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Abstract

In a household, female labor force participation has important consequences for the household production processes.
As a result of the decision to participate more money is coming into the household, but less time is available to spend on housework and leisure activities.

The objective of this paper is to estimate household cost functions and the shodow price assigned by households to housework. We assume that these concepts are significantly different in families where both spouses are participating in the labor force, and those where only one of them is participating. Hence they depend on the discrete choice of the household whether the female will participate or not. We describe the behavior of the household by means of two distinct régimes and an endogenous switchig equation explaning the participation decision. Some of the basic determinants of the participation decision are: number of children at home, the age of the female and the income opportunities for the female. The two régimes are both described by the simultaneous equation model explaning the labor supply, the hours spent on household work by both partners and the shadow price assigned to housework.
The model is estimated on a large data base containing 4000 households, collected in the Netherlands in 1983.

1. Introduction

Recently, Dutch policy makers ~~encountered~~ in their ever lasting search for money imposed a new tax system at the expense of two breadwinner families. Since the beginning of 1984 these families are subjected to higher taxes than they were used to. The tax reform is justified by the following reasoning. Compare two families A and B, say, with two adults and with almost all other characteristics equal. Assume that the husbands*) of both families are working and earning the same annual income. The only difference between the two households is the fact that in family A the wife has a job in the labour market, whereas the wife in household B allocates her time between homework and leisure solely. As a result of the labour market participation of the wife an additional income is accruing to household A. If one supposes that the two families have the same preferences, family A reaches a higher welfare level than family B does. In the opinion of Dutch policy makers the welfare gap between these two household types in the old tax system was too big, and a new system has been introduced in which two earner families have to pay higher taxes, in order to reduce or diminish hypothetical welfare gap.

In our view a major lack in this reasoning is that it does not sufficiently take into account differences in home production. As a result of female labour market participation more money is coming into the household, but on the other hand less time will be available to spend on home production. In this paper we obtain income equivalence scales to correct for the differences in home production between one- and two-earner families. Comparisons between household types must be based on a hypothetical income concept defined as the money income corrected for differences in home production. Taxation should also be based on this extended income concept, and not on earned income solely.

The relevance of household production is more and more recognized in economic research. Becker (1965) introduced a model incorporating the allocation of time spent on home production. According to this view, the household purchases goods on the market and combines them with time in a household production

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*) The terms husband, wife, man, female, head of the household and partner are used indiscriminately. With husband, man or head of the household we mean the main breadwinner and with wife, female or partner we mean the adult earning the lower income or no income at all.

function to produce household commodities. Not the market goods but these commodities determine the welfare of the household. Hence time spent on home production plays an important role in the determination of welfare.

In this paper we use an approach to the derivation of equivalence scales of home production which is based on direct measurement of household cost functions (see Van Praag (1985)). We focus on differences between one and two breadwinner families. The method can easily be extended in order to deal with other household types like singles, one-parent families, unemployed, et cetera. As major differences in cost functions are expected between these families the model will be estimated for the two household types separately. In order to get consistent estimators of the parameters in these two different régimes, we use a general switching equation system (see e.g. Lee (1978) and Maddala (1983)). The equation describing the labour market participation decision of the wife is considered to be the endogenous switching equation.

The paper is structured as follows. In section 2 we describe the method to derive household cost functions. In section 3 we present the statistical model. Section 4 contains the description of the sample, the estimation results and the implied family equivalence scales and correction factors for differences in home production. For different household types the marginal value of an hour spent on home production is calculated. Section 5 concludes.

2. Household Cost Functions

In this paper a model is adopted describing the needs and the behaviour of households introduced by Van Praag (1968). Later on, this method is elaborated by Van Praag and many other researchers (e.g. Van Praag (1971), Van Praag, Kapteyn (1973), Kapteyn, Van Praag (1976), Kapteyn (1977), Goedhart et al. (1977), Van Praag et al. (1980), Van Praag (1985) and Hagenaars (1985)). In Colasanto et al. (1983), Danziger et al. (1984) and Van Praag et al. (1984) similar analyses have been performed on American data.

The fact that the method has been useful in dealing with related problems concerning the economic behaviour of households made us decide to use this model here as well. In this section we discuss briefly the method and deal with a few theoretical and practical problems.

The principle of the method is as follows. The respondent in a household survey is presented with a set of verbal descriptions of some situations of well-being. The answers, in money terms, are the costs associated with the offered welfare levels. An example of such a question is:

"What after-tax family income would you consider, in your circumstances, to be very bad, bad, insufficient, sufficient, good and very good?*

very bad	Dfl. ..... per period of a week/month/year
bad	Dlf. ..... per period of a week/month/year
insufficient	Dfl. ..... per period of a week/month/year
sufficient	Dfl. ..... per period of a week/month/year
good	Dfl. ..... per period of a week/month/year
very good	Dfl. ..... per period of a week/month/year

* Please enter an answer on each line. Underline the period you refer to."

