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A HOUSEHOLD PRODUCTION MODEL OF PAID LABOR, HOUSEHOLD WORK AND CHILD CARE**

BY

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Key words: household production, child care, allocation of time

1 INTRODUCTION

Despite the fact, that – on average – more than 80 percent of women's time is devoted to non-market activities, little is known about how women allocate time not devoted to paid labor. A cross-country comparison of time allocation in Juster and Stafford (1991) shows that on average women spend between 24 and 35 hours per week on market work, between 27 and 34 hours on housework, about 70 hours on personal care (including sleeping), and between 25 an 42 hours on leisure. Women in paid employment spend less time on housework and child care than women who are not employed.

The time men spend on housework is roughly the same in all countries, the only exceptions being Norway, Sweden, and Japan. Norwegian and Swedish men spend relatively more time on housework, whereas Japanese men do not spend any time at all on caring for their children or doing housework. The international differences in housework time for women are much smaller than for men (Juster and Stafford 1991 and SCP 1992).

A study by the Dutch Central Bureau of Statistics on time use shows that men and women devote a similar amount of time to their personal care, eating, and sleeping (CBS, 1994). Men and women have about an equal total amount of leisure time at their disposal. Women, however, devote more of their time to household work and looking after the children while men spend more time on the labor market. There are also important differences across types of households. For instance, couples consisting of partners who are both in the labor market, have less leisure time than couples in which only one of the partners, or neither partner, is employed. Meijer (1996) also concludes that women of double income

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earners have the least amount of leisure. From this latter study it emerges that women with a child under the age of 5, on average, spend more time on care for children, paid employment, and household work than their partners or other women. Unemployed women whose youngest child is over 5, employed women without children, and male partners have the lightest work load. The greatest difference in average load between men and women is observed when the children are under 5 and the women is on the labor market for more than 24 hours per week.

Van der Lippe (1992) found that household work is most evenly distributed between husband and wife when there are no children. The arrival of children generally gives rise to a specialization. Women apply themselves to housework and care for the children, men to paid employment outside the house. The presence of children increases household work and child care by women by about 17 hours, while the share of men in these tasks remains about the same.

During the past twenty years the amount of time women spend on housework and child care has decreased, while the amount of time women spend on market work has increased. Despite this increase, surveys of female labor supply studies show that the (own) wage elasticity of female labor supply is fairly high, and certainly higher than that of male labor supply (see for example Theeuwes and Woittiez 1992 for a survey of wage elasticities of labor supply in The Netherlands). An explanation that has been advanced for this high wage elasticity is that women have more alternative uses for their time than men (Mincer 1962, 1963). An increase in market wage leads men to substitute leisure for market work, whereas a wage increase leads women to substitute not only leisure but also housework and child care for market work (Killingsworth and Heckman 1986, p. 134). According to the theory of household production the explanation for this is that women are more productive at home, relative to their productivity on the labor market, than men.

In this paper we extend an individual labor supply model to a time allocation model or household production model.[1] This implies that we no longer assume that time can be divided simply into two categories – market time and leisure time – but that it can be allocated to more than these two activities. We formulate a household production model including four activities: market work, housework, child care and leisure. According to the theory of household production in this paper, in equilibrium there will be an equality (for women in paid employment) between the marginal value of household production, the marginal rate of substitution between child care and consumption, the reservation wage (the marginal rate of substitution between consumption and leisure) and the market wage rate. For each of these four marginal values we specify a separate equation. From the equilibrium condition we derive the optimal allocation of time between mar-

1 In this paper, the expressions ‘time allocation model’ and ‘household production model’ are used as each other’s equivalents.

ket work, housework, and child care. These estimates are then used to calculate the value of market and non-market production. The time allocation model developed in this paper can both be seen as an extension of the Heckman (1974) labor supply model with more time use activities, and as a structural approach (also with more activities distinguished) of the household production model estimated by Gronau (1980).

In Homan (1988) the advantages and disavantages of the household production model are discussed. As argued by Homan (1988), an advantage of the household production model is that it is an elegant way to account for the productive activities that take place within the household. Household activities are an important part of total productive activities. Most of the disadvantages of the household production approach are similar to the objections that can be raised to the simple neo-classical model of market behavior. These concern for example the assumptions of maximizing behavior, full information, and perfect certainty.

