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Preference Interdependence and Habit Formation in Family Labor Supply

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Preliminary

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Abstract

This paper investigates the joint labor supply decision in households in a neo-classical framework. Besides the more traditional explanatory variables like wages, taxes, welfare-benefits and demographic factors, we highlight the importance of two psychological factors.

First of all individual preferences change in the course of time under the influence of habit formation. Secondly, preferences are influenced by the behavior of other individuals. We will call this interdependence of preferences. Habit formation adds a dynamic aspect to the standard neo-classical model.

Incorporation of interdependent preferences yields a micro-model that implies different wage elasticities of labor supply for individual households than for aggregates. As such it may account for the often observed inconsistencies between predictions from micro-models and macro-models.

We find that the model with habit formation and preference interdependence produces results different from the standard model without these factors. Since the extended model must be preferred on statistical grounds, we conclude that the standard model may give rise to misleading results.
1. \textbf{Introduction}

In this paper the joint labor supply decision of households is modelled in a neo-classical framework. The specification of the supply equations is second order flexible and consistent with utility maximization\(^1\). Concavity of the cost function is imposed a priori for a certain range of the wage rates and unearned income.

The main contribution of this paper is the implementation of habit formation and interdependent preferences in a standard labor supply model. We assume that individuals get used to working a certain number of hours (habit formation) and that the number of hours they prefer to work is also dependent upon how many hours other people work (interdependence of preferences). To operationalize these psychological influences a number of stochastic assumptions have to be made. The assumptions are adaptations of the assumptions made by Van de Stadt, Kapteyn, Van de Geer (1985).

Since we are only dealing with the supply side of the labor market, the number of hours people \textit{would like} to work is the correct dependent variable. It is assumed that individuals determine the number of hours they would like to work conditional on the number of hours the partner actually works. Thus rationing theory is appropriate.

A last aspect our model takes account of is a non-convex budget set. The existence of various kinds of benefits (e.g. unemployment benefits) results in non-convex budget sets for various households. In these cases explicit utility comparisons are required.

The structure of the paper is as follows: Section 2 deals with the specification of a standard neo-classical household labor supply model. In section 3 this model is extended with the aforementioned social psychological factors. The application of rationing theory to this model is explained in section 4. Section 5 briefly discusses the difficulties that arise when dealing with a non-convex budget set. Finally in section 6 the estimation results are presented.

\(^1\) The specification is due to Hausman and Ruud (1984).
2. The Model Specification

We consider households\(^1\) with at least two adults capable of working in paid jobs. The joint labor supply decision of husbands and wives is described by the following model, due to Hausman and Ruud (1984):

\[
\begin{align*}
\tilde{h}_{mk} &= \delta_{mk} + \gamma_m \cdot w_{mk} + \alpha_w \cdot f_{wk} + \beta_m \cdot u_k, \\
\tilde{h}_{fk} &= \delta_{fk} + \gamma_f \cdot w_{fk} + \alpha_w \cdot m_{mk} + \beta_f \cdot u_k,
\end{align*}
\]

\[k = 1, \ldots, N\]

\[\quad (2.1)\] \[\quad (2.2)\]

\[u_k = u_k + \theta + \delta_{mk} \cdot w_{mk} + \delta_{fk} \cdot w_{fk} + \frac{1}{2} (\gamma_m \cdot w_{mk}^2 + \gamma_f \cdot w_{fk}^2) + \alpha_w \cdot m_{mk} \cdot w_{fk}\]  \[2.3\]

where \(\tilde{h}_{mk}\) := number of hours the male partner in household \(k\) would like to work per week.

\(\tilde{h}_{fk}\) := number of hours the female partner in household \(k\) would like to work per week.

\(w_{mk}\) and \(w_{fk}\) := after tax marginal wage rates of male and female, respectively.

\(u_k\) := (weekly) non-labor income of household \(k\).

\(N\) := total number of households.

\(\theta, \delta_{mk}, \delta_{fk}, \gamma_m, \gamma_f, \alpha, \beta_m, \beta_f\) are parameters.

As these supply equations are quadratic in wages, the system is second order flexible. Given that the parameters in the system satisfy certain restrictions, \(\tilde{h}_{mk}\) and \(\tilde{h}_{fk}\) can be considered as the results of the maximization of a well-behaved household utility function with male and female leisure and total consumption as arguments. Since this is strictly a model of labor supply, equations (2.1) and (2.2) describe the number of hours the male and female partners would like to work, given the wage rates and non-labor income. We will refer to the number of hours each partner would like to work as preferred hours, whereas the number of hours actually worked by each partner is referred to as actual

\(^1\) The words "households" and "families" are used as synonyms. This also applies to the pairs "husband, wife", "male, female" and "man, woman".
hours. The actual hours are generally the result of the interplay of household preferences, institutional constraints, and the demand for labor. In the Netherlands institutional constraints play a very important role. Therefore it is necessary to use the conceptually superior variable preferred hours instead of actual hours of work.

The indirect household utility function and cost function corresponding to (2.1) - (2.3) are respectively:

\[
\psi(w_{mk}, w_{fk}, \mu_k) = \exp(\beta_m w_{mk} + \beta_f w_{fk}) \cdot \mu_k
\]

\[
C(u, w_{mk}, w_{fk}) = u \exp(-\beta_m w_{mk} - \beta_f w_{fk}) - \left[ \delta_m - T \right] w_{mk} + \left[ \delta_f - T \right] w_{fk} + \frac{1}{2} \left( \gamma_m w_{mk}^2 + \gamma_f w_{fk}^2 \right) + \alpha w_{mk} \cdot w_{fk}
\] (2.5)

As is well-known, concavity of the cost-function is implied by utility maximization. In most empirical studies concavity is not imposed a priori, but checked afterwards. In this study, however, concavity is imposed a priori for a certain range of the wage rates and non-labor income. A sufficient condition for concavity to hold on the interval \((0, \hat{w}) \times (0, \hat{w}) \times (0, \hat{u})\) in Euclidean \((w_m, w_f, u)\)-space can be written as a restriction on the parameter \(\theta\) (See Kapteyn, Kooreman, van Soest (1986)), as follows

\[
\theta < \min (a_1, a_2)
\]

(2.6)

where

\[
a_i = \phi_i - \hat{u} - \max \{ 0, (h + \delta_i) \hat{w} + \frac{1}{2} \gamma_i \hat{w}^2 \} \quad i=m, j=f \text{ or } i=f, j=m
\]

\[
\delta_i = \text{maximum value of } \delta_{ik} \text{ in the sample } i=m, f
\]

\[
h = \text{maximum number of actual working hours per week in the sample}
\]

\[
\phi_{1i} = -\phi_1 / 2 \beta_i^2 \gamma_i + \gamma_i / 2 \beta_i
\]

\[
\phi_1 = (\alpha \beta_i^2 - \gamma_i \beta_j^2) / (\gamma_i \beta^2 + \gamma_j \beta^2 - 2 \alpha \beta_i \beta_j)^2 \quad i=m, j=f \text{ or } i=f, j=m
\]

1) m stands for male and f for female.
Moreover it is assumed:

\[ \gamma_m^\alpha \]
\[ (\alpha \gamma_f) \] is Positive semi-definite.
3. Incorporation of Preference Interdependence, Habit Formation and Demographic variables

The main purpose of this section is to incorporate preference interdependence and habit formation into the neo-classical family labor supply model described in section 2. In most labor supply models it is assumed that the individual utility functions are constant. As a matter of fact few economists have analyzed models of interdependent preferences, although the idea that social interactions between individuals are important determinants of one's utility is common in sociology and psychology. Some economic studies are theoretical papers by Becker (1974), Scott (1972), Schall (1972), and empirical papers by Tomes (1983) and Kapteyn et al. (1985). Here we want to allow for the possibility of endogeneous preferences, pretty much along the lines discussed by Pollak (1978) and by Van de Stadt, Kapteyn and Van de Geer (1985). We assume that preferences are influenced by own past labor supply behavior: people get used to working a certain number of hours. In the literature this is generally referred to as habit-formation. Moreover it is plausible to assume that the number of hours someone would like to work depends on the number of hours other people actually work. That is individuals refer to other people in their their reference group. We call this interdependence of preferences. The influence of preference interdependence and habit formation jointly will be referred to as preference formation.

Habit formation is incorporated into the model by writing certain parameters of the labor supply model as a function of number of hours worked in the previous period by the male and the female. Preference interdependence is modelled by making the same parameters also dependent upon the number of hours worked by other individuals in the social reference group (a concept to be defined later on), lagged one period.