This type of questions is called an Income Evaluation Question (IEQ).
One of the basic presumptions in a language community is that words and verbal expressions have approximately the same emotional meaning and connotation to all members of the community. Obviously this is not perfectly true; there are many misunderstandings in verbal communications, but it is true to a reasonable extent. We shall assume, however, that the verbal descriptions in

the IEQ have the same meaning to all respondents in the survey. For a justification of this assumption the reader is referred to Van Praag (1985). Denote the answers of respondent n by c_{in} (i = 1, ..., 6 corresponding to very bad to very good, n = 1, ..., N (N is the number of respondents)). It is intuitively clear that c_{in} depends on objective factors like family size, home production, et cetera. However, a problem arises because the answers also depend on current income of the household. The existence of this effect, in Van Praag (1971) this effect was called "preference drift", is actually a specific instance of a general phenomenon, studied in psychophysical adaptation theory (e.g. Helson (1969)). Adaptation theory states that people relate their judgments on the brightness of light, the loudness of sounds, et cetera, to an "anchor point", a level to which they are accustomed. When a judgment on household costs is made the prominent anchor point is own current income. Based on empirical evidence gathered in the last decade, the follcwing specification describes the relation between the answers c_{in} and current income very well

$$(2.1) \qquad \ln c_{in} = \alpha_{0i} + \alpha_{1i} X_n + \alpha_{2i} \ln y_{cn} \qquad (i = 1, \ldots, 6, \; n = 1, \ldots, N)$$

where X stands for a vector of variables describing demographic and other characteristics of the household and α_{1i} for the corresponding coefficientvector, y_c for current income, and ln stands for natural logarithm. Typically, α_{2i} is estimated in the range of 0.4 to 0.9. This implies that there is not one income level which corresponds to a specific welfare level, say "good" (i = 5) for all respondents, but that for respondents with different current incomes a different cost level is found. A natural way to aggregate all these individual cost levels into a national level associated with "good", is to find the income level that separate people who consider their own income as worse than "good" and those who consider their own income to be better than "good". On the borderline between these two we find households who evaluate their own actual situation as good. For these respondents the cost associated with "good", c_{5n}, equals their current income. Denote this income level by $\hat{c}_5(X)$. It is clear that the amounts corresponding to the other welfare levels can be defined in the same manner. The solution $\hat{c}_i(X)$ (i = 1, ..., 6) gives us a true household cost function, differentiated with respect to the objective characteristics of the family included in X. Mathematically $\hat{c}_i$ (i = 1, ..., 6) can be found by solving

$$(2.2) \qquad \ln \hat{c}_i = \alpha_{0i} + \alpha_{1i} X + \alpha_{2i} \ln \hat{c}_i$$

for $\hat{c}_i$ yielding

$$(2.3) \qquad \hat{c}_i(X) = \exp((\alpha_{0i} + \alpha_{1i} X)/(1 - \alpha_{2i})) \qquad i = 1, \ldots, 6$$

From now on, we shall call c_i <u>virtual</u> and $\hat{c}_i$ <u>true</u> costs corresponding to welfare level i. In our analysis we use a summary statistic defined as

$$(2.4) \qquad \overline{\ln c} = \Big(\sum_{i=1}^{6} \ln c_i \Big)/6. \; *)$$

For each respondent this amount corresponds with the welfare level between "insufficient" and "sufficient".

In the derivation of the true household cost function the income used as anchor point plays a crucial role. The question is which income concept the household uses as anchor point to fill in the IEQ. In two-breadwinner families current household income has two components, viz. a permanent regular income earned by the man and a (sometimes transistory) income component earned by the female. Which income is used as anchor? The permanent component solely, the sum of both incomes or the permanent income plus a part of the transistory component? Preliminary calculations indicate that the anchor income is determined by the regular income of the main breadwinner mainly, but that the effect of the second component cannot be neglected. We assume that two earner families who expect that within a period of a year their status will change because the wife will leave the labour market, may anticipate a lower level of expected income and use the permanent income of the man as anchor, whereas families that do not expect such a change use total regular income as anchor. Other non-earned household income (including family allowances) are omitted in our definition of anchor income.

The income evaluation question from which the virtual costs are derived refers to welfare situations varying from very bad to very good. Respondents

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*) This summary statistic can be shown to equal the variable μ used in earlier work of researchers using the IEQ in their analysis.

therefore estimate costs for hypothetical welfare situations different from their actual situation as well. Obviously inference based on actual situations is more reliable. Some people value this reliability so highly that they discard attitude questions altogether and accept only the information derived from actual behaviour. On the other hand in many social studies attitude questions are freely used. In our opinion the reliability of attitude questions is a matter of gradual variation, where the general principle is that the information on hypothetical behaviour becomes more reliable the more the hypothetical situation resembles the actual one. This calls for an estimation method where observations are weighted according to their reliability. In the next section we describe the procedure we used to overcome this problem. If this weighting procedure is used, there does not seem to be any reason to avoid the use of attitude questions as a substitute or in addition to questions on actual behaviour.

3. Estimation Method

In this section we describe the estimation method used in our analysis. We have to deal with two problems. First, as major differences in cost functions are expected between one and two breadwinner families the model will be estimated for these two household types separately. If this separation is based on an endogenous decision least squares estimation ends up with inconsistent estimates. Below, we describe the estimation method used to handle this problem. Secondly, as mentioned in the last part of section 2 we have to correct for decreased reliability of the information on hypothetical behaviour if the hypothetical situation is far away from the actual one. This correction method is described in the last part of this section.