The outline of this paper is as follows. Section 2 gives a brief survey of the literature on empirical models of time allocation based on household production models. In section 3 the household production model of paid labor, household labor, maternal child care and leisure is presented. Details of the econometric analysis can also be found in this section.

The data we use are taken from a written survey among women, conducted in 1992. Unfortunately, we have no information about the time use of men. We are therefore restricted to analyzing female time allocation only. Section 4 offers a brief description of the data used in the empirical analysis of labor supply and time allocation. Section 5 contains the estimation results of the time allocation model. Section 6 presents some estimations of the value of household production and some simulations on the allocation of time for different types of households. Sections 7 concludes.

2 A BRIEF SURVEY OF LITERATURE ON HOUSEHOLD PRODUCTION MODELS

In the empirical literature on the allocation of time within a household production framework two approaches can be distinguished. The first approach specifies a specific functional form for the preference structure and/or household production to derive the time allocation equations. Examples of this approach are Graham and Green (1984), Kerkhofs (1994) and Kooreman and Kapteyn (1987). Graham and Green (1984) use a Cobb-Douglas specification for the household production function, while Kerkhofs (1994) uses a more flexible specification in which household production is a linear function of time spent on household activities by husband and wife, the square of these time inputs and the interaction between male and female time inputs in household production. Kooreman and Kapteyn (1987) use the indirect translog utility function as a specification for their model. Their translog specification is a reduced-form model which reflects both preferences and household production.

The second approach is used to specific functional forms for the equilibrium conditions of the household production model. This approach is taken in Gronau (1980) and in Kiker and Mendes de Oliveira (1992). In equilibrium, there is equality (for persons who spend time on each activity and do not spend all of their time on one activity) between the marginal productivity of work at home, the marginal rate of substitution between leisure and income (the reservation wage), and the market wage rate. Gronau (1980) specifies a functional form for the home production function, from which the equation for work at home is derived.

The empirical results presented in Gronau (1980) suggest that in the United States the value of household production is approximately 70% of household income after tax. For households with young children, the value of household production is about equal to family income after tax. For women with young children, the loss of household production when the woman enters the labor market almost equals the net earnings from paid work. Gronau (1980) also finds that the value of household production increases with education, but the increase in the value of household production with education is less than the increase in the market wage with education. Kiker and Mendes de Oliveira (1992) also find that the returns to formal education in the non-market sector are lower than in the market place, while Homan (1988) finds that higher educated women spend less time on household production than lower educated women. Kiker and Mendes de Oliveira (1992) further find that there are diminishing returns to non-market production. The marginal value of the 1,000th hours of non-market work for women is about 65% of the value of the first hour.

Graham and Green (1984) conclude from their empirical findings that the elasticity of household production with respect to market goods is higher than the elasticity with respect to the time spent on household production. They also conclude that there are no economies of scale in household production, and that both men and women human capital is more productive in market work than in housework.

Kooreman and Kapteyn (1987) find that the presence and age of children have a large effect on the time women spend on the care of children. The presence of children reduces the time spent on entertainment and social activities. However, the allocation of time by the husband is hardly affected by the presence of children. In Homan (1988) and Kerkhofs (1994) it is also found that the presence of young children has a strong positive effect on home productivity of men and women. In Kerkhofs (1994) it is further found that for both men and women home productivity increases with age. For women home productivity declines with education: higher educated women spend less time on housework and more time on paid work. Homan (1988) concludes that two of the most important determinants of the allocation of time are the size and life-stage of the household. Especially young children increase the time men and women spend on household production.

Only a few studies distinguish more than two categories of time use. Most of them only distinguish between time spent on housework and 'pure' leisure. An exception is Kooreman and Kapteyn (1987) which distinguishes seven types of leisure activities: 1) household activities, 2) child care, 3) obtaining goods and services, 4) personal needs and care (including sleeping), 5) organization activities, hobbies and sports, 6) entertainment and social activities, and 7) radio, television, reading books etc. Gronau (1980), Graham and Green (1984), Homan (1988), Kiker and Mendes de Oliveira (1992), and Kerkhofs (1994) estimate the coefficients of only one activity equation: housework.