The choice of the parameters that are made dependent is somewhat arbitrary. We have selected the "translation parameters" (cf. Pollak and Wales (1981)) $\delta_{mk}$ and $\delta_{fk}$, mainly for reasons of simplicity. The specification adopted is:
\[ \delta_{mk} = \delta_{m0} + \eta_{mm} \sum \lambda_{m}^{\lambda_{m}} h_{mk}(-1) + \eta_{mf} \sum \lambda_{f}^{\lambda_{f}} h_{fk}(-1) \quad (3.1) \]

\[ \delta_{fk} = \delta_{f0} + \eta_{ff} \sum \lambda_{f}^{\lambda_{f}} h_{fk}(-1) + \eta_{fm} \sum \lambda_{m}^{\lambda_{m}} h_{mk}(-1) \quad (3.2) \]

\[ h_{mk}(-1) := \text{lagged value of actual hours worked by the male in household } k. \]

\[ h_{fk}(-1) := \text{lagged value of actual hours worked by the female in household } k. \]

\[ \delta_{m0}, \delta_{f0}, \eta_{mm}, \eta_{ff}, \eta_{mf}, \eta_{ff} \text{ are parameters, } 0 < \eta_{mm} + \eta_{mf}, \eta_{ff} + \eta_{fm} < 1, \]

\[ \lambda_{m}^{\lambda_{m}}, \lambda_{f}^{\lambda_{f}}, \lambda_{mf}, \lambda_{ff} > 0, \text{ for all } k, \lambda, \]

\[ \sum \lambda_{m}^{\lambda_{m}} = 1, \sum \lambda_{f}^{\lambda_{f}} = 1, \sum \lambda_{mf}^{\lambda_{mf}} = 1, \sum \lambda_{ff}^{\lambda_{ff}} = 1, \text{ for all } k, \lambda, \]

Notice that it is assumed that the male (female) parameter \( \delta_{mk} (\delta_{fk}) \) not only depends on male (female) hours but also on female (male) hours. In other words men and women refer both to individuals of their own sex and to individuals of the other sex.

The \( \lambda_{m}^{\lambda_{m}} \)'s are so called reference weights. For example \( \lambda_{mf} \) represents the importance attached by the male in family \( k \) to labor supply behavior of the female in family \( \lambda \). If, for instance \( \lambda_{mf} = 0 \) the female in family \( \lambda \) doesn't belong to the reference group of the male in family \( k \), if \( \lambda_{mf} \neq 0 \) she does. Similar interpretations can be given to \( \lambda_{ff} \) and \( \lambda_{ff} \).

The parameters \( \eta_{..} \) measure the importance of preference formation. The higher \( \eta_{..} \) is, the more ones preferences are influenced by past labor supply behavior of other people (preference interdependence) or by own past labor supply behavior (habit formation). If the \( \eta \)'s would be zero, preferences would be immune to habit formation or preference interdependence. More specifically if, for example \( \eta_{mf} \) equals zero, past labor supply behavior of females has no influence on the male's preferences.
By inserting (3.1) and (3.2) into (2.1) - (2.3) we obtain a model which relates observables to observables, but with far too many parameters to be estimated. To reduce this huge number of parameters, some additional assumptions will be made, which are basically identical to the assumptions made by Kapteyn, Van de Geer, Van de Stadt, Wansbeek (1984) and Van de Stadt, Kapteyn, Van de Geer (1985).

First of all it is assumed that \( v_{kk}^{mm} \) and \( v_{kk}^{ff} \) do not vary with \( k \), say \( v_{kk}^{mm} = \tau_m \) and \( v_{kk}^{ff} = \tau_f \). This means that the relative influence of habit formation is the same across households. Since \( \sum_{k \neq \ell} v_{kk}^{mm} = 1-\tau_m \) and \( \sum_{k \neq \ell} v_{kk}^{ff} = 1-\tau_f \) the relative influence of preference interdependence is also assumed to be the same across households. The larger \( \tau_m \) (\( \tau_f \)) the more important habit formation is relative to preference interdependence.

Next we introduce new parameters \( q_{k\ell} \) defined by

\[
q_{k\ell}^{mm} := \frac{v_{k\ell}^{mm}}{1-\tau_m} \quad k \neq \ell
\]

\[
q_{k\ell}^{mm} := 0 \quad k = \ell
\]

\[
\sum_{k \neq \ell} q_{k\ell}^{mm} > 0 \quad \text{for all } k, \ell, \quad \sum_{\ell=1}^{N} q_{k\ell}^{mm} = 1 \quad \text{for all } k
\]

\[
q_{k\ell}^{ff} := \frac{v_{k\ell}^{ff}}{1-\tau_f} \quad k \neq \ell
\]

\[
q_{k\ell}^{ff} := 0 \quad k = \ell
\]

\[
\sum_{k \neq \ell} q_{k\ell}^{ff} > 0 \quad \text{for all } k, \ell, \quad \sum_{\ell=1}^{N} q_{k\ell}^{ff} = 1 \quad \text{for all } k
\]

\[
q_{k\ell}^{mf} := v_{k\ell}^{mf} \quad \text{for all } k, \ell, \quad \sum_{\ell=1}^{N} q_{k\ell}^{mf} = 1 \quad \text{for all } k
\]

\[
q_{k\ell}^{fm} := v_{k\ell}^{fm} \quad \text{for all } k, \ell, \quad \sum_{\ell=1}^{N} q_{k\ell}^{fm} = 1 \quad \text{for all } k
\]
Also the parameters $q_{k\ell}$ will be called "reference weights". We shall refer to the set of females for which $q_{k\ell}^m > 0$ as the social reference group of the male in family $k$. Define

$$h_{mmk} := \sum_{\ell=1}^{N} q_{k\ell}^m h_{m\ell}$$  \hspace{1cm} (3.3)$$

$$h_{ffk} := \sum_{\ell=1}^{N} q_{k\ell}^f h_{f\ell}$$  \hspace{1cm} (3.4)$$

$$h_{mfk} := \sum_{\ell=1}^{N} q_{k\ell}^m h_{f(-1)\ell}$$  \hspace{1cm} (3.5)$$

$$h_{fmk} := \sum_{\ell=1}^{N} q_{k\ell}^f h_{m(-1)\ell}$$  \hspace{1cm} (3.6)$$

The quantities $h_{..k}$ are reference group means of working hours. For example the quantity $h_{mmk}$ is the mean of female hours in the reference group of the male in family $k$. This makes it possible to rewrite (3.1) and (3.2) as:

$$\delta_{mk} = \delta_{m0} + \eta_{mm}[\xi_m h_{m(-1)k} + (1-\xi_m)h_{mmk(-1)}] + \eta_{mf}[h_{mfk(-1)}] \hspace{1cm} (3.7)$$

$$\delta_{fk} = \delta_{f0} + \eta_{ff}[\xi_f h_{f(-1)k} + (1-\xi_f)h_{ffk(-1)}] + \eta_{fm}[h_{fmk(-1)}] \hspace{1cm} (3.8)$$

with $\xi_m < 1$, $\xi_f < 1$.

The second terms in both equations represent habit formation and the last terms represent interdependence of preferences.

Three more assumptions are made to reduce the number of unknown parameters implicit in $h_{mmk(-1)}$ and $h_{ffk(-1)}$. These are listed and discussed in Van de Stadt, Kapteyn and Van de Geer (1985) in detail. Here we only mention their implication, namely that the unobservable reference group means can be approximated by a convex combination of the social group means and the population means.

A social group is defined as a set of individuals who share certain characteristics, like age and education. We assume that the reference group of the male in family $k$ depends on his own social group, but also on his wife's social group. (These two need not coincide.)
\[ \hat{h}_{mmk} = (1 - \kappa_m) (\lambda_{mm} \hat{h}_{mmk} + (1 - \lambda_{mm}) \hat{h}_{fmk}) + \kappa_m \hat{h}_m + \nu_{mmk} \] (3.9)

\[ \hat{h}_{ffk} = (1 - \kappa_f) (\lambda_{ff} \hat{h}_{ffk} + (1 - \lambda_{ff}) \hat{h}_{mfk}) + \kappa_f \hat{h}_f + \nu_{ffk} \] (3.10)

\[ \hat{h}_{mfk} = (1 - \kappa_f) (\lambda_{mf} \hat{h}_{mfk} + (1 - \lambda_{mf}) \hat{h}_{ffk}) + \kappa_f \hat{h}_f + \nu_{mfk} \] (3.11)

\[ \hat{h}_{fmk} = (1 - \kappa_m) (\lambda_{fm} \hat{h}_{fmk} + (1 - \lambda_{fm}) \hat{h}_{mmk}) + \kappa_m \hat{h}_m + \nu_{fmk} \] (3.12)

where

\[ \hat{h}_{mmk} \]: mean hours worked per week by other men in the same social group as the male in family k.

\[ \hat{h}_{ffk} \]: mean hours worked per week by other women in the same social group as the female in family k.

\[ \hat{h}_{mfk} \]: mean hours worked per week by women in the same social group as the male in family k.

\[ \hat{h}_{fmk} \]: mean hours worked per week by men in the same social group as the female in family k.

\[ \tilde{h}_m \]: the mean of the number of hours worked by all men in society.

\[ \tilde{h}_f \]: the mean of the number of hours worked by all women in society.

\[ \nu_{mmk}, \nu_{ffk}, \nu_{mfk}, \nu_{fmk} \]: error terms that are uncorrelated with \( \hat{h}_{mmk}, \hat{h}_{fkk}, \hat{h}_{mkk} \) and have zero-mean.

\[ \kappa_m, \kappa_f, \lambda_{mm}, \lambda_{ff}, \lambda_{mf}, \lambda_{fm} \] are parameters.