When dividing the sample in two subsamples it may be that ordinary least squares estimation of the model on the two datasets separately produces inconsistent estimates of the parameters. If the labour market participation decision of the female is exogenous then OLS or GLS estimation yields consistent estimates. If, however, this decision is endogenous, least squares estimation generally fails to produce consistent estimates. In order to avoid this problem we apply a general switching equation system where the female participation decision determines the régime. We briefly discuss the two-stage estimation technique we used. For a more thorough discussion the reader is referred to e.g. Heckman (1974), Lee (1978), Maddala (1983).

Consider the following model:

(3.1) $\quad I_n^* = \gamma' Z_n + e_n \qquad$ female participation decision

(3.2) régime 1: $\quad y_{1n} = \alpha_1 X_{1n} + e_{1n} \qquad$ if $I_n^* \leq 0$

régime 2: $\quad y_{2n} = \alpha_2 X_{2n} + e_{2n} \qquad$ if $I_n^* > 0$

y_{1n} and y_{2n} are endogenous variables, X_{1n} is a vector of m_1 exogenous variables, X_{2n} is a vector of m_2 exogenous variables and Z_n is a vector of k exogenous variables. The parameter vectors γ, α_1 and α_2 have to be estimated. Finally, I_n^* is an unobservable variable. What we observe is a dummy variable, I_n, which equals one if both partners participate and zero if only the main

breadwinner joins the labour market. The residuals e_{1n}, e_{2n}, and e_{r_n} are assumed to have a trivariate normal distribution with mean vector 0 and covariance matrix

$$(3.3) \qquad \Sigma = \begin{vmatrix} \sigma_{11} & \sigma_{12} & \sigma_{1e} \\ \sigma_{12} & \sigma_{22} & \sigma_{2e} \\ \sigma_{1e} & \sigma_{2e} & \sigma_{ee} \end{vmatrix}$$

In those cases in which the sample separation is observed, as in our case, we can use a probit maximum likelihood method to estimate γ. Because γ is estimable only up to a scale factor, we assume that $\sigma_{ee} = 1$.
Consider the expectation of e_{1n} under the condition that $I_n^* \leq 0$, that is under the condition that the female does not join the labour force.

$$E(e_{1n} | I_n^* \leq 0) = E(e_{1n} | e_n \leq -\gamma' Z_n)$$

$$(3.4) \qquad = -\sigma_{1e} \frac{\phi(\gamma' Z_n)}{1 - \Phi(\gamma' Z_n)}$$

(See Johnson and Kotz (1970, pp.81-3)). ϕ is the standard normal density and Φ the cummulative standard normal distribution function.
This conditional expectation only equals zero if σ_{1e} equals zero. So if $\sigma_{1e} \neq 0$ the disturbance term in (3.2) has a non-zero expectation, and we cannot apply OLS. We have to correct for this bias. Similarly, one can derive the conditional expectation of the error term e_{2n}

$$(3.5) \qquad E(e_{2n} | I_n^* > 0) = \sigma_{2e} \frac{\phi(\gamma' Z_n)}{\Phi(\gamma' Z_n)}.$$

Define the two "Heckman"-variables H_{1n} and H_{2n} as

$$(3.6) \qquad H_{1n} = -\phi(\gamma' Z_n)/(1 - \Phi(\gamma' Z_n))$$

and

$$(3.7) \qquad H_{2n} = \phi(\gamma' Z_n)/\Phi(\gamma' Z_n) \qquad (n = 1, \ldots, N).$$

The estimation procedure is as follows: first, we get an estimate of γ using a probit method with observations I. Then we get estimates of the correction

terms H_1 and H_2 using the estimated value of γ. We add these terms as explanatory variables to X_1 and X_2 respectively in order to correct for the non-zero expectation of the errorterms. At the second stage we estimate the thus extended version of (3.2) on the two data sets separately.

Having dealt with the endogenous switching problem adequately, we now discuss the second problem, viz. that our analysis is based on attitude questions referring also to more or less hypothetical situations and not to actual situations solely. Consider a household evaluating his income as "good" which is asked to give an estimation of the amount they need to reach welfare level between "insufficient" and "sufficient". It is obvious that this family will be rather vague in assessing this amount, while a household in the actual situation between "insufficient" and "sufficient" can assess it exactly. Estimation of

$$(3.8) \qquad \overline{\ln c_n} = \alpha_0 + \alpha_1 X + \alpha_2 \ln y_{cn} + \varepsilon_n$$

under the assumption that ε_n is an i.i.d. error-term with constant variance σ^2_ε does not take this effect into account. Therefore, we assume that the variance of the error ε_n tends to increase with the difference between actual income and the theoretical virtual costs corresponding with welfare level "very bad", $\ln y_c - \overline{\ln c_n}$. We hypothesize

$$(3.9) \qquad \varepsilon_n^2 = \beta e^{\delta(\ln y_{cn} - \overline{\ln c_n})^2} \cdot e^{\eta_n}$$

where e^η is a postive random variable. Following Harvey (1976) we assume that e^η obeys a χ^2_1-distribution and hence

$$(3.10) \qquad \sigma^2(\varepsilon_n) = \beta e^{\delta(\ln y_{cn} - \overline{\ln c_n})^2}.$$

Furthermore we assume that $\overline{\ln c_n}$ is given by the structural part of equation (3.8). In that case the parameters β and δ can be estimated on the basis of the calculated first-round OLS-residuals ε_n in (3.8). Having assessed in this way $\sigma^2(\varepsilon_n)$ by inserting $\hat{\beta}$ and $\hat{\delta}$ in (3.10), we may re-estimate (3.8) by weighted least squares and repeat the procedure until convergence is reached. Using this procedure we may derive more reliable estimators of the coefficients in (3.8). Moreover, the estimation of (3.10) sheds light on the

extent to which responses on attitude questions vary according to the divergence between the actual and the hypothetical situation.