3 AN EMPIRICAL MODEL OF TIME ALLOCATION AND HOUSEHOLD PRODUCTION

The model developed in this section assumes that women can derive utility from three goods: leisure, child care services and other commodities. Commodities are 'produced' by women by combining market goods and time inputs. Child care services are measured in time input by the mother, hence these services are valued through the mother's time only. The woman maximizes her utility subject to two restrictions: a time restriction and a budget restriction. Utility maximization yields the equilibrium conditions. These conditions state that in equilibrium the marginal value of housework and the marginal rate of substitution between child care time and consumption by the mother equal the net market wage rate.[2] Moreover, in equilibrium the reservation wage equals the market wage rate. Following Heckman (1974) and Gronau (1980), we specify forms for the market wage rate, the reservation wage, the marginal value of housework and the marginal rate of substitution between child care and consumption. From these equations we derive the equations for the time allocation on paid work, housework and child care by the mother. In the econometric specifications we describe how these three time allocation equations can be estimated jointly and how we account for possible correlation between the time allocation equations.

Assume that a woman's preferences for consumption, child care services and leisure can be described by a utility function U:

$$U = U(Z, H_c, L) \tag{1}$$

where Z represents the consumption of commodities in the household by the woman, L is the amount of leisure consumed and H_c is the time spent on child care by the mother.

Commodities within the household are produced by combining market goods (X) and time inputs (H_z). We assume that household production technology can be represented by a production function, where input factors X and H_z are used

2 In this paper the role of taxes is ignored. See Kooreman (1987) for a discussion on the impact of taxation in the Gronau model for one-adult households.

to produce Z:

$$Z = Z(X,H_z). \tag{2}$$

We assume the following functional form for goods produced in the household (Z):

$$Z = X + Z(H_z). \tag{3}$$

Commodities Z consist of goods bought at the market plus goods produced by the time inputs of the woman in housework.

The woman is confronted with two restrictions on her behavior: a budget restriction and a time restriction. The budget restriction is given by:

$$X = WN + \mu \tag{4}$$

where μ is non-labor income (including earnings of the spouse), W is the real wage rate and N is the number of hours of paid labor. The price of market goods is normalized to one. The time restriction is:

$$L + N + H_c + H_z = T \tag{5}$$

where T is the total time endowment.

If we substitute the time constraint (4) into the budget constraint (3), and rearrange we get:

$$X + WL + WH_c + WH_z = WT + \mu \tag{6}$$

where $WT+\mu$ is full income, i.e. the virtual income available for allocation between income, household work, child care, and leisure.

The woman allocates her full income over commodities, leisure, child care, and housework in order to maximize her utility or welfare level, i.e. she maximizes the utility function (equation 1) under the budget and time restrictions (equation 6). The Lagrange equation for this optimization problem is:

$$L = U(Z(X,H_z),H_c,L) + \lambda(Y - X - WL - WH_c - WH_z) \tag{7}$$

where Y is full income.

Maximization of the utility function yields the first-order or equilibrium conditions of the model. For the interior allocation in the time-uses space (i.e. where $0 < N < T$, $0 < H_c < T$, $0 < H_z < T$ and $0 < L < T$), it is easy to verify that:

$$\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right) = \lambda \tag{8}$$

and

$$\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial H_z}\right) = \left(\frac{\partial U}{\partial H_c}\right) = \left(\frac{\partial U}{\partial L}\right) = \lambda W. \tag{9}$$

Combining (8) and (9) yields:

$$\frac{\left(\frac{\partial U}{\partial L}\right)}{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right)} = \frac{\left(\frac{\partial U}{\partial L}\right)}{\left(\frac{\partial U}{\partial Z}\right)} = W \tag{10}$$

as $\partial Z/\partial X = 1.(\partial U/\partial L)/(\partial U/\partial Z)$ is the marginal rate of substitution between leisure L and commodities Z.

From (8) and (9) we further derive:

$$\frac{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial H_z}\right)}{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right)} = \frac{\partial Z}{\partial H_z} = W \tag{11}$$

where $(\partial Z/\partial H_z)$ is the marginal value of household work.