The quantity \((1 - \kappa_m)\) indicates which part of the total reference weight is assigned specifically to individuals within the social group.

The parameter \( \kappa_m \) indicates the share of the total reference weight that is assigned to all people in society, irrespective of whether they are within or outside an individual's social group. In other words, \( \kappa_m \) signifies how informative the social group is about the reference group. If \( \kappa_m = 0 \), then

\[ \hat{h}_{mmk} = \lambda_{mm} \hat{h}_{mmk} + (1 - \lambda_{mm}) \hat{h}_{fmk} + \nu_{mmk} \] (3.13)

\[ \hat{h}_{fmk} = \lambda_{fm} \hat{h}_{fmk} + (1 - \lambda_{fm}) \hat{h}_{mmk} + \nu_{fmk} \] (3.14)
In this case the reference group does not extend beyond one's social group. On the other hand if \( \kappa_m = 1 \), then

\[
\hat{h}_{mmk} = \bar{h}_m + \nu_{mmk} \tag{3.15}
\]

\[
\hat{h}_{fmk} = \bar{h}_f + \nu_{fmk} \tag{3.16}
\]

The reference group means of working hours of all families are then approximated by the same constant, namely the average number of hours worked in society as a whole. In this case social groups give no information at all about reference groups. Thus we observe that the smaller \( \kappa \) is, the better a proxy is a household's social group for its reference group.

The \( \lambda \)'s measure the relative reference weight assigned to individuals in the own social group compared to individuals in the partner's social group. For example, if \( \lambda_{mf} = 0 \), then

\[
\hat{h}_{mfk} = (1-\kappa_f)\bar{h}_{f} + \kappa_f \bar{h}_f + \nu_{mfk} \tag{3.17}
\]

In this case the male in family \( k \) is only referring to women who are in his wife's social group and not to women in his own social group.

A central concept in this approach is the notion of a social group. The exact definition of a social group is dictated by the availability of information on household characteristics like education, occupation etc. In our data the information available is rather limited. We have constructed social groups on the basis of education and age\(^1\).

Combining (3.7) and (3.8) with (3.9) - (3.10) results in:

\[\text{References}\]

1) In his Theory of Social Comparison Processes (1954) Festinger states that people compare oneself with others who share the same relevant characteristics. Considering labor market behavior relevant characteristics are, among others, age and education.
\[
\delta_{mk} = \delta_{m0} + \eta_{mm} \left[ \zeta_{m} \bar{h}_{mk}(-1) + (1-\zeta_{m}) \cdot (\bar{\kappa}_{m} \bar{h}_{m}(-1) + (1-\bar{\kappa}_{m}) \right. \\
+ \left. (1-\lambda_{mm})(\bar{h}_{mk}(-1) + (1-\lambda_{mm})\bar{h}_{m}(-1)) \right] + \eta_{mf} \left[ \kappa_{f} \bar{h}_{f}(-1) + (1-\kappa_{f}) \right. \\
+ \left. (1-\lambda_{mf})(\bar{h}_{mk}(-1) + (1-\lambda_{mf})\bar{h}_{m}(-1)) \right] + \eta_{mm} \left[ (1-\zeta_{m})v_{mmk} + \eta_{mf} v_{mkf} \right] 
\]

(3.18)

\[
\delta_{fk} = \delta_{f0} + \eta_{ff} \left[ \zeta_{f} \bar{h}_{fk}(-1) + (1-\zeta_{f}) \cdot (\bar{\kappa}_{f} \bar{h}_{f}(-1) + (1-\bar{\kappa}_{f}) \right. \\
+ \left. (1-\lambda_{ff})(\bar{h}_{mk}(-1) + (1-\lambda_{ff})\bar{h}_{m}(-1)) \right] + \eta_{fm} \left[ \kappa_{m} \bar{h}_{m}(-1) + (1-\kappa_{m}) \right. \\
+ \left. (1-\lambda_{fm})(\bar{h}_{mk}(-1) + (1-\lambda_{fm})\bar{h}_{m}(-1)) \right] + \eta_{ff} \left[ (1-\zeta_{f})v_{ffk} + \eta_{fm} v_{mkf} \right] 
\]

(3.19)

Thus far we have not taken into account demographic factors in our analysis. The effect of household size has been incorporated by means of 'translating' (Pollak and Wales (1981)).

Then equations (3.1) and (3.2) become:

\[
\delta_{mk} = \delta_{m0} + \pi_{m} \cdot \bar{f}_{k} + \eta_{mm} \sum_{k} v_{kk}^{mm}(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) \\
+ \eta_{mf} \sum_{f} v_{ff}^{mf}(h_{f}(-1) - \pi_{f} \bar{f}_{k}) 
\]

(3.20)

\[
\delta_{fk} = \delta_{f0} + \pi_{f} \cdot \bar{f}_{k} + \eta_{ff} \sum_{f} v_{ff}^{ff}(h_{f}(-1) - \pi_{f} \bar{f}_{k}) \\
+ \eta_{fm} \sum_{m} v_{kk}^{mf}(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) 
\]

(3.21)

Going through the same procedure as described above yields the following expressions for the delta's:

\[
\delta_{mk} = \delta_{m0} + \pi_{m} \cdot \bar{f}_{k} + \eta_{mm} \left[ \zeta_{m} (h_{mk}(-1) - \pi_{m} \bar{f}_{k}) + (1-\zeta_{m}) \cdot (\bar{\kappa}_{m} (h_{m}(-1) - \pi_{m} \bar{f}_{k}) \\
+ (1-\lambda_{mm})(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) \right] \right. \\
+ \left. (1-\lambda_{mm})(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) \right] + \eta_{mf} \left[ \kappa_{f} (h_{f}(-1) - \pi_{f} \bar{f}_{k}) \\
+ (1-\lambda_{mf})(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) \right] \\
+ \eta_{ff} \left[ \kappa_{f} (h_{f}(-1) - \pi_{f} \bar{f}_{k}) \\
+ (1-\lambda_{ff})(h_{mk}(-1) - \pi_{m} \bar{f}_{k}) \right] \\
+ \eta_{ff} \left[ (1-\zeta_{f})v_{ffk} + \eta_{fm} v_{mkf} \right] 
\]

(3.20)
(1-\lambda_{mf})(\bar{h}_{ffk}(-1) - \pi_{f}\bar{f}_{sk})] + \eta_{mm}(1-\tau_{m})\nu_{mmk} + \eta_{mf}\nu_{mkf} \tag{3.22}

\delta_{fk} = \delta_{f0} + \pi_{f}\bar{f}_{sk} + \eta_{ff}[\xi_{f}(\bar{h}_{fk}(-1) - \pi_{f}\bar{f}_{sk}) + (1-\tau_{f})\{(\bar{h}_{f}(-1) - \pi_{f}\bar{f}_{sk})

+ (1-\kappa_{f})(\lambda_{ff}(\bar{h}_{f}(-1) - \pi_{s}\bar{f}_{sk}) + (1-\lambda_{ff})(\bar{h}_{mk}(-1) - \pi_{f}\bar{f}_{mk})\}]

+ \eta_{fm}[\kappa_{m}(\bar{h}_{m}(-1) - \pi_{m}\bar{f}_{sk}) + (1-\kappa_{m})(\lambda_{fm}(\bar{h}_{mk}(-1) - \pi_{m}\bar{f}_{mk})(-1))

+ (1-\lambda_{fm})(\bar{h}_{mmk}(-1) - \pi_{m}\bar{f}_{mk})] + \eta_{ff}(1-\tau_{f})\nu_{ffk} + \eta_{fm}\nu_{fmk} \tag{3.23}

where \bar{f}_{sk} := \text{logarithm of the size of household } k

\bar{f}_{mk} := \text{mean of the logarithm of the size of the households in the social group of the male in family } k.

\bar{f}_{sk} := \text{mean of the logarithm of the size of the households in the social group of the female in family } k.

\bar{f}_{s} := \text{mean of the logarithm of the size of the households in society as a whole.}

\pi_{m}, \pi_{f} \text{ are parameters}

By now we have constructed a flexible neo-classical labor supply model in which habit formation and preference interdependence are incorporated by means of translating. An important issue is the identification of the parameters. From the labor supply equations (2.1) – (2.3) it is easy to see that the "basic model" is (over)identified.