4. Data and Empirical Results

One way to compare one- and two-earner families is to estimate the true household costs associated with a certain welfare level for both household types, and analyze the differences between these two cost levels. As described in section 2 we use the Income Evaluation Question, introduced by Van Praag (1971), to obtain the true cost level corresponding to the welfare level between "insufficient" and "sufficient". Therefore, the relationship between virtual costs, corresponding to this welfare level, and characteristics of the household has to be estimated. As described in the previous section we use a method that enables us to correct for endogenous switching and to correct for varying reliability of information on hypothetical behaviour.

When analyzing the resulting differences in cost levels for one- and two-earner households, we assume that the difference arises as a result of differences in home production. Hence, by comparing the cost levels between one- and two-breadwinner households with a given family size, the value of home production is estimated. In order to see how this value of household work is related to actual hours spent on home production in both family types, we estimate a time allocation model, which may be used to predict for each family type the numbers of hours spent on home production, given a set of other household characteristics. By comparing the value of home production and the hours spent on household work we may derive the marginal value of home production for each family type.

Both in the estimation of the cost functions and in the estimation of the time allocation model within a household no behavioural assumptions such as utility maximization is made. We merely describe the household's actual situation.

The structure of this section is as follows: first we describe the data. Secondly, the estimation results of the virtual costs are presented and true costs are derived for the two types of households, differentiated with respect to family size and labour time of the female, from which equivalence scales and the value of home production are derived. In a third part of the section, the estimation results of the time allocation model are presented. Finally, estimates of the marginal value of hours spent on home production in one- and two-earner families are given.

Description of the data

In this study we use a data set gathered in September 1983 in a rather

unorthodox manner. In co-operation with the Center for Research in Public Economics of the Leyden University ten regional Dutch newspapers have offered their readers (about 700,000 in total) a set of 67 questions. These questions were inserted in a Saturday edition of the newspapers. About 20,000 households have returned this two-page wide questionnaire. Although there is no guarantee that the resulting sample is representative for the population as a whole, it has been found on the basis of extensive comparisons with samples obtained in a more traditional way that after a weighting procedure*) the sample may be said to be representating for the Dutch population. We study a subsample of about 6,000 households, relevant to the present research project: i.e. households, consisting of an adult couple with or without children, where at least one of the two adults participates in the labour market.

The estimation of household costs

To obtain true household costs corresponding to the welfare level between "insufficient" and "sufficient" we have to estimate the relation between virtual costs, corresponding to the same welfare level, and characteristics of the household. As described in section 3 we have to correct for endogenous switching and for varying reliability of information on hypothetical behaviour. The estimation results of the female labour market participation, which serves as the switching equation are as follows:

$$I = \underset{(3.25)}{-45.03} - \underset{(0.09)}{2.16}\ \ln(1+ch_4) - \underset{(0.05)}{1.24}\ \ln(1+ch_{12}) - \underset{(0.05)}{0.37}\ \ln(1+ch_{18}) - \underset{(0.06)}{0.16}\ \ln(1+ch_{18}^{+})$$

$$+ \underset{(0.04)}{0.29}\ educ_{p2} + \underset{(0.05)}{0.38}\ educ_{p3} + \underset{(0.08)}{0.35}\ educ_{p4} + \underset{(0.06)}{0.56}\ educ_{p5}$$

$$+ \underset{(1.86)}{27.07}\ \ln age_p - \underset{(0.27)}{4.01}\ \ln^2 age_p$$

where I = 1 if both spouses join the labour market, 0 otherwise, and where ch_4, ch_{12}, ch_{18} and ch_{18+} stand for the number of children in the age between

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*) The weights are chosen in such a way that the marginal frequencies of the sample with respect to age, family size, education and political opinion match simultaneously with those of the population.

zero and four, four and twelve, twelve and eighteen and the number of children aged eighteen or more respectively. $Educ_{pj}$ (j = 1, ..., c) for dummies, representing the female's education (the higher the index the higher the educational level) and age_p for the age of the female. It can be seen that the presence and the number of children lowers the probability of labour market participation of the partner. This effect decreases with increasing age of the children. The higher the educational level, the higher the participation probability. The age of the partner, finally, is seen to have an increasing effect on participation until a maximum is reached at about 29 years of age. After that age, participation decreases with age. All coefficients are significantly different from zero. The estimated coefficients of this equation are used to calculate the correction terms H_1 and H_2 (see equation (3.6) and (3.7)), after which these terms are added as explanatory variables to X_1 and X_2 respectively in order to correct for the non-zero expectation of the error terms.

The estimation results of equation (3.9), relating the squared error term to the divergence between the actual and hypothetical situation, are presented in Appendix A. We shall not discuss them here in detail. Convergence of the iterative procedure (with an accuracy of 0.001) appeared to be reached after one iteration, hence only the first iteration is presented.