Finally, combining (8) and (9) yields:

$$\frac{\left(\frac{\partial U}{\partial H_c}\right)}{\left(\frac{\partial U}{\partial Z}\right)\left(\frac{\partial Z}{\partial X}\right)} = \frac{\left(\frac{\partial U}{\partial H_c}\right)}{\left(\frac{\partial U}{\partial Z}\right)} = W \tag{12}$$

where $(\partial U/\partial H_c)/(\partial U/\partial Z)$ is the marginal rate of substitution between child care time and commodities.

For the empirical implementation of the model we can specify either functional forms for the household production functions (2) and utility function (1) or specify functional forms for the marginal rates of substitution expressions in equation (12), (11) and (10). In this paper we take the latter approach.

Let $MV_z=(\partial Z/\partial H_z)$ be the value of housework; $MRS_c=(\partial U/\partial H_c)/(\partial U/\partial Z)$ is the marginal rate of substitution between child care time and commodities. Further, let $MRS_r=(\partial U/\partial L)/(\partial U/\partial Z)$ be the marginal rate of substitution between leisure and commodities, or the reservation wage.

For the wage equation we follow the standard Mincerian semi-logarithmic specification:

$$LogW = \mathbf{Y}_w\boldsymbol{\beta}_w + \boldsymbol{\epsilon}_w \tag{13}$$

where the log of the net wage rate W is a function of human capital variables $\mathbf{Y}_w$ with associated coefficient $\boldsymbol{\beta}_w$, and $\boldsymbol{\epsilon}_w$ is a random term capturing unmeasurable variables. Let

$$\overline{Log\mathbf{W}} = \mathbf{Y}_w\boldsymbol{\beta}_w \tag{14}$$

be the predicted wage rate. In the estimation of the time allocation equations we used the log of the wage rate instead of the wage rate, as this specification produces a better fit to the data.

For the reservation wage, we specify the following equation:

$$LogMRS_r = \mathbf{Y}_r\boldsymbol{\beta}_r + \alpha_r N + \boldsymbol{\epsilon}_r \tag{15}$$

where $\mathbf{Y}_r$ is a vector of individual characteristics with coefficient $\boldsymbol{\beta}_r$. The level of the reservation wage further depends on the number of hours of paid labor N with coefficient α_r. This specification of the reservation wage corresponds to the Heckman (1974) approach to modelling labor supply. The inverse of the coefficient α_r measures the wage effect on hours of paid labor.

For the marginal value of housework, we specify the following equation:

$$LogMV_z = \mathbf{Y}_z\boldsymbol{\beta}_z + \alpha_z H_z + \boldsymbol{\epsilon}_z. \tag{16}$$

We assume that the marginal value of household time depends on individual characteristics (Y_z) and the time spent on housework (H_z). The inverse of α_z measures the productivity effect on the time spent on housework.

For the marginal rate of substitution between child care time and commodities, we specify:

$$LogMRS_c = \mathbf{Y}_c\boldsymbol{\beta}_c + \alpha_c H_c + \boldsymbol{\epsilon}_c. \tag{17}$$

The log of the marginal rate of substitution between time spent on child by the mother and commodities is a linear function of characteristics of the child (Y_c) and the time spent on child care (H_c).

Using the equilibrium conditions (12, 11, and 10), we can derive the time allocation equations for women who participate in the labor market. The equation for the supply of paid labor hours is found by equating equations (13) and (14):

$$LogMRS_r = \overline{LogW} \tag{18}$$

$$Y_r + \alpha_r N + \epsilon_r = \overline{LogW}$$

and solving for N - the number of hours of paid labor. This yields the supply of paid labor hours equation for the individual:

$$N = \frac{\overline{LogW} - Y_r\beta_r}{\alpha_r} + \mu_r \tag{19}$$

where $\mu_i = \epsilon_i/\alpha_i$ $(i = r,z,c)$.

To derive the equation for the time spent on housework, we use the equality between the log of the marginal value of housework ($log\ MV_z$) and the log of the market wage rate ($log\ W$) in equilibrium (equations 13 and 15). From this, we derive that:

$$H_z = \frac{\overline{LogW} - Y_z\beta_z}{\alpha_z} + \mu_z. \tag{20}$$

In the same way, we derive the equation for the optimum hours of child care for the woman from the equality between $log\ MRS_c$ and $log\ W$:

$$H_c = \frac{\overline{LogW} - Y_c\beta_c}{\alpha_c} + \mu_c. \tag{21}$$

There are two econometric problems to be solved. The first concerns the data at our disposal. The data are stratified by labor force status, i.e. we have stratified samples of employed and non-employed women. For the empirical implementation we only use the observations on employed women with children. The derivation of the time allocation equations of the household production was based on so-called interior solutions. With non-employed women we are faced with corner solutions. This implies that we only use observations on women for whom we may assume that the interior solutions hold. However, using employed women only may introduce sample selection bias in the estimates. We have tested for

selection bias by including the inverse Mills ratios based on a probit equation on participation in the labor market in the time allocation equations. As all three coefficients of the inverse Mills ratios were highly insignificant and the inclusion of the Mills ratios did not significantly alter the other coefficients in the equations, we decided not to include the selection correction terms in the final estimations.

The second problem concerns the possibility that the time allocation equations are correlated. If the residuals of the time allocation equations are correlated, OLS estimates will not be efficient. The equations were therefore estimated by Full Information Maximum Likelihood (FIML).

4 THE DATA

The data for the estimations are taken from a written survey, entitled 'Women on Work,' conducted among women in 1992 (see Maassen van den Brink 1994 for details). This is a stratified sample of approximately 1200 women in The Netherlands. Stratification of the sample was by labor market status, marital status and the presence of children. From the sample we selected women with children who have a paid job and are married/cohabiting.

The survey contains information on time allocation, wages and individual characteristics. The data set has the further advantage that it contains information on the time-consuming quality of children. It also provides information on the women's actual and preferred time allocations.

Measurement problems are an important factor in time use studies (Juster and Stafford 1991). Essentially, there are two methods of collecting time budget data: the time diary method and the recall method. Time diary data are usually considered to be more accurate (Juster and Stafford 1991, Gronau 1986, and Flood and Klevmarken 1992), but are more expensive to collect. In our data, time use was measured by asking the women to allocate hours per week to the following activities: market work, voluntary work, household work, caring for children, personal care and leisure. For the analyses we used three categories of time use: market work, household work and caring for children. To comply with the adding-up constraint, we omitted one category: leisure.

Table 1 contains the average sample values of the allocation of time of employed women with children (in hours per week). The average period of paid employment of the women participating is 19 hours per week. Employed married women with children spend an average of 32 hours per week on household activities and 23 hours on child care.

In the wage equation, we include the following human capital variables (i.e. variables included in the vector $\mathbf{Y}_w$): years of education, years of work experience, experience squared and a dummy for whether the woman has had an interruption period from the labor market. We further include five dummies for industry (the catagory being women working in the industrial sector).

The parameter estimates of the wage equation are found in the appendix. To account for possible selection bias in wages, the wage equation was jointly estimated with a labor force participation equation, by maximum likelihood methods. As shown in the appendix, the correlation coefficient between the residuals of the labor force participation equation and the wage equation is small and highly insignificant.

The coefficients of the wage equation show that the rate of return to a year of education is appoximately 4%. Experience has an inverse U-shaped effect on market wages, as expected. The dummy variable for a period away from the labor market is positive but not significantly different from zero. There are few significant differences in female wages across industries.

In the reservation wage equation, the marginal value of housework equation, and the equation for marginal rate of substitution between child care and commodities, the following variables are included: labor earnings of the partner and non-labor income, number of children aged 0–3 years, number of children aged 4–12 years, and number of children aged 13 and older. By including the labor earnings of the husband in the reservation wage equation, we implicitly assume a so-called 'male chauvinist' decision structure in the household, in which the woman is the secondary worker in the household: the male partner determines his hours of paid work irrespective of his wife's allocation of time and the wife adjusts her hours of paid labor to suit her husband's decision. The same holds for time spent on child care and time spent on housework.

We further include variables for the time-consuming quality of the child: a dummy variable if any of the children is boisterous, a dummy if any of the children is disobedient, a dummy if any of the children demands a lot of attention, a dummy if any of the children has a sleeping problem, a dummy if any of the children is frequently ill, and a dummy if any of the children has any other peculiarities as a result which it needs more attention.

5 ESTIMATION RESULTS OF THE TIME ALLOCATION MODEL

The parameter estimates of the household production model are found in Table 1. Other income in the household has an insignificant effect in all three equations. This suggest that the time allocation of the mother is independent of the earnings of the husband and other non-labor income. This finding suggests that the 'male chauvinist model' does not hold.

