.6)			(1.1)			
$^{1}/D * C1$	-0.001	-0.009	-0.004	0.001	-0.000	0.008	0.005	0.005
		(-4.9)				(2.5)	(1.3)	
$^{1}/D * C2$	0.001	-0.002	-0.004	0.003	0.003	0.004	0.003	0.008
		(-1.6)		(1.1)	(1.4)	(2.1)	(1.4)	(1.7)
$^{1}/D * C3$	-0.000	-0.001	0.001	-0.002	0.001	-0.001	-0.000	-0.004
		(-1.1)		(-1.0)				
$^{1}/D * C4$	-0.001	-0.000	-0.001	-0.001	0.001	0.000	-0.002	-0.003
$\hat{\lambda}$	0.077	0.003	-0.061	-0.130	0.063	0.061	0.070	0.082
	(1.1)		(-1.8)	(-1.9)	(1.1)	(1.2)	(1.2)	
R^2	0.83	0.70	0.65	0.99	0.60	0.65	0.84	0.99

Although we cannot draw any firm statistical conclusion from this comparison, the second step parameter estimates do not seem to differ dramatically from the corresponding first step estimates.

Whereas the results of the estimation of the aggregate model reveal few significant coefficients, table 5.2 shows that a disaggregation of leisure time reveals some pronounced effects of both economic and demographic variables on the household allocation of time. As could be expected, there is a strong positive effect of the presence of young children on child care by the wife. This effect decreases with increasing age of the children. In addition we observe that having young children has a negative impact on spending time on entertainment and social activities by the wife. The allocation of time by the husband is hardly affected by the presence of children. In general, age has a minor impact on time use. Only for the time spent by the husband at household activities (which includes gardening, repairs etc.) we found a significant parabolic effect with a maximum at 45 years. The husband's education has a slight positive effect on the time spent at listening to the radio, watching TV and reading books etc. by both the male and the female partner. Non-white males seem to spend more time at organizational activities, hobbies and active sports than white males.

Since the β's are not amenable to direct interpretation, we concentrate the discussion of price and income effects on the elasticities

$$E_{w_m}^{\ell_{ji}} \equiv \partial \log \ell_{ji}/\partial \log w_m, \quad E_{w_f}^{\ell_{ji}} \equiv \partial \log \ell_{ji}/\partial \log w_f \quad \text{and}$$

$$E_{\mu}^{\ell_{ji}} = \partial \log \ell_{ji}/\partial \log \mu, \quad E_{Y}^{\ell_{ji}} = \partial \log \ell_{ji}/\partial \log Y, \; i = 1,\ldots, K;$$

$$j = m,f. \text{ (table 5.3)}$$

and on the elasticities of total consumption with respect to the wage rates.

Table 5.3. Elasticities[1)]

Male	$E^{\ell_{mi}}_{w_m}$	$\tilde{E}^{\ell_{mi}}_{w_m}$	$E^{\ell_{mi}}_{w_f}$	$\tilde{E}^{\ell_{mi}}_{w_f}$	$E^{\ell_{mi}}_{Y}$	$E^{\ell_{mi}}_{\mu}$
Household act.	-0.63	-0.48	0.69	0.77	-0.92	-0.01
Child care	-1.61	-0.96	2.89	3.24	-4.14	-0.04
Obtaining goods/serv.	0.41	-0.12	0.79	0.51	3.36	0.03
Personal needs/care	0.05	-0.16	-0.05	-0.16	1.31	0.01
Org.act./hobbies/sports	0.95	-0.36	-0.50	-1.19	8.28	0.07
Entertainment/soc. act.	0.66	0.12	-2.63	-2.91	3.41	0.03
Radio/TV/reading	-0.46	-0.25	0.23	0.34	-1.31	-0.01
Total leisure	-0.04	-0.18	0.06	-0.01	0.86	0.01