The estimation results of the virtual costs corresponding to the welfare level between "insufficient" and "sufficient" are as follows

one-earner family: (4.1)
$$\overline{\ln c} = \underset{(0.10)}{2.47} + \underset{(0.01)}{0.06} \ln fs + \underset{(0.01)}{0.74} \ln y_c + \underset{(0.07)}{0.001} H_1 \quad ^{*)}$$
$$(n = 3504,\ \bar{R}^2 = 0.66)$$

two-earner family: (4.2)
$$\overline{\ln c} = \underset{(0.13)}{4.37} + \underset{(0.02)}{0.09} \ln fs + \underset{(0.01)}{0.54} \ln y_c + \underset{(0.01)}{0.06} \ln N_p - \underset{(0.01)}{0.03} H$$
$$(n = 2545,\ \bar{R}^2 = 0.48)$$

N_p stands for the labour time of the female and as discussed in section 2 y_c is defined as the permanent income of the household**). For both household

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*) Standard errors between brackets.

types family size has a positive effect on virtual costs; the family size elasticity of virtual costs equals 0.06 for one- and 0.09 for two-earner families. It is seen that labour time of the female has a positive effect on virtual costs. This indicates that the higher the labour time the higher the virtual costs associated with the welfare level between "insufficient" and "sufficient".

As described in section 2 true household costs may be derived from equations (4.1) and (4.2). Table 4.1 contains true costs differentiated with respect to family size and female labour time. The correction terms H_1 and H_2 are ignored in this calculations.

Table 4.1

True household costs[1] differentiated with respect to family size and female labour time.

		fs = 2	3	4	5
one-earner family	N_p = 0	17,825	19,677	21,106	22,287
two-earner family	10	23,003	24,962	26,453	27,670
	20	25,299	27,454	29,094	30,433
	30	26,748	29,026	30,759	32,175
	40	27,825	30,195	31,999	33,471

1) in Dutch guilders per year.

It is seen that family size has a positive effect on the true costs given a constant labour time. The same holds ceteris paribus for increasing labour time. These amounts can be used to obtain money equivalence scales for variations in family sizes and female labour time. In tabel 4.2 two equivalence scales are presented; one for varying family size holding labour time constant, and another for varying female labour time holding family size constant.

Table 4.2

Equivalence scales for variations in family size given a constant female labour time and for variations in labour time given a constant family size

Family size variable		fs=2	3	4	5
One-earner family		1.00	1.10	1.18	1.25
Two-earner family		1.00	1.09	1.15	1.20
Labour time variable		**fs=2**	**3**	**4**	**5**
One-earner family	$N_p = 0$	1.00	1.00	1.00	1.00
Two-earner family	10	1.29	1.27	1.25	1.24
	20	1.42	1.40	1.38	1.37
	30	1.50	1.48	1.46	1.44
	40	1.56	1.53	1.52	1.50

Another use that can be made of the true cost estimation in table 4.1 is to derive the value of the differences in home production between one- and two-earner households. If we assume that home production is the only remaining cause of cost differences (given family size), this value may be found by substracting the one-earner cost level from the two-earner cost level in table 4.1*). The resulting value of differences in home production is presented in table 4.3.

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*) Actually we measure the result of work related costs, work related joy and differences in home production. In the discussion of the marginal value of home production we return to this problem.

Table 4.3

Value of differences[1] in home production between one- and two-earner households, for varying family size and labour time

		fs=2	3	4	5
Two-earner family	N_p = 10	5,178	5,285	5,347	5,383
	20	7,474	7,777	7,988	8,146
	30	8,923	9,349	9,653	9,888
	40	10,000	10,918	10,893	11,184

1) in Dutch guilders per year.

It is seen that the marginal value of the difference in home production between one- and two-earner households varies between about 5,200 and 11,200 per year. The differences in the value of home production between households with different family size, for a constant number of labour hours, is relatively small (between 107 and 1,184 per year) compared to the differences due to varying labour time, given family size. Even when only a small number of hours is worked by the partner, the loss in home production, compared to the one-earner household is substantial, indicating the existence of large fixed costs of working. Once we know the substitution rate between labour time and hours spent on home production, we may calculate the marginal value of hours spent on home production. In order to obtain this substitution rate, a time allocation model is estimated.

Estimation of the time allocation model

In this part of this section the estimation results of the simultaneous equation model describing the relationship between hours spent on home production and labour time of both main breadwinner and partner are presented. The model is estimated for one-earner families and two-earner families separately; Heckman correction terms are added to each equation to correct for possible endogeneity of the decision of the partner to participate in the labour market. Within a régime the model is estimated using LISREL V for simultaneous equation models. In the remaining, we discuss the coefficients of the structural model only. In order to obtain the total effect of exogenous variables on the endogenous variables one would have to solve for the reduced form equations. We do not discuss these reduced form results here in order to economize on space.