Children have a significant effect on the marginal rate of substitution between child care by the mother and commodities but not on her reservation wage or on the marginal value of housework. Young children - aged between 0 and 3 and between 4 and 5 years - decrease the marginal rate of substitution of child care and increase the time spent on child care by the mother. The presence of older children decreases the time spent on child care by the mother. An explanation for these negative effects of older children may be that older children take over some

TABLE 1 – FULL INFORMATION MAXIMUM LIKELIHOOD PARAMETER ESTIMATES OF THE TIME ALLOCATION MODEL (*T*-VALUES IN PARENTHESES)

	Reservation wage	Marginal value of housework	Marginal rate of substitution between child care and commodities
intercept	−0.389 (0.228)		
other income in household/1000	0.299 (0.916)	−0.011 (0.018)	−0.204 (0.430)
number of children aged 0–3 years	0.711 (1.623)	−0.375 (0.614)	−1.946** (1.965)
number of children aged 4–12 years	0.587 (1.533)	−0.927 (1.187)	−0.355 (0.911)
number of children aged over 13 years	0.242 (0.739)	−0.933 (1.196)	1.090* (1.843)
child boisterous	0.041 (0.306)	−0.074 (0.280)	0.158 (0.831)
child disobedient	−0.028 (0.151)	0.043 (0.114)	−0.209 (0.801)
child demands attention	−0.160 (0.931)	−0.080 (0.270)	−0.219 (0.896)
child has problems sleeping	−0.124 (0.901)	−0.213 (0.733)	−0.046 (0.265)
illness of child	0.142 (1.082)	−0.182 (0.610)	0.023 (0.152)
child has other peculiarities	0.064 (0.240)	−0.362 (0.611)	0.066 (0.196)
time spent on the activity (α)	0.117** (2.144)	0.181 (1.511)	0.174** (2.352)
mean dependent variable	19.33	31.59	22.94
#observations		187	
log likelihood		−1955.65	

* significant at 10% level; ** significant at 5% level; *** significant at 1% level.

of the care for younger children from the mother. A child between ages 0 and 3 decreases the marginal rate of substitution of child care by almost 200%, while a child aged 13 or older increases it by 100%.

The estimation results do not show that there are economies of scale associated with household size. Children have no effect on time spent on housework, but young children do have a major effect on time spent on child care by the mother. The time spent on child care by women with young children apparantly goes at the expense of their leisure time, not at the expense of labor supply.

The characteristics of the children all have an insignificant effect on the time allocation of the mother.

An hour of paid work raises the reservation wage by almost 12%. The inverse of the hours of work coefficient measures the wage effect on hours of paid labor. A 1% increase in the hourly wage rate implies that the hours spent on paid employment per week increase by a little less than five minutes. Calculated in the mean value of the actual hours of work variable (19 hours per week) the wage

elasticity of actual labor supply is 0.45. This is somewhat less than the labor supply elasticities presented in Theeuwes and Woittiez (1992).

An hour of housework increases the marginal value of housework by 18%, although this coefficient is not significantly different from zero. In the average value of actual hours spent on housework (32 hours per week), the elasticity of housework with respect to the marginal value of housework is 0.17. A 10% increase in the marginal value of housework increases the time spent on this activity by 1.7%

An hour of child care increases the marginal rate of substitution between child care and commodities by approximately 17%. In the average hours of child care (23 hours per week); the marginal rate of substitution elasticity of child care time is 0.25. A 10% increase in the marginal rate of substitution between child care and commodities increases the time devoted to child care by approximately 2.5%.

6 THE VALUE OF MARKET AND NON-MARKET PRODUCTION

The parameter estimates of the time allocation model can be used to calculate the value of household production and the value of child care provided by the mother. The value of non-market production is determined by the market wage rate. The calculated value says something about the value of atlernative time use (time spent on non-market activities instead of market activities). The calculated values of total production do not express judgements about quality of household care and child care.

Using the parameters, it is possible to estimate the value the woman attaches to market work (*VMW*):

$$VMW = \int_0^N MRS_r(t)\mathrm{d}t = \int_0^N exp(Y_t\beta_r + \alpha_r t)\mathrm{d}t = exp(Y_r\beta_r)\,\frac{exp(\alpha_r N) - 1}{\alpha_r}. \tag{22}$$

It is assumed that the value of market work is zero if the women does not participate in the labor market. We can compare this with the earnings received from doing market work. These earnings are calculated by multiplying the hours of market work N with the wage rate W.