Female	$E^{\ell_{fi}}_{w_m}$	$\tilde{E}^{\ell_{fi}}_{w_m}$	$E^{\ell_{fi}}_{w_f}$	$\tilde{E}^{\ell_{fi}}_{w_f}$	$E^{\ell_{fi}}_{Y}$	$E^{\ell_{fi}}_{\mu}$
Household act.	-0.83	-0.79	1.02	1.04	-0.23	-0.00
Child care	0.46	0.60	0.51	0.58	-0.87	-0.01
Obtaining goods/serv.	2.40	1.28	-0.42	-1.01	7.11	0.06
Personal needs/care	0.32	0.04	-0.75	-0.90	1.76	0.02
Org.act./hobbies/sports	-0.71	-0.55	0.31	0.39	-0.99	-0.01
Entertainment/soc.act.	-2.85	-2.25	2.49	2.80	-3.77	-0.03
Radio/TV/reading	-0.57	-0.08	0.40	0.66	-3.13	-0.03
Total leisure	-0.13	-0.19	-0.02	-0.05	0.41	0.00
Total consumption	0.65	0.72	0.27	0.31	-0.48	0.03

1) Evaluated at the sample means. Elasticities with a tilde on top are compensated elasticities. The other ones are uncompensated.

The elasticities, both compensated and uncompensated, are given in Table 5.3. We present two income elasticities, one with respect to μ and one with respect to Y. The elasticities with respect to μ are very small, simply because μ is small on average, viz. approximately \$ 14 per week. Hence, a 1% percent change in μ amounts to an unearned income change of 14 cents. On the other hand, Y is equal to \$ 1644 per week on average so that a 1% percent change implies a change in μ with \$ 16.

Both male and female leisure are normal goods as could be expected, but the subdivision into categories yields a very diverse picture. For the male, household activities, child care and radio/TV/reading are inferior goods. When income increases, the male substitutes away from these activities and spends more time on the other categories. Presumably, the typical household production categories (household activities and child care) are substituted by market goods, whereas radio/TV/reading may be replaced by entertainment/social activities and hobbies.

It is of interest to contrast these outcomes with the simple household production model presented by Gronau (1977, 1980). Assuming the absence of joint production he derives predictions of the income effects on pure leisure time and time spent on household work. For someone with a paid job the amount of household work done is exclusively a function of the wage rate. An increase in unearned income does not change the market wage, so that the amount of household work will be unaffected and pure leisure will increase, if pure leisure is a normal good. If we take categories IV, V, VI, VII as pure leisure categories, than it is clear that for the male pure leisure increases with a rise in μ. However, this rise does not only come at the expense of market work but also at the expense of the household production activities I and II. This is at variance with Grounau's prediction. The obvious explanation for this outcome is the existence of joint production. If the male does not like household chores, an increase in income is used to reduce the amount of time spent on it, for example by purchasing labor saving appliances. Graham and Green (1984) extend Gronau's model by allowing for a particular form of joint production, but their model would still imply no effect of income on household work. So their model appears to be at variance with our results as well.

The income elasticities for female activities have generally the same sign as those for the male, with two exceptions. If income goes up, the female partner spends less time on organizational activities/hobbies/sports and on entertainment/social activities. It appears that most of the time saved on these activities is then spent on obtaining goods and services. The elasticity with respect to full income of categories I, II and III combined is 1.14, which would again seem to contradict both Gronau's and Graham and Green's prediction.

The compensated own wage elasticities of total male and female leisure are negative as they should be. Total male and female leisure are complements whereas they are both substitutes with respect to total consumption.

Regarding an increase in the wage rate, Gronau's model predicts a negative effect on the amount of work done at home. The reason for this is simply that at a higher wage rate it is more efficient for an individual to purchase commodities in the market than to produce them himself. Gronau's prediction pertains to individuals rather than to households. A complicating factor in the present context is that if, for example, w_f rises, it not only affects the relative cost of home production vis-à-vis purchase in the market, but also the cost of household production by the wife relative to the cost of household production by the male. Both factors work in the same direction, however. If w_f increases, the female will spend less time on household production. The results with respect to $\tilde{E}_{w_f}^{\ell_{f_i}}$ do not offer much support for this model, but the results with respect to $\tilde{E}_{w_m}^{\ell_{m_i}}$ do: If the male wage rate goes up (keeping utility constant) the male reduces the amount of time spent on household production (and more so than in other leisure activities).