Table 4.4

Time allocation model for one-earner families

	$\ln H_h$	$\ln H_s$	$\ln H_p$	$\ln w_h$	Const	$\ln(1+ch_4)$	$\ln(1+ch12)$	$\ln(1+ch18)$	$\ln(1+ch_{18^+})$	$\ln age_h$	$\ln^2 age_h$	$\ln age_p$	$educ_{h2}$	$educ_{h3}$	$educ_{h4}$	$educ_{h5}$	$educ_{p2}$	$educ_{p3}$	$educ_{p4}$	$educ_{p5}$	occ_{h2}	occ_{h3}	occ_{h4}	occ_{h5}	E_1
$\ln H_h$				−0.31	5.48	0.02	0.03	0.04	0.01	0.07											−0.00	0.04	0.15	0.25	0.00
				(0.01)	(0.07)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)											(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\ln H_s$	−0.73		−0.54	−0.37	7.04	0.78	0.40	0.08	0.07	0.28			−0.02	0.17	−0.11	0.26									0.04
	(0.15)		(0.20)	(0.09)	(1.09)	(0.10)	(0.06)	(0.06)	(0.07)	(0.14)			(0.06)	(0.06)	(0.08)	(0.06)									(0.13)
$\ln H_p$	0.32	0.18		0.01	0.64	0.34	0.17	0.16	0.11			0.44					−0.07	−0.12	−0.15	−0.36					0.20
	(0.07)	(0.04)		(0.04)	(0.47)	(0.06)	(0.03)	(0.02)	(0.03)			(0.06)					(0.02)	(0.03)	(0.04)	(0.04)					(0.05)
$\ln w_h$					−0.19					5.46	−0.70		(0.15)	(0.15)	(0.30)	(0.36)									2.02
					(0.74)					(0.41)	(0.06)		(0.01)	(0.01)	(0.02)	(0.01)									(0.01)

Table 4.5

Time allocation model for two-earner families

	$\ln H_h$	$\ln H_p$	$\ln H_s$	$\ln H_p$	$\ln w_h$	$\ln w_p$	Const	$\ln(1+ch_2)$	$\ln(1+ch_{12})$	$\ln(1+ch_{18})$	$\ln(1+ch_{18^+})$	$\ln age_h$	$\ln^2 age_h$	$\ln age_p$	$\ln^2 age_p$	$educ_{h2}$	$educ_{h3}$	$educ_{h4}$	$educ_{h5}$	$educ_{p2}$	$educ_{p3}$	$educ_{p4}$	$educ_{p5}$	occ_{h2}	occ_{h3}	occ_{h4}	occ_{h5}	occ_{p2}	occ_{p3}	occ_{p4}	occ_{p5}	E_2
$\ln H_h$					−0.43	−0.09	6.25	0.07	0.07	0.02	0.04	0.22													−0.21	0.08	0.19	0.25					−0.05
					(0.01)	(0.01)	(0.09)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)													(0.01)	(0.01)	(0.01)	(0.01)					(0.02)
$\ln H_p$					−0.04	−0.46	7.38	−0.60	−0.40	−0.29	−0.17			−0.30															0.17	0.25	0.52	0.17	−0.18
					(0.04)	(0.03)	(0.30)	(0.09)	(0.05)	(0.03)	(0.03)			(0.07)															(0.03)	(0.03)	(0.05)	(0.05)	(0.06)
$\ln H_s$	−1.25	0.60		0.88	−0.18	0.25	2.31	0.30	−0.24	−0.05	−0.15	−0.34				0.21	0.30	0.25	0.38													−0.05
	(0.33)	(0.27)		(0.18)	(0.09)	(0.06)	(1.13)	(0.16)	(0.09)	(0.06)	(0.09)	(0.13)				(0.06)	(0.06)	(0.07)	(0.06)													(0.10)
$\ln H_p$	−0.30	−0.26	−0.16		−0.09	−0.02	3.59	0.01	0.36	0.17	0.24			0.56						−0.16	−0.16	−0.21	−0.23									−0.01
	(0.09)	(0.03)	(0.06)		(0.04)	(0.04)	(0.57)	(0.12)	(0.06)	(0.03)	(0.05)			(0.07)						(0.03)	(0.03)	(0.05)	(0.04)									(0.07)
$\ln w_h$							1.91					2.16	−0.25			0.11	0.11	0.29	0.30													0.01
							(1.06)					(0.60)	(0.08)			(0.02)	(0.02)	(0.02)	(0.01)													(0.01)
$\ln w_p$							1.68							2.33	−0.23					0.09	0.16	0.29	0.36									0.03
							(1.25)							(0.72)	(0.13)					(0.02)	(0.02)	(0.03)	(0.02)									(0.02)

We first discuss the results for one-earner families, presented in tabel 4.4. For these families it is estimated which variables effect the hours the main breadwinner and partner spend on home production and which variables influence the labour time of the main breadwinner. Labour time of the partner is per definition equal to zero for these families. Furthermore, an equation explaining the wage rate of the breadwinner is added.

Looking first at the equation describing the labour time of the breadwinner, we see that labour time decreases with 0.31% when wages increase with 1%. It is seen that an increasing number of children under eighteen results in a significantly higher labour time of the main breadwinner. The age of the breadwinner has also a positive effect on labour time. Self-employed and senior employees, finally, have longer working weeks than manual workers, employees and civil servants.

Turning now to the hours spent by the breadwinner on housework, we see a large negative coefficient of labour time: an increase in labour time of 10% results in a decrease of hours worked on home production of 7.3%. Substitution of housework by partner and breadwinner is reflected by a coefficient of -0.54: if the hours spent on housework by the partner increase, the main breadwinner reduces his own hours spent on housework, with an elasticity of 0.54. The higher the wage rate of the main breadwinner, the less hours worked at home. The presence of children has an increasing effect on the hours spent on housework, especially when they are younger than four years, where an elasticity of 0.78 is found. Older men tend to spend more time on household production. Two levels of education have an increasing effect on hours spent on housework, viz. intermediary professional education ($educ_{h3}$) and university and higher professional education ($educ_{h5}$). The latter category spends exp(0.26) = 1.30 times as many hours on housework than people with primary education.