Thus if we examine the identification of the extended model with preference formation we can confine ourselves to examination of the equations for the \delta's. A discussion of the identifiability of the parameters can be found in Appendix 1. At this stage it is sufficient to notice that all but 2 parameters (\kappa_{m}, \kappa_{f}) are identified.
4. Rationing

We wish to explain the number of hours the male and the female partner would like to work per week thus confining ourselves strictly to the supply side of the labor market. In our dataset these variables are measured by asking both partners the following question: "Suppose you could freely choose the number of hours you work per week. How many hours would you like to work in your present job, if you could choose them yourself and if you would earn on average the same amount of money per hour as you do at the moment. If you choose for less hours of work, you choose for less income. And more hours of work means more income. Assume that the number of hours of other members of the household, if any, do not change."

Since in the survey from which our data comes, both partners have answered the question independently, we interpret the answers to the question in the following way. We assume that the male answers the question under the condition that the number of hours the female actually works doesn't change (and vice versa). This means that the partner's number of hours is taken as given and rationing theory is appropriate.

There is a well-known relationship between a rationed and an unrationed cost function (See e.g. Deaton and Muellbauer (1980)). Consider, for instance, the case where the female leisure is rationed at $\bar{k}_f$. Then we have

$$ C^R(u, w_m, w_f | \bar{k}_f) = C(u, w_m, \bar{w}_f) + \bar{k}_f(w_f - \bar{w}_f) $$

(4.1)

where $C^R(u, w_m, w_f | \bar{k}_f)$ is the cost of reaching utility level $u$ at wage rates $w_m$ and $w_f$ and under the restriction that female leisure is rationed at $\bar{k}_f$. The shadow wage, $\bar{w}_f$, is the wage rate that would make the preferred number of female hours of leisure $k_f$ equal to $\bar{k}_f$. From the rationed cost function $C^R$ we can obtain the preferred number of hours of leisure for the male given that the female leisure equals $\bar{k}_f$. Going through the same procedure for the female and moving from hours of leisure to hours worked then yields the following system:

$$ h_{mk} = \delta_{mk} + \gamma_m w_{mk} + \alpha_w \bar{w}_{fk} + \beta_m \bar{w}_k $$

(4.2)
\begin{align}
\bar{h}_{fk}^r &= \delta_{fk} + \gamma_{f^*w_{fk}} + \alpha \bar{w}_{mk} + \beta_{f^*\bar{u}_{k}} \\
\bar{u}_{k}^f &= \mu_k + h_{fk}(\bar{w}_{fk} - \bar{w}_{mk}) + \theta + \delta_{mk} \bar{w}_{mk} + \delta_{f^*w_{fk}} \\
\frac{1}{2}(\gamma_{m^2} w_{mk} + \gamma_{f^*w_{fk}}) + \alpha \bar{w}_{mk} \bar{w}_{fk} \\
\bar{u}_{k}^{-m} &= \mu_k + h_{mk}(\bar{w}_{mk} - \bar{w}_{mk}) + \theta + \delta_{mk} \bar{w}_{mk} + \delta_{f^*w_{fk}} \\
\frac{1}{2}(\gamma_{m^2} w_{mk} + \gamma_{f^*w_{fk}}) + \alpha \bar{w}_{mk} \bar{w}_{fk} \\
\end{align}

with \( \bar{h}_{mk} \) := the number of hours the man in household \( k \) prefers to work, given that his wife continues to work her actual number of hours \( h_{fk} \).

\( \bar{h}_{fk} \) := the number of hours the female in household \( k \) prefers to work, given that her husband continues to work his actual number of hours \( h_{mk} \).

\( \bar{w}_{mk} \) := the male shadow wage rate, implicitly defined by:

\begin{align}
\bar{h}_{mk} &= \delta_{mk} + \gamma_{m^2} w_{mk} + \alpha \bar{w}_{mk} + \beta_{m^*\bar{u}_{k}} \\
\end{align}

\( \bar{w}_{fk} \) := the female shadow wage rate implicitly defined by:

\begin{align}
\bar{h}_{fk} &= \delta_{fk} + \gamma_{f^*w_{fk}} + \alpha \bar{w}_{mk} + \beta_{f^*\bar{u}_{k}} \\
\end{align}
5. A non-linear, non-convex budget set

The wording of the survey question quoted at the beginning of the previous section clearly invites the respondent to provide his or her optimal number of hours given a linear budget constraint. However, the question only applies to those who already have a job. Those without work were simply asked whether they were looking for a job or not.

If a respondent without a job is receiving unemployment or welfare benefits, then his or her budget constraint is non-convex. An example of such a budget constraint is given in Figure 5.1.

![Figure 5.1: Non-convex budget set.](image)

The budget constraint is ABC. An individual who is unemployed and receives unemployment benefits CD faces a very high marginal tax rate if he or she manages to find a job with less than $T-t_0$ hours per week (BC is almost horizontal). Beyond $T-t_0$ hours no unemployment benefits are being received.

In the case illustrated in Figure 5.1, the individual prefers not to work. The budget set ABC only applies to individuals who are currently receiving unemployment or welfare benefits. Individuals who have a job and who quit voluntarily do not receive unemployment benefits, so for them the budget constraint is ABO. Thus we treat individuals in the sample differently depending on whether they are currently receiving benefits or not. For those who do receive some kind of benefit we have simplified the budget set by assuming that their budget set is actually
ABO plus point C. So we effectively eliminate BC except for point C. As it is unlikely that individuals will choose a point on BC, this simplification is of no great consequence. The choice between point C and some optimal point on ABO requires explicit utility comparison, and that is what our model does for all individuals who receive currently some kind of benefit. Suppose the man in family k doesn't work and receives an unemployment compensation. We introduce a new variable

\[ V_k^m = U_{1k}^m - U_{0k}^m \]  

(5.1)

where \( U_{1k}^m \) := family utility if the man in family k works \( h_{mk} \) hours per week.

\( U_{0k}^m \) := family utility if the man in family k is unemployed and receives some kind of benefit.

If \( V_k^m > 0 \) the man prefers working to being unemployed and receiving some kind of benefit. A similar model is used for the female.

Calculation of \( U_{1k}^m \) and \( U_{0k}^m \) is somewhat tedious, since there is no explicit formula for the direct utility function of the Hausman-Ruud system available. Given a point \( h_{mk}, h_{fk} \) and total expenditures \( x_k \), we must find wages \( w_m, w_f \) and non-labor income \( u \) satisfying the two labor supply equations (2.1) and (2.2) and the budget-constraint:

\[ x = u + w_m h_m + w_f h_f \]  

(5.2)

Substitution into the indirect utility function yields the direct utility of the point \((h_{mk}^r, h_{fk}^r, u)\).

1) Details of the calculation can be found in Kapteyn, Kooreman, Van Soest (1986).
6. Estimation Results

Summarizing, we use the following model to explain the joint labor supply decision of both partners within a household:

\[
\begin{align*}
\hat{h}_{mk} &= \delta + \gamma w_{mk} + \alpha w_{fk} + \beta u_k, \\
\hat{h}_{fk} &= \delta + \gamma w_{fk} + \alpha w_{mk} + \beta u_k, \\
\hat{w}_{fk} &= \hat{w}_{fk} + \frac{1}{2} \left( \gamma w_{mk} + \gamma w_{fk} \right) + \alpha w_{mk} \hat{w}_{fk} + h_{fk}(\hat{w}_{fk} - \hat{w}_{mk}) \tag{6.3}
\end{align*}
\]

\[
\begin{align*}
\hat{v}_{mk} &= \hat{v}_{mk} + \theta + \delta w_{mk} + \delta w_{fk} + \frac{1}{2} \left( \gamma w_{mk} + \gamma w_{fk} \right) + \alpha w_{mk} \hat{w}_{fk} + h_{mk}(\hat{w}_{mk} - \hat{w}_{mk}) \tag{6.4}
\end{align*}
\]

\[
\begin{align*}
\hat{h}_{mk} &= \delta + \gamma w_{mk} + \alpha w_{fk} + \beta u_k, \\
\hat{h}_{fk} &= \delta + \gamma w_{fk} + \alpha w_{mk} + \beta u_k, \\
\hat{w}_{fk} &= \hat{w}_{fk} + \frac{1}{2} \left( \gamma w_{mk} + \gamma w_{fk} \right) + \alpha w_{mk} \hat{w}_{fk} + h_{fk}(\hat{w}_{fk} - \hat{w}_{mk}) \tag{6.6}
\end{align*}
\]

\[
\begin{align*}
\hat{v}_{mk} &= \hat{v}_{mk} + \theta + \delta w_{mk} + \delta w_{fk} + \frac{1}{2} \left( \gamma w_{mk} + \gamma w_{fk} \right) + \alpha w_{mk} \hat{w}_{fk} + h_{mk}(\hat{w}_{mk} - \hat{w}_{mk})
\end{align*}
\]

\[
\begin{align*}
\delta &= \delta + \pi_m \cdot f_{s_k} + \eta_m \cdot \left\{ \left[ \gamma_m \left( h_{mk}(-1) - \pi_m f_{s_k} \right) \right] + (1 - \gamma_m) \left[ (1 - \pi_m) \cdot f_{s_k} \right] \right\} \tag{6.7}
\end{align*}
\]

\[
\begin{align*}
\delta &= \delta + \pi_m \cdot f_{s_k} + \eta_m \cdot \left\{ \left[ \gamma_m \left( h_{mk}(-1) - \pi_m f_{s_k} \right) \right] + (1 - \gamma_m) \left[ (1 - \pi_m) \cdot f_{s_k} \right] \right\} \tag{6.8}
\end{align*}
\]
To make this an estimable model, a stochastic specification is added to the model.