If the female wage rate goes up, however, the female increases the amount of time spent on household activities and child care. To understand this result, notice that a rise in w_f affects the price of all female leisure activities and that consumption becomes relatively cheaper. Thus we see for example, that the amount of time spent on entertainment/social activities and radio/TV/reading increases, probably because the money outlays involved in these activities have relatively fallen.

The same explanation may hold with respect to child care and household activities. These may be goods-intensive and hence become more attractive if the relative price of consumption falls. On the other hand personal needs/care (including sleeping) is not goods-intensive and therefore the amount of time spent on it falls with an increase in the wage rate.

Regarding the cross-wage elasticities we note that a rise in the female wage rate increases the male's activities on household work, as could be expected. The complementarity of female and male leisure is mainly due to the pure leisure activities, where it is important to undertake activities jointly (Hill and Juster (1980) report the same result on the basis of the same data, but with a different methodology). For household activities female and male leisure act rather as substitutes.

6. Concluding remarks

The results of this paper show that there are no great difficulties in modelling time use within a neoclassical framework and estimating a disaggregated model of time use. By employing a flexible specification of the utility function, we have been able, moreover, to shed some light on the empirical validity of certain more restrictive models, in particular Gronau's. A number of issues have not been addressed in this paper, however, that should be the subject of future research. We note a few of them.

We have only used two earner households and corrected for selection bias. Also using one earner households creates major complications (c.f. Lee and Pitt (1983), Wales and Woodland (1983), Kooreman and Kapteyn (1984)), but for a complete understanding of time use behavior, the corner solutions implied by non-working individuals have to be analyzed.

The categories of time use distinguished are an improvement over earlier work with more aggregated data. The empirical results show clearly that relatively little movement in an aggregate time use category may m ask substantial shifts in its components. Evidently, further disaggregation would add extra information. Ideally, one would like to employ data that contain detailed information on time use, household production, stock of durables and consumption. Moreover, these data should be longitudinal in order to generate the price variation that is necessary to identify the connection between time use and the purchase of specific goods.

References

Becker, G.S. (1965), "A theory of the allocation of time", The Economic Journal, 75, pp. 493-517.

Christensen, L.R., D.W. Jorgenson and L.J. Lan (1975), "Transcendental logarithmic utility functions", American Economic Review, 65, pp. 367-383.

Graham, J.W. and C.A. Green (1984), "Estimating the parameters of a household production function with joint products", The Review of Economics and Statistics, 66, pp. 277-282.

Gronau, R. (1977), "Leisure, home production, and work; the theory of the allocation of time revisited", Journal of Political Economy, 85, pp. 1099-1123.

Gronau, R. (1980), "Home production - a forgotten industry", The Review of Economics and Statistics, 62, pp. 408-416.

Heckman, J.J. (1979), "Sample selection bias as a specification error", Econometrica, 47, pp. 153-161.

Hill, M.S. and F.T. Juster (1980), "Constraints and complementarities in time use", The University of Michigan, ISR working paper.

Juster, F.T. (1978), "Time use in economic and social accounts", University of Michigan, Survey Research Center.

Kooreman, P. and A. Kapteyn (1984), "Estimation of rationed and unrationed household labor supply functions using flexible forms", Discussion Paper, Tilburg University.

Lee, L.F. and M.M. Pitt (1983), "Specification and estimation of demand systems with limited dependent variables", Discussion Paper, University of Minnesota.

Neary, J.P. and K.W.S. Roberts (1980), "The theory of household behavior under rationing", European Economic Review, 13, pp. 25-42.

Pollak, R.A. and M.L. Wachter (1975), "The relevance of the household production function and its implications for the allocation of time", Journal of Political Economy, 83, pp. 255-277.