With respect to the housework of the partner, we see that more hours spent on housework by the man do not lead to a reduction of the wife's housework: she increases her housework slightly as a result. Hence substitution between male and female housework is in one direction only. The hours spent on home production by the partner do not depend on the wage rate of the man. The effect of children on housework is positive; the effect is largest for very young children. The age of the partner has a large positive effect on hours spent on home production. Education, however, has a negative effect on the wife's housework hours; women with the highest level of education e.g. spent

70% of the time on housework of woman with primary education.
The last equation explains the male wage-rate by age and education; it shows the familiar concave age-profile, with a maximum at 49 years, and it increases with education.
The Heckman correction term, which was added to each equation, is significantly positive in the wage-equation and the equation describing the partners household work.

The results for two-earner families are presented in table 4.5. In addition to the equation already introduced for one-earner families, we now also include the labour time and wage rate of the partner. We first discuss the hours of work of the main breadwinner. Again, a negative own wage-rate elasticity is found, which is slightly higher than the one found for one-earner households. The elasticity of the man's labour time with respect to the wife's wage rate is also negative, although much smaller (-0.09). The presence of children induces the man to work more. Age has a large positive effect on the man's working week and for occupation the results are similar to the one-earner households.
The labour time of the woman has negative elasticities both with respect to her own wage rate and with respect to the man's wage rate. Hence her labour supply function is backward-bending as well. Her labour hours strongly decrease within the number of (especially young) children, and with her age. With respect to occupation we see that higher employees have significantly longer working weeks and manual workers are lowest. Female employees, however, work more hours than self-employed women.
When looking at the hours spent on housework by the man, we see the (negative) elasticity with respect to his own labour time is larger than in one-earner households and is ever larger than 1. When the partner's labour time increases, however, the man increases his housework effort with an elasticity of 0.60. A ceteris paribus increase in housework hours of the partner increases the man's homework hours as well, with a coefficient of 0.88. Again, the elasticity of household work with respect to the man's own wage rate is negative; with respect to the woman's wage rate, however, a positive coefficient is found. Although the presence of children under four increases the man's household work, this does not hold for older children, where negative coefficients are found (though not significantly different from zero). Age has a negative effect on housework. For education we find the same

effects found for one-earner households; the difference, however, between men with primary education and men with higher education is much larger in two-earner families.

With respect to the hours spent on housework by the female, we see that these hours do not react on hours worked by the man. They do decrease, with a coefficient of -0.26, if her own labour time increases. This direct effect is much smaller than the analogous effect for men, which was found to be -1.25, but measured at a higher level of hours. In these two-earner households the woman decreases her housework if men increase their hours spent on home production. These figures suggest that whereas in one-earner families the woman does not consider male housework hours as substitution for her own, in two-earner households she does (to some extent). The hours spent on housework by the woman decrease both when her own and when her husband's wage rate increases, in contrast to the absence of a wage rate effect in one-earner households. The hours of housework increase with the presence of children, especially young children, with an elasticity which is larger than the one found for one-earner households. Again, her household production increases with age, and decreases with education. Finally, the wage rate of man and woman are presented as a function of income and education. The effect of education on the man's wage rate equals the effect found for one-earner households. With respect to age, however, in overall increasing age-profile is found during working life. For women we find a concave age profile with a maximum at 49 years. The effect of education on wage rate almost equals the effect found for men; it appears that university education and intermediary vocational education is slightly more rewarding for women compared to primary education. The overall wage profile for women is, however, lower than the profile for men at all ages.

The Heckman correction term, added to each equation, is significantly different from zero in the labour equations only.

Estimation of marginal value of home production

The time allocation model described above now enables us to compute the hours spent on home production in one- and two-earner households given other household characteristics, and to calculate the marginal value of an hour spent on home production. We have used the structural equation describing the relationship between labour time and hours spent on home production of the wife, to calculate for a certain household (with age_h = 40, age_p = 37,

intermediary education of both husband and wife, and occupation employee) the number of hours spent on home production. In our analysis variations in family size are caused by variations in the number of children between four and twelve years of age. These predicted hours are presented in table 4.6. In this table we have also presented the marginal value of home production for different levels of the wife's labour time.

Table 4.6

Predicted hours per week spent on home production and the marginal value of one hour spent on home production, differentiated with respect to family size and labour time

		fs=2	fs=3	fs=4	fs=5
one-earner family	$Np = 0$ $\hat{H}_p$	28.3	37.1	42.9	47.2
two-earner family	$Np = 10$ $\hat{H}_p$	23.7	29.7	33.8	37.0
	$Np = 20$ $\hat{H}_p$	19.1	23.9	27.3	29.9
	$\frac{\Delta \hat{\bar{c}}}{\Delta \hat{H}_p * 52}$	9.60[1)]	8.27	7.81	7.48
	$Np = 30$ $\hat{H}_p$	16.9	21.1	24.1	26.4
	$\frac{\Delta \hat{\bar{c}}}{\Delta \hat{H}_p * 52}$	12.67	10.79	9.71	9.31
	$Np = 40$ $\hat{H}_p$	15.4	19.3	22.0	24.3
	$\frac{\Delta \hat{\bar{c}}}{\Delta \hat{H}_p * 52}$	13.81	12.48	11.92	11.33

1) in Dutch guilders per hour.