For individuals who do not receive any kind of benefit:

\[
\begin{align*}
\tilde{h}_{mk}^p &= \tilde{h}_{mk}^r + \varepsilon_{mk} & \text{if } \tilde{h}_{mk}^r + \varepsilon_{mk} > 0 \\
&= 0 & \text{if } \tilde{h}_{mk}^r + \varepsilon_{mk} < 0
\end{align*}
\]

\[
\begin{align*}
\tilde{h}_{fk}^p &= \tilde{h}_{fk}^r + \varepsilon_{fk} & \text{if } \tilde{h}_{fk}^r + \varepsilon_{fk} > 0 \\
&= 0 & \text{if } \tilde{h}_{fk}^r + \varepsilon_{fk} < 0
\end{align*}
\]

\[
(\varepsilon_{mk}) \sim N \left( 0, \begin{pmatrix} \sigma_m^2 & \rho_{mf} \sigma_m \sigma_f \\ \rho_{mf} \sigma_m \sigma_f & \sigma_f^2 \end{pmatrix} \right)
\]

where \( h_{mk}^p \) and \( h_{fk}^p \) are observed preferred hours of man and woman and \( \varepsilon_{mk} \) and \( \varepsilon_{fk} \) are error terms.

For individuals who receive a benefit:

Define:

\[
\begin{align*}
V_{mk} &= U_{mk}^m - U_{mk}^m + v_{mk} \\
V_{fk} &= U_{mk}^f - U_{mk}^f + v_{fk}
\end{align*}
\]

\[
\begin{align*}
v_{mk} \sim N(0, \sigma_{vm}^2), & \quad v_{fk} \sim N(0, \sigma_{vf}^2)
\end{align*}
\]

\( v_{mk} \) is assumed uncorrelated with \( \varepsilon_{fk} \) and so is \( v_{fk} \) with \( \varepsilon_{mk} \).

\[
\begin{align*}
\tilde{h}_{mk}^p &= \tilde{h}_{mk}^r + \varepsilon_{mk} & \text{if } \tilde{h}_{mk}^r + \varepsilon_{mk} > 0 \text{ and } U_{mk}^m - U_{mk}^m + v_{mk} > 0 \\
&= 0 & \text{if } \tilde{h}_{mk}^r + \varepsilon_{mk} < 0 \text{ or } U_{mk}^m - U_{mk}^m + v_{mk} < 0
\end{align*}
\]

\[
\begin{align*}
\tilde{h}_{fk}^p &= \tilde{h}_{fk}^r + \varepsilon_{fk} & \text{if } \tilde{h}_{fk}^r + \varepsilon_{fk} > 0 \text{ and } U_{fk}^f - U_{fk}^f + v_{fk} > 0 \\
&= 0 & \text{if } \tilde{h}_{fk}^r + \varepsilon_{fk} < 0 \text{ or } U_{fk}^f - U_{fk}^f + v_{fk} < 0
\end{align*}
\]

The model has been estimated for data on 847 households from a labor mobility survey in The Netherlands which was held in 1985.
In table 6.1 the sample means of the main variables are presented, in table 6.2 some information is given on the composition of the sample.

As mentioned in section 3 the sample of individuals has been partitioned in social groups in which the individuals have identical characteristics. The characteristics considered are age and education level. (Four and five categories, respectively) In table 6.3 social group means of working hours 1 year lagged are presented. The main results of the maximum likelihood estimation of the model are presented in table 6.4.1) In appendix 4 more results are presented.

Table 6.1: Sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>mean in the subsample of working individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>male</strong></td>
<td></td>
</tr>
<tr>
<td>actual hours per week</td>
<td>42.23</td>
</tr>
<tr>
<td>actual hours per week, lagged 1 year</td>
<td>40.60</td>
</tr>
<tr>
<td>preferred hours per week</td>
<td>38.83</td>
</tr>
<tr>
<td>net wage rate2)</td>
<td>13.66</td>
</tr>
<tr>
<td><strong>female</strong></td>
<td></td>
</tr>
<tr>
<td>actual hours per week</td>
<td>27.38</td>
</tr>
<tr>
<td>actual hours per week, lagged 1 year</td>
<td>30.78</td>
</tr>
<tr>
<td>preferred hours per week</td>
<td>24.70</td>
</tr>
<tr>
<td>net wage rate</td>
<td>10.60</td>
</tr>
</tbody>
</table>

1) For the explicit form of the likelihood function, see Appendix 2.

2) This is based on predicted wage rates. In appendix 3 the wage equations used for prediction are given.
### Table 6.2: Sample composition

<table>
<thead>
<tr>
<th>female</th>
<th>male</th>
<th>no benefit</th>
<th>benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>working</td>
<td>not working, looking for a job</td>
<td>not working, not looking for a job</td>
</tr>
<tr>
<td>no benefit</td>
<td>working</td>
<td>314</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>not working, looking for a job</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>not working, not looking for a job</td>
<td>450</td>
<td>0</td>
</tr>
<tr>
<td>benefit</td>
<td>not working, looking for a job</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>not working, not looking for a job</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>799</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 6.3: Social group means b)

<table>
<thead>
<tr>
<th>education level a)</th>
<th>male</th>
<th>female</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.823</td>
<td>0.923</td>
</tr>
<tr>
<td></td>
<td>0.838</td>
<td>0.951</td>
</tr>
<tr>
<td></td>
<td>0.699</td>
<td>0.775</td>
</tr>
<tr>
<td></td>
<td>0.505</td>
<td>0.571</td>
</tr>
<tr>
<td>18-30</td>
<td>32.442</td>
<td>12.743</td>
</tr>
<tr>
<td></td>
<td>35.057</td>
<td>16.232</td>
</tr>
<tr>
<td></td>
<td>34.216</td>
<td>20.209</td>
</tr>
<tr>
<td></td>
<td>29.983</td>
<td>24.831</td>
</tr>
<tr>
<td>18-30</td>
<td>43</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>88</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>134</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>65</td>
</tr>
<tr>
<td>18-30</td>
<td>1.178</td>
<td>1.256</td>
</tr>
<tr>
<td></td>
<td>1.113</td>
<td>1.283</td>
</tr>
<tr>
<td></td>
<td>1.159</td>
<td>1.200</td>
</tr>
<tr>
<td></td>
<td>1.078</td>
<td>0.944</td>
</tr>
<tr>
<td>30-40</td>
<td>40.803</td>
<td>7.434</td>
</tr>
<tr>
<td></td>
<td>38.396</td>
<td>4.904</td>
</tr>
<tr>
<td></td>
<td>40.498</td>
<td>11.350</td>
</tr>
<tr>
<td></td>
<td>38.688</td>
<td>18.630</td>
</tr>
<tr>
<td>30-40</td>
<td>71</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>281</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>160</td>
<td>92</td>
</tr>
<tr>
<td>30-40</td>
<td>1.284</td>
<td>1.255</td>
</tr>
<tr>
<td></td>
<td>1.252</td>
<td>1.338</td>
</tr>
<tr>
<td></td>
<td>1.263</td>
<td>1.276</td>
</tr>
<tr>
<td></td>
<td>1.279</td>
<td>1.106</td>
</tr>
<tr>
<td>40-50</td>
<td>34.108</td>
<td>6.009</td>
</tr>
<tr>
<td></td>
<td>37.776</td>
<td>4.661</td>
</tr>
<tr>
<td></td>
<td>39.348</td>
<td>9.904</td>
</tr>
<tr>
<td></td>
<td>39.692</td>
<td>17.980</td>
</tr>
<tr>
<td>40-50</td>
<td>74</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>161</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>107</td>
<td>50</td>
</tr>
<tr>
<td>40-50</td>
<td>0.899</td>
<td>0.964</td>
</tr>
<tr>
<td></td>
<td>1.022</td>
<td>0.868</td>
</tr>
<tr>
<td></td>
<td>1.052</td>
<td>0.832</td>
</tr>
<tr>
<td></td>
<td>0.956</td>
<td>0.645</td>
</tr>
<tr>
<td>50-65</td>
<td>20.993</td>
<td>2.952</td>
</tr>
<tr>
<td></td>
<td>29.565</td>
<td>7.359</td>
</tr>
<tr>
<td></td>
<td>31.893</td>
<td>9.857</td>
</tr>
<tr>
<td></td>
<td>34.151</td>
<td>13.083</td>
</tr>
<tr>
<td>50-65</td>
<td>136</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>159</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>93</td>
<td>24</td>
</tr>
</tbody>
</table>

log (family size)

hours worked, 1 year lagged

number of individuals

a) Education has been coded in 5 levels ranging from 1 (lowest) till 5 (highest).
b) 3690 Individuals in households and single persons were used to form the social group means.
Table 6.4: Estimation Results$^{a, b}$