In a similar way as the *VMW*, we can estimate the value of household production (*VHP*):

$$VMP = \int_0^{H_z} MV_z(t)\mathrm{d}t = \int_0^{H_z} exp(Y_z\beta_z + \alpha_z t)\mathrm{d}t = exp(Y_z\beta_z)\,\frac{exp(\alpha_z H_z) - 1}{\alpha_z}. \tag{23}$$

VHP is the value of the household work measured in the value of the commodities *Z*.

The value of child care (*VCC*) is given by:

$$VCC = \int_0^{H_c} MRS_c(t)\mathrm{d}t = \int_0^{H_c} exp(Y_c\beta_c + \alpha_c t)\mathrm{d}t = exp(Y_c\beta_c)\,\frac{exp(\alpha_c H_c) - 1}{\alpha_c}. \tag{24}$$

The value of child care is expressed in terms of the value of the commodities *Z* that is required by the mother to compensate for a loss in child care time. Finally, we can calculate the total value of production as the sum of *VMP*, *VHP* and *VCC*.

The estimations of the value of (household) production are given in Table 2. The value of production is calculated for woman in our sample individually. The values in Table 2 are sample means of the individual values of production.

Table 2 shows that the value of non-market production (household production and child care) is substantial and exceeds that of market production. The expected labor earnings for all women with children are 276 guilders. For all women with children, the total value of production is 1138 guilders per week.

The value of market work increases with the age of the children. The value of market work is 247 guilders per week for women with children aged 0–3 years and 296 guilders for women with children aged 13 or older. This is probably an effect of experience: women with older children (potentially) possess more human capital due to their greater (potential) labor market experience. This increases the value of their market work.

The value of child car decreases with the age of children. The value of child care is 365 guilders for women with children aged 0–3 years and 189 guilders

TABLE 2 – MEAN VALUES OF MARKET AND NON-MARKET PRODUCTION FOR EMPLOYED WOMEN WITH CHILDREN, IN DFL. PER WEEK

	all women with children	women with children aged 0-3 years	women with children aged 4-12 years	women with children aged 13 or older
labor earnings	276	247	260	296
value of market work	219	220	208	241
value of household production	634	643	698	640
value of child care	285	365	303	189
total value of production	1138	1229	1209	1070
# observations	178	67	108	60

for women with children aged 13 years or older. This reflects the reduction in time spent on child care as the children get older.

In order to gain greater insight into the results, we have calculated the expected value of market and non-market production for three types of women: a woman in a traditional household (full-time homemaker and no market work), a woman in a 'one-and-a-half' earner household (part-time market work), and a woman in a modern career household (full-time market work). Each of these three types of women is assumed to allocate 70 hours per week to a combination of market work, housework and child care. A woman in a traditional household - oriented towards non-market work - is defined as a woman who does not perform market work, who works 40 hours a week in the household and spents 30 hours a week on child care. A woman in a 'one-and-a-half' earner household works 20 hours a week in the labor market, spents 30 hours on housework and 20 hours on caring for her children. These values roughly correspond to the mean in our sample. A woman in a modern career household - oriented towards market work - works 40 hours a week on the labor market, spents 10 hours on housework and 20 hours a week on child car. For each of these three women we have calculated teh value of market and non-market work setting the exogenous variables at their respective average values.

The results in Table 3 show that the total value of market and non-market production is highest for women who specialize in market work. The total value of production for the woman in the modern career household is 632 guilders per week. Of course, it must be kept in mind that this 'modern career woman' has to buy services on the market such as non-parental child care, house cleaning, etc. The total value of production for the woman in the traditional household is also high compared to that of the woman in the 'one-and-a-half' earner household. In fact, if the woman in the 'one-and-a-half' earner household has to buy services on the market such as non-parental child care, her total welfare is probably the lowest of the three.