Variations in family size are caused by variations in the number of children between four and twelve year of age. It is seen that the number of hours spent on home production gradually decreases when labour time is increased. For a two person household, for example, 28.3 hours per week are spent on home

production in a one-earner household, and 15.4 hours are spent on home production in a two-earner household where the partner is working full time. By dividing the difference in costs between $N_p = 10$ and $N_p = 20$ by the difference in hours spent on home production corresponding to these labour times, the marginal value of one hour spent on home production in that situation is found, which is 9.60 Dutch guilders for a two-person household. This amount is in the same range as the wage rate. The estimated wage rate for this household type equals 11.10 Dutch guilders. Marginal costs at other labour times and family sizes are computed analogously. We have abstained from computing the marginal costs at $N_p = 10$, as the initial fixed costs are also included in the difference between $N_p = 0$ and $N_p = 10$. The table shows that for each family size the marginal value of an hour spent on home production increases when labour time increases. In other words, the loss of an hour home production is valued more and more, the scarcer the remaining hours are. Comparing families with different sizes, we see that a family of four places the same value on an hour home production at a higher level of hours than a family of two: The latter values the loss of one hour home production at about 9.60 at 19 hours of home production, while for the family of four the same value is found at 24 hours of home production. This reflects the fact that larger families find it harder to reduce their home production than small families. The marginal values of an hour spent on home production may be interpreted as the shadow price of an hour of home production. We have already noted that this price is in the same order or magnitude as the wage rate. In a next paper we will analyze to what extent the results described here correspond to the model of utility maximization, which would imply that households adapt their hours in such a way that the price of home production equals the wage rate.

5. Conclusions

In this paper a method is presented, that enables us to assess the marginal value of an hour spent on home production, without making a priori assumptions on the household's behaviour, like utility maximization. Using this method, the value (in terms of after-tax income) of the difference in home production between one- and two-earner households is estimated to be in between about Dfl. 5,000 for a two-person household and Dfl. 11,0000 Dutch guilders per year for a five-person household. This value is also dependent of the number of hours the partner spends in the labour market.

In order to derive the marginal value per hour of home production, the number of hours worked on home production in each household type is estimated, which varies between 15 hours per week for a two-person two-breadwinner household and 47 hours per week for a five-person one-breadwinner household. Combining the value of home production and the number of hours spent on home production, we obtain estimates of the marginal value of an hour of home production. The marginal value increases when hours of home production decrease, which happens when more hours are spent in the labour market. For large families the loss of an hour of home production at 24 of housework is valued the same as the loss of a marginal hour at 19 hours of housework in a two-person household. The estimated marginal value of an hour spent on home production is in the same order of magnitude as the wage rate.

Appendix A

The estimation results of the relation of the squared error term and the divergence between the actual and hypothetical situation (see equation (3.9)).

One-earner families:

$$\ln(\varepsilon_1)^2 = \underset{(0.05)}{-5.90} + \underset{(2.43)}{24.18}\,(\ln y_c - \widetilde{\ln c})^2 \qquad \bar{R}^2 = 0.03, \quad n = 3504$$

Two-earner families:

$$\ln(\varepsilon_2)^2 = \underset{(0.05)}{-4.64} + \underset{(0.81)}{1.98}\,(\ln y_c - \widetilde{\ln c})^2 \qquad \bar{R}^2 = 0.002, \quad n = 2545$$

Appendix B

In this Appendix we give the description of the variables we have used in the simultaneous equations. They are only described for the head of the household; the corresponding variables of the partner are defined in the same way (for the latter variables a subscript p is used).

Symbol	Description
$\bar{c}$	the virtual costs assessed by the household to attain welfare level between "insufficient" and "sufficient"
N_h	the number of hours worked per week by the head of the household in the labour market
H_h	the number of hours spent on household production by the head of the household
w_h	the after-tax wage rate of the head of the household
y_c	the "anchor" money income of the family (defined as the regular income of the main breadwinner; two-earner families who do not expect that within a period of a year their status will change because one of the spouces will leave the labour market are assessed the sum of both regular incomes as the anchor income)
fs	the family size of the household
ch4	the number of children younger than four years of age
ch12	the number of children between four and twelve years of age
ch18	the number of children between twelve and eighteen years of age
$ch18^+$	the number of children older than eighteen
age_h	the age of the head of the household
Occ_{h1}	dummy variable, 1 for manual workers
Occ_{h2}	dummy variable, 1 for junior employees
Occ_{h3}	dummy variable, 1 for senior employees
Occ_{h4}	dummy variable, 1 for high office employees
Occ_{h5}	dummy variable, 1 for self-employed
$Educ_{h1}$	dummy variable, 1 for primary education
$Educ_{h2}$	dummy variable, 1 for extended primary education
$Educ_{h3}$	dummy variable, 1 for secundary education
$Educ_{h4}$	dummy variable, 1 for higher non-academic schooling
$Educ_{h5}$	dummy variable, 1 for university
H_1	correction term for the first Régime
H_2	correction term for the second Régime

The structure of the covariance matrix of the endogenous variables is assumed to be a full matrix for the six cost functions, and a diagonal matrix.

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