<table>
<thead>
<tr>
<th>parameters</th>
<th>extended model</th>
<th>basic model $\eta_m^<em>=\eta_f^</em>=0$ (no preference formation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.145* (0.003)</td>
<td>- 0.003 (0.008)</td>
</tr>
<tr>
<td>$\beta_m$</td>
<td>- 0.0008 (0.3 $10^{-5}$)</td>
<td>- 0.0015* (0.3 $10^{-5}$)</td>
</tr>
<tr>
<td>$\beta_f$</td>
<td>- 0.0027* (0.7 $10^{-5}$)</td>
<td>- 0.0002* (0.1 $10^{-4}$)</td>
</tr>
<tr>
<td>$\gamma_m$</td>
<td>0.106* (0.006)</td>
<td>0.312* (0.015)</td>
</tr>
<tr>
<td>$\gamma_f$</td>
<td>1.27* (0.05)</td>
<td>2.16* (0.08)</td>
</tr>
<tr>
<td>$\gamma_m^*$</td>
<td>2.21</td>
<td>1.1* (0.2)</td>
</tr>
<tr>
<td>$\gamma_f^*$</td>
<td>-1033* (30.1)</td>
<td>- 40.6* (0.7)</td>
</tr>
<tr>
<td>$\delta_m^0$</td>
<td>80.9* (0.2)</td>
<td>129.7* (0.2)</td>
</tr>
<tr>
<td>$\delta_f^0$</td>
<td>180.3* (0.5)</td>
<td>35.0* (0.9)</td>
</tr>
<tr>
<td>$\theta$</td>
<td>71087* (147)</td>
<td>62565* (148.0)</td>
</tr>
<tr>
<td>$\eta_{mm}$</td>
<td>0.210* (0.006)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\eta_{ff}$</td>
<td>0.9976* (0.005)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\eta_{mf}$</td>
<td>0.13* (0.02)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\eta_{m2}$</td>
<td>0 (l.b)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\eta_{f1}$</td>
<td>1 (u.b)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\eta_f^*$</td>
<td>0.993* (0.002)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\lambda_{mm}$</td>
<td>-</td>
<td>- 0</td>
</tr>
<tr>
<td>$\lambda_{ff}$</td>
<td>0.98 (0.89)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\lambda_{mf}$</td>
<td>0.53 (0.48)</td>
<td>- 0</td>
</tr>
<tr>
<td>$\lambda_{fm}$</td>
<td>-</td>
<td>- 0</td>
</tr>
<tr>
<td>$\sigma_m$</td>
<td>6.00* (0.08)</td>
<td>6.33* (0.07)</td>
</tr>
<tr>
<td>$\sigma_f$</td>
<td>12.7* (0.3)</td>
<td>21.7* (0.9)</td>
</tr>
<tr>
<td>$\sigma_{vm}$</td>
<td>7069 (1075)</td>
<td>2616* (590)</td>
</tr>
<tr>
<td>$\sigma_{vf}$</td>
<td>4708 (9393)</td>
<td>3209 (33575)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>- 0.07* (0.04)</td>
<td>- 0.08* (0.04)</td>
</tr>
</tbody>
</table>

Log likelihood: -4114.07 $\quad$ -4400.65

a) It is not possible to identify the parameter $\kappa$. We have assumed it to be equal to 0.5.

b) * := absolute $t$ value $> 1.6$
Standard errors in parentheses.
Both columns of table 6.4 show negative income effects, implying leisure to be a normal good, and positive own linear wage effects. Moreover we see that in both models family size has a positive effect on the male's labor supply and a negative on the female's. The huge value of $\pi_f (-1033.65)$ in the extended model is due to the fact that $\pi_f$ is close to 1. In fact the coefficient for (log) family size is $\pi_f (1-\eta_{ff} \zeta_f) = -9.69$ (See Appendix 1). This means that if a family of 2 is extended to three persons, the wife works 4 hours less per week, ceteris paribus. A second child reduces the wife's working hours with 3 more hours per week.

In the basic model the first child reduces the number of working hours of the wife by 16, the second child by 12 additional hours.

Male labor supply appears to be less influenced by preference formation than female labor supply ($\eta_{mm}$ and $\eta_{mf}$ together are less than $\eta_{ff}$ and $\eta_{fm}$ together). Furthermore men not only seem to refer to men but also to women, whereas women do not seem to refer to men. For both male and female the importance of habit formation relative to preference interdependence is overwhelming ($\zeta_m = 1$, $\zeta_f = 0.9931$). As there is no preference interdependence between males ($\zeta_m = 1$) $\lambda_{mm}$ is unidentified. Likewise because women do not refer to men $\lambda_{fm}$ is unidentified. A high $\lambda_{ff}$ (0.9790) means that a female's social group mainly consists of women of their own age and education, and hardly of any women of the same age and education as their husband. A value of $\lambda_{mf}$ of about $\frac{1}{2}$ implies that men refer to women of their own age and education as well as to women of the same age and education as their wives. Table 6.5 summarizes the "total" influence of habit formation and preference interdependence on the parameters $\delta_{mk}$ and $\delta_{fk}$.

1) These numbers are invariant to the (arbitrary) choice of the unidentified parameters $\kappa_m$ and $\kappa_f$. 
Table 6.5: "Total influence of habit formation and preference interdependence"

<table>
<thead>
<tr>
<th>Influence on</th>
<th>$\delta_{mk}$</th>
<th>$\delta_{fk}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h_{mk}(-1)$ own lagged hours (male)</td>
<td>0.2103</td>
<td>-</td>
</tr>
<tr>
<td>$h_{fk}(-1)$ own lagged hours (female)</td>
<td>-</td>
<td>0.9907</td>
</tr>
<tr>
<td>$\bar{h}_{mmk}(-1)$ s.g. mean of male hours in s.g. of male</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$\bar{h}_{ffk}(-1)$ s.g. mean of female hours in s.g. of female</td>
<td>0.0307</td>
<td>0.0034</td>
</tr>
<tr>
<td>$\bar{h}_{mfk}(-1)$ s.g. mean of female hours in s.g. of male partner</td>
<td>0.0343</td>
<td>0</td>
</tr>
<tr>
<td>$\bar{h}_{fmk}(-1)$ s.g. mean of male hours in s.g. of female partner</td>
<td>0</td>
<td>0.0001</td>
</tr>
<tr>
<td>$\bar{h}_m(-1)$ population mean of male hours</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$\bar{h}_f(-1)$ population mean of female hours</td>
<td>0.0650</td>
<td>0.0034</td>
</tr>
</tbody>
</table>

In appendix 4 more estimation results are presented for various alternative specifications of the model. These shed light on the robustness of the results discussed so far. Hence we have a brief look at them. From the first two columns in table A4.1 can be concluded that the $\lambda$'s are hardly identified. (Different values of $\lambda$'s lead to almost the same estimation results.) For that reason we take the $\lambda$'s fixed from now on. Column 3 and 4 show that the hypotheses $\eta_{mf} = 0$ and $\eta_{fm} = 0$ can be rejected at the 0.5% level. The hypotheses of no habit formation ($\tau_m = \tau_f = 0$) is even more decisively rejected (column 5).

We re-estimated the model without the assumption of rationing, thus deleting a possible endogeneity problem. The problem arises if actual hours (that appear in the shadow wages) depend on preferred hours.

In that case male preferred hours depend on female actual hours (via the shadow wage (cf. Kapteyn, Kooreman, van Soest (1986))). And female actual hours may depend on female preferred hours. That generates a system of simultaneous equations. In the model summarized in equations (6.1) - (6.10.b) we have assumed that actual hours do not depend on preferred hours although they may depend on lagged preferred hours. Comparison of the first 2 columns of table A4.2. and the second 2 columns yields almost identical estimation results. This suggests that the potential en-
dogeneity problem is not serious. It also suggests that rationing is not an important problem.

We also estimated the model using only a subsample of 796 individuals who are not receiving any benefits. The results are shown in the first 2 columns of table A4.2. It appears that the results hardly differ from the results based on the total sample.