Rosenzweig, M.R. and T.P. Schultz (1983), "Estimating a household production function: heterogeneity, the demand for health inputs, and their effects on birth weights", Journal of Political Economy, 91, pp. 723-746.

Wales, T.J. and A.D. Woodland (1977), "Estimation of the allocation of time for work, leisure, and housework", Econometrica, 45, pp. 115-132.

Wales, T.J. and A.D. Woodland (1983), "Estimation of Consumer Demand Systems With Binding Non-Negativity Constraints", Journal of Econometrics, 21, pp. 263-285.

IN 1983 REEDS VERSCHENEN

126 H.H. Tigelaar
Identification of noisy linear systems with multiple arma inputs.

127 J.P.C. Kleijnen
Statistical Analysis of Steady-State Simulations: Survey of Recent Progress.

128 A.J. de Zeeuw
Two notes on Nash and Information.

129 H.L. Theuns en A.M.L. Passier-Grootjans
Toeristische ontwikkeling - voorwaarden en systematiek; een selectief literatuuroverzicht.

130 J. Plasmans en V. Somers
A Maximum Likelihood Estimation Method of a Three Market Disequilibrium Model.

131 R. van Montfort, R. Schippers, R. Heuts
Johnson S_U-transformations for parameter estimation in arma-models when data are non-gaussian.

132 J. Glombowski en M. Krüger
On the Rôle of Distribution in Different Theories of Cyclical Growth.

133 J.W.A. Vingerhoets en H.J.A. Coppens
Internationale Grondstoffenovereenkomsten.
Effecten, kosten en oligopolisten.

134 W.J. Oomens
The economic interpretation of the advertising effect of Lydia Pinkham.

135 J.P.C. Kleijnen
Regression analysis: assumptions, alternatives, applications.

136 J.P.C. Kleijnen
On the interpretation of variables.

137 G. van der Laan en A.J.J. Talman
Simplicial approximation of solutions to the nonlinear complementarity problem with lower and upper bounds.

IN 1984 REEDS VERSCHENEN

138 G.J. Cuypers, J.P.C. Kleijnen en J.W.M. van Rooyen
Testing the Mean of an Asymetric Population:
Four Procedures Evaluated

139 T. Wansbeek en A. Kapteyn
Estimation in a linear model with serially correlated errors when observations are missing

140 A. Kapteyn, S. van de Geer, H. van de Stadt, T. Wansbeek
Interdependent preferences: an econometric analysis

141 W.J.H. van Groenendaal
Discrete and continuous univariate modelling

142 J.P.C. Kleijnen, P. Cremers, F. van Belle
The power of weighted and ordinary least squares with estimated unequal variances in experimental design

143 J.P.C. Kleijnen
Superefficient estimation of power functions in simulation experiments

144 P.A. Bekker, D.S.G. Pollock
Identification of linear stochastic models with covariance restrictions.

145 Max D. Merbis, Aart J. de Zeeuw
From structural form to state-space form

146 T.M. Doup and A.J.J. Talman
A new variable dimension simplicial algorithm to find equilibria on the product space of unit simplices.

147 G. van der Laan, A.J.J. Talman and L. Van der Heyden
Variable dimension algorithms for unproper labellings.

148 G.J.C.Th. van Schijndel
Dynamic firm behaviour and financial leverage clienteles

149 M. Plattel, J. Peil
The ethico-political and theoretical reconstruction of contemporary economic doctrines

150 F.J.A.M. Hoes, C.W. Vroom
Japanese Business Policy: The Cash Flow Triangle
an exercise in sociological demystification

151 T.M. Doup, G. van der Laan and A.J.J. Talman
The $(2^{n+1}-2)$-ray algorithm: a new simplicial algorithm to compute economic equilibria

IN 1984 REEDS VERSCHENEN (vervolg)

152 A.L. Hempenius, P.G.H. Mulder
Total Mortality Analysis of the Rotterdam Sample of the Kaunas-Rotterdam Intervention Study (KRIS)