TABLE 3 – EXPECTED VALUE OF MARKET AND NON-MARKET PRODUCTION FOR THREE HOUSEHOLD TYPES, IN DFL. PER WEEK

	traditional full-time home maker, no market work	woman in one-and-a-half earner house-hold, part-time market work	woman in modern career household, full-time market work
labor earnings	0	296	593
value of market time	0	98	618
value of household production	361	59	9
value of child care by mother	224	38	15
total value of production	585	195	632

The results in this paper can be compared with two other studies that have used data for The Netherlands. The calculated values for household production can be compared with those presented in Homan (1988). In our study the value of female household production in families with children aged 0–3 years is 643 guilders per week. Homan (1988) found that the average value of male and female household production in families with one child aged 0–4 years is between 547 and 863 guilders per week, depending on the hours of market work of the woman. Although our estimated value of household work is similar to the ones calculated by Homan (1988), there are at least two important differences between the calculations. First, the figures in Homan (1988) refer to the total value of household production of both partners in the household while ours refer to female household production only. Second, households in Homan's study were only asked to specify how much time they spend on housework, and not time spent on other activities. This may have resulted in joint activities being reported as housework (for example taking care of children while doing housework) in Homan's study, where in our data this shows up in both activities.

In Bruyn-Hundt (1985) the value of home production is calculated on the basis of women's average gross hourly wage rate. This study estimates that the value of household production for a standard household of an adult female, an adult male and children is 3,350 guilders a month before taxes (with calculations being based on the average time spent on housework by all women). Our calculations imply that the value of household production is about 4,931 guilders a month (net after taxes) for women who participate in the labor market and have children. However, our calculations refer to mothers who are both working on the labor market and spend less time doing housework. If we compare the estimates in Bruyn-Hundt (1985) with our calculations for a woman who is a full-time homemaker in a traditional household, the total value of production is about 2,535 guilders a month (net after tax) in our study, which is closer to the gross monthly amount of 3,350 guilders in Bruyn-Hundt (1985). All in all, it can be concluded that in all three studies the value of household production is substantial.

7 CONCLUSION

In this paper we have formulated a time allocation model of paid work, household work, child care, and leisure. Time allocation models provide a framework in which the value of household production can be estimated and the division of non-market time into diffent uses like child-rearing, housework, *etc.* can be analyzed.

It was found that the value of household production is substantial. The total value of production of a woman in the modern career household who works full-time on the labor market appears to be greater than that of either the full-time homemaker or the woman in the 'one-and-a-half' earner household who works part-time in the labor market. The total welfare of this latter woman is probably the lowest of the three.

APPENDIX

MAXIMUM LIKELIHOOD PARAMETER ESTIMATES OF THE PARTICIPATION AND WAGE EQUATIONS (*T*-VALUES IN PARENTHESES)

	Participation equation	Wage equation
intercept	−2.554 (1.252)	1.587*** (4.154)
years of education	0.053** (2.247)	0.037*** (3.545)
age	0.122 (1.118)	
age^2/100	−0.200 (1.361)	
experience		0.074*** (2.550)
experience^2/100		−0.211** (2.162)
career interruption		0.109 (1.240)
other income in household/1000	0.138 (0.768)	
number of children aged 0-3 years	−0.572*** (2.803)	
number of children aged 4-12 years	−0.246 (1.454)	
number of children aged over 13 years	0.055 (0.253)	
child boisterous	−0.190** (2.160)	
child desobedient	0.045 (0.370)	
child demands attention	0.100 (0.883)	
child has problems sleeping	0.007 (0.073)	
illness of child	0.124* (1.689)	
child has other peculiarities	0.130 (0.721)	
industry code missing		−0.383** (2.217)
trade and commerce		−0.186 (0.897)
banking and commercial services		−0.111 (0.654)
public services		−0.073 (0.460)
other industries		−0.143 (0.895)
σ		0.358*** (29.325)
ρ		−0.043 (0.106)
mean dependent variable	0.482	2.561
#observations		388
log likelihood		−325.906

* significant at 10% level; ** significant at 5% level; *** significant at 1% level.

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Summary

A HOUSEHOLD PRODUCTION MODEL OF PAID LABOR, HOUSEHOLD WORK AND CHILD CARE

In this paper we use data on time allocation of women to estimate the value of market and non-market work. Four time use categories are distinguished: paid work, houshold work, care for children, and leisure. The estimation results show that the value of non-market production (household production and child care) is substantial and exceeds that of market production (paid work).