In the last 2 columns of this table results are presented of the estimation with actual hours as the endogeneous variable instead of preferred hours and without application of rationing theory. Although we realize that there might be noise in the data on preferred hours due to interpretation problems, we feel that preferred hours is the appropriate variable in a model that describes the supply side of the labor market. Actual hours are generally the result of the interplay of the supply side and the demand side of the labor market. For the basic model the 2 versions do not differ very much. Looking at the values of the log-likelihood it seems that preferred hours are explained somewhat better by the model than actual hours. However, since the 2 versions are not nested, no inference can be made from this difference in the values of the log likelihood. In the extended model especially the parameters corresponding to preference formation differ quite a bit. But also the wage and income coefficients are smaller in the actual hours version than in the preferred hours version. The obvious explanation for this is that actual hours are largely determined by institutional constraints. Here too, the version with preferred hours yields a higher value of the log-likelihood than the actual hours version.

Overall, the fit of the model, measured by the standard-deviation of the residuals and the value of the log-likelihood, improves significantly by adding preference interdependence and habit formation to the model.

In figures 6.1 and 6.2 labor supply curves of male and female are drawn.
Figure 6.1 Labor supply curves
basic model

- short term
--- long term

Figure 6.2 Labor supply curves
The labor supply curves in figure 6.1 and 6.2 are drawn for a family without children. We distinguish between short term supply curves (the partner is rationed at his/her actual number of hours) and long term supply curves (the partner is not rationed and the model has converged to an equilibrium state).

Figure 6.1 shows a very flat male labor supply curve and there is hardly any difference between the short and the long term. Due to the positive cross wage effect men want to work more hours the higher the wife's wage rate. Both the wife's short term and long term labor supply curve is forward bending, which means that the positive own wage effect dominates the negative income effect. The kink in the long term curve is caused by the fact that at wage rate increases until a wage rate of 20 quite a lot women start working a few hours. The long term supply curve is steeper than the short term due to interdependence of preferences and habit formation.

Figure 6.2 shows labor supply curves from the basic model. In this case the short term and the long term curves coincide because there is no preference formation. Once again we see a steep female labor supply curve and a flat male labor supply curve. Also cross wage effects are small.
Conclusions

It is encouraging to find that our extended model explains household labor supply significantly better than the standard model. Although the lack of strong preference interdependence was surprising, considering other empirical studies. (cf. Kapteyn e.a. (1984), Kapteyn and Alessie (1986)) In the model with preference formation short term wage effects are small, but long term effects are larger. This implies that for policy purposes considerable attention should be given to the timing of policy measures.

There are a few important limitations to this study that deserve attention. First the simple way in which dynamics in behavior is incorporated needs to be improved. This can only be done when panel data are available. Secondly the stochastic specification of the supply equations needs improvement, because random preferences are ruled out by our specification (See Kapteyn, Kooreman, Van Soest (1986)). It would be of interest to extend the model with random preferences. Despite these shortcomings the empirical results so far suggest it to be worthwhile to take social psychological variables into account when analyzing labor supply behavior.
Appendix 1: Identification of the model

As mentioned in section 3 the model without preference formation is (over)identified. Thus it is sufficient to examine the delta-equations (3.21) - (3.22) for identification of the model with preference formation.

Table A1.1 presents equation (3.21) - (3.22) in a slightly different form. From this table we infer there are 18 reduced-form parameters \((a_1 - a_{18})\) and 16 structural parameters, namely: \(\eta_{mm}, \eta_{ff'}, \eta_{mf}, \eta_{fm}, \lambda_{mm}, \lambda_{ff'}, \lambda_{mf}, \lambda_{fm}, \zeta_{m}, \zeta_{f}, \kappa_{m}, \kappa_{f}, \pi_{m}, \pi_{f}, \delta_{m0}, \delta_{f0}\). It is easy to see that from \(a_1\) and \(a_6\) \(\pi_{m}\) can be identified, and likewise from \(a_{10}\) and \(a_{15}\). From \(a_2\) and \(a_4\) \(\lambda_{mm}\) can be identified, from \(a_3\) and \(a_5\) \(\lambda_{mf}\), from \(a_{11}\) and \(a_{13}\) \(\lambda_{fm}\) and from \(a_{12}\) and \(a_{14}\) \(\lambda_{ff'}\). This leaves us with 12 equations \((a_1, a_2 + a_4, a_3 + a_5, a_7, a_8, a_9, a_{10}, a_{11} + a_{13}, a_{12} + a_{14}, a_{16}, a_{17}, a_{18})\) to identify 10 parameters \((\eta_{mm}, \eta_{ff'}, \eta_{mf}, \eta_{fm}, \lambda_{mm}, \lambda_{mf}, \lambda_{fm}, \lambda_{ff'}, \zeta_{m}, \zeta_{f}, \kappa_{m}, \kappa_{f})\).

The equations \(a_7\) and \(a_8\) do not yield independent identifying information, and neither do the equations \(a_{16}\) and \(a_{17}\). For these equations can be written as follows:

\[
a_7 = -a_{2} \cdot \pi_{m} - a_5 \cdot \pi_{f} \tag{A1.1}
\]

\[
a_8 = -a_{4} \cdot \pi_{m} - a_3 \cdot \pi_{f} \tag{A1.2}
\]

\[
a_{16} = -a_{14} \cdot \pi_{f} - a_{11} \cdot \pi_{m} \tag{A1.3}
\]

\[
a_{17} = -a_{12} \cdot \pi_{f} - a_{13} \cdot \pi_{m} \tag{A1.4}
\]

In fact we have only 8 independent equations \((a_1, a_2 + a_4, a_3 + a_5, a_9, a_{10}, a_{11} + a_{13}, a_{12} + a_{14}, a_{18})\) to identify 10 parameters. If 2 parameters are fixed, the remaining 8 parameters are identified.\(^1\) Overall it is necessary to fix only 2 parameters to identify the extended model.

\(^1\) Special combinations of fixed parameters still cause problems (for example fixed \(\eta_{mm}\) and \(\zeta_{m}\)).
Table A1.1: The delta-equations

<table>
<thead>
<tr>
<th>dependent variables</th>
<th>( \delta_m )</th>
<th>independent variables</th>
<th>( \delta_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \eta_{mn} )</td>
<td>( h_{mk}(-1) )</td>
<td>( a_1 )</td>
</tr>
<tr>
<td>( h_{fk}(-1) )</td>
<td>( \eta_{mf} )</td>
<td>( h_{ffk}(-1) )</td>
<td>( \eta_{fff} )</td>
</tr>
<tr>
<td>( h_{mmk}(-1) )</td>
<td>( \eta_{nm} (1-\zeta_m)(1-\kappa_m) ) ( \lambda_{mm} )</td>
<td>( h_{fmk}(-1) )</td>
<td>( \eta_{m} (1-\kappa_{m}) \lambda )</td>
</tr>
<tr>
<td>( h_{ffkmk}(-1) )</td>
<td>( \eta_{nmf} (1-\kappa_f)(1-\lambda_{mf}) )</td>
<td>( h_{mfk}(-1) )</td>
<td>( \eta_{ff}(1-\zeta_f)(1-\kappa_f)(1-\lambda_{ff}) )</td>
</tr>
<tr>
<td>( f_{sk} )</td>
<td>( \pi_{m} (1-\eta_{\zeta}) )</td>
<td>( f_{sk} )</td>
<td>( \pi_{f} (1-\eta_{\zeta}) )</td>
</tr>
<tr>
<td>( \bar{f}_{mk} )</td>
<td>( -\eta_{nm} (1-\zeta_m)(1-\kappa_m) \lambda_{m} \mu - \eta_{mf} (1-\kappa_{m}) \lambda_{m} \mu )</td>
<td>( \bar{f}_{fmk} )</td>
<td>( -\eta_{m} (1-\kappa_{m}) \lambda \mu - \eta_{m} (1-\kappa_{m}) \lambda \mu )</td>
</tr>
<tr>
<td>( \bar{f}_{fs} )</td>
<td>( -\eta_{nm} (1-\zeta_m)(1-\kappa_m) \lambda_{m} \mu - \eta_{mf} (1-\kappa_{m}) \lambda_{m} \mu )</td>
<td>( \bar{f}_{fs} )</td>
<td>( -\eta_{m} (1-\kappa_{m}) \lambda \mu - \eta_{m} (1-\kappa_{m}) \lambda \mu )</td>
</tr>
<tr>
<td>constant term</td>
<td>( \delta_{0} + \eta_{nm} (1-\zeta_m)(1-\kappa_m) \lambda_{m} \mu - \eta_{mf} (1-\kappa_{m}) \lambda_{m} \mu )</td>
<td>( \delta_{f0} + \eta_{m} (1-\kappa_{m}) \lambda \mu - \eta_{m} (1-\kappa_{m}) \lambda \mu )</td>
<td></td>
</tr>
</tbody>
</table>

For explanation of the variables, see paragraph 3.
Appendix 2: Likelihood contributions

The likelihood function consists of different parts \((L_k)\) corresponding with the different situations households are in. Let \(\Phi\) and \(\phi\) be the standard normal distribution function and density function respectively. Let \(B\Phi\) and \(b\phi\) be the bivariate standard normal distribution function and density function, respectively.

We distinguish the following situations: (where \(i\) stands for \(m(ale)\) or \(f(emale)\))

1) \(h_{ik}^p > 0, h_{jk}^p > 0, \text{unbef}_{ik} = 0^1, \text{unbef}_{jk} = 0\)

\[
L_k^1 = \frac{1}{\sigma_i \cdot \sigma_j \cdot \sqrt{1-\rho^2}} \cdot b\phi\left(\frac{h_{ik}^p - \tilde{h}_{ik}^r}{\sigma_i}, \frac{h_{jk}^p - \tilde{h}_{jk}^r}{\sigma_j}\right)
\]

2) \(h_{ik}^p = 0, h_{jk}^p > 0, \text{unbef}_{ik} = 0, \text{unbef}_{jk} = 0\)

a) \(ik\) is not seriously looking for a job:

\[
L_k^2 = \phi\left[\frac{-h_{ik}^p}{\sigma_i \sqrt{1-\rho^2}} - \frac{\rho(h_{jk}^p - \tilde{h}_{jk}^r)}{\sigma_j \sqrt{1-\rho^2}}\right] \cdot \frac{1}{\sigma_j} b\phi\left(\frac{-h_{ik}^p}{\sigma_i}, \frac{h_{jk}^p - \tilde{h}_{jk}^r}{\sigma_j}\right)
\]

b) \(ik\) is seriously looking for a job:

\[
L_k^2 = \{1-\phi\left[\frac{-h_{ik}^p}{\sigma_i \sqrt{1-\rho^2}} - \frac{\rho(h_{jk}^p - \tilde{h}_{jk}^r)}{\sigma_j \sqrt{1-\rho^2}}\right]\} \cdot \frac{1}{\sigma_j} b\phi\left(\frac{-h_{ik}^p}{\sigma_i}, \frac{h_{jk}^p - \tilde{h}_{jk}^r}{\sigma_j}\right)
\]

3) In the sample none of the households consist of two non-working individuals, both without an unemployment benefit. Therefore specification of the likelihood contribution in this situation is omitted.

1) \(\text{Unbef}_{ik} := \text{unemployment benefit of the male or female in household } k.\)
4) \( h_{ik}^p = 0, h_{jk}^p > 0, \text{unbef}_{ik} > 0, \text{unbef}_{jk} = 0 \)

a) \( \text{ik is not seriously looking for a job:} \)

\[
L_k^4 = \left\{ 1 - \left[ 1 - \phi \left( \frac{h_{ik}^p}{\sigma_i \sqrt{1 - \rho^2}} - \frac{\rho (h_{jk}^p - \tilde{h}_{jk}^r)}{\sigma_j \sqrt{1 - \rho^2}} \right) \right] \cdot \left[ \phi \left( -\frac{(U^i_{1k} - U^i_{0k})}{\sigma_v} \right) \right] \right\} \\
\frac{1}{\sigma_j} \phi \left( \frac{h_{jk}^p - \tilde{h}_{jk}^r}{\sigma_j} \right)
\]

b) \( \text{ik is seriously looking for a job:} \)

\[
L_k^4 = \left\{ 1 - \phi \left( \frac{h_{ik}^p}{\sigma_i \sqrt{1 - \rho^2}} - \frac{\rho (h_{jk}^p - \tilde{h}_{jk}^r)}{\sigma_j \sqrt{1 - \rho^2}} \right) \right\} \cdot \left[ \phi \left( \frac{(U^i_{1k} - U^i_{0k})}{\sigma_v} \right) \right] \\
\frac{1}{\sigma_j} \phi \left( \frac{h_{jk}^p - \tilde{h}_{jk}^r}{\sigma_j} \right)
\]

5) \( h_{ik}^p = 0, h_{jk}^p = 0, \text{unbef}_{ik} > 0, \text{unbef}_{jk} = 0 \)

a) both \( \text{ik} \) and \( \text{jk} \) are seriously looking for a job:

\[
L_k^5 = B \phi \left[ \frac{\tilde{h}_{ik}^r}{\sigma_i \sqrt{1 - \rho^2}}, \frac{\tilde{h}_{jk}^r}{\sigma_j \sqrt{1 - \rho^2}} \right] \cdot \phi \left[ \frac{(U^i_{1k} - U^i_{0k})}{\sigma_v} \right]
\]

b) \( \text{ik} \) is seriously looking for a job, \( \text{jk} \) is \text{not}:

\[
L_k^5 = B \phi \left[ \frac{\tilde{h}_{ik}^r}{\sigma_i \sqrt{1 - \rho^2}}, -\frac{\tilde{h}_{jk}^r}{\sigma_j \sqrt{1 - \rho^2}} \right] \cdot \phi \left[ \frac{(U^i_{1k} - U^i_{0k})}{\sigma_v} \right]
\]

A situation in which \( \text{ik is not seriously looking for a job} \) doesn't exist.
6) \(h^p_{ik} = 0, \ h^p_{jk} = 0, \ \text{unbef}_{ik} > 0, \ \text{unbef}_{jk} > 0\)

a) both \(ik\) and \(jk\) are seriously looking for a job:

\[
L_k^6 = B \Phi \left[ \frac{h^r_{ik}}{\sigma_i \sqrt{1 - \rho^2}}, \frac{h^r_{jk}}{\sigma_j \sqrt{1 - \rho^2}} \right] \cdot \Phi \left[ \frac{U^i_{ik} - U^i_{Ok}}{\sigma_i} \right] \cdot \Phi \left[ \frac{U^j_{ik} - U^j_{Ok}}{\sigma_j} \right]
\]

b) \(ik\) is seriously looking for a job, \(jk\) is not:

\[
L_k^6 = B \Phi \left[ \frac{h^r_{ik}}{\sigma_i \sqrt{1 - \rho^2}}, - \frac{h^r_{jk}}{\sigma_j \sqrt{1 - \rho^2}} \right] \cdot \Phi \left[ \frac{U^i_{ik} - U^i_{Ok}}{\sigma_i} \right] + B \Phi \left[ \frac{h^r_{ik}}{\sigma_i \sqrt{1 - \rho^2}}, \frac{h^r_{jk}}{\sigma_j \sqrt{1 - \rho^2}} \right] \cdot \Phi \left[ \frac{U^i_{ik} - U^i_{Ok}}{\sigma_i} \right] \cdot \Phi \left[ \frac{U^j_{ik} - U^j_{Ok}}{\sigma_j} \right]
\]
Appendix 3: Wage equations

In our dataset not only actual net wage rates for working individuals are available, but also expected net wage rates for non-working individuals. We assume that for non-working individuals the expected net wage rate is the appropriate variable for the explanation of the labor supply decisions. Thus we estimate for each level of education (log)wage equations for both workers and non-workers together, with the log of family size, the log of age and the squared log of age as explanatory variables. Estimation results are presented in Table A3.1.

For purpose of comparison we also estimated wage-equations using data on workers only. We corrected for selection-bias. (Heckman (1979)). In tables A3.2 and A3.3 the participation-equations and wage equations are presented.
Table A3.1: Wage-equations$^a), b)$

### Log wage-equation for men

<table>
<thead>
<tr>
<th>Level of education</th>
<th>Constant</th>
<th>log(age)</th>
<th>$[\log(\text{age})]^2$</th>
<th>Number of observations</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- 9.34</td>
<td>6.40</td>
<td>- 0.86</td>
<td>290</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(2.31)</td>
<td>(1.29)</td>
<td>(0.18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>- 12.60</td>
<td>8.12</td>
<td>- 1.08</td>
<td>340</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>(2.06)</td>
<td>(1.17)</td>
<td>(0.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>- 7.72</td>
<td>5.30</td>
<td>- 0.67</td>
<td>656</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(1.94)</td>
<td>(1.08)</td>
<td>(0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>- 6.01</td>
<td>4.27</td>
<td>- 0.52</td>
<td>385</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(2.75)</td>
<td>(1.53)</td>
<td>(0.21)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Log wage-equation for women

<table>
<thead>
<tr>
<th>Level of education</th>
<th>Constant</th>
<th>log(age)</th>
<th>$[\log(\text{age})]^2$</th>
<th>Number of observations</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- 6.11</td>
<td>4.46</td>
<td>- 0.59</td>
<td>250</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(2.30)</td>
<td>(1.31)</td>
<td>(0.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>- 10.46</td>
<td>7.04</td>
<td>- 0.96</td>
<td>280</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>(2.28)</td>
<td>(1.31)</td>
<td>(0.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>- 8.41</td>
<td>5.85</td>
<td>- 0.78</td>
<td>540</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>(1.79)</td>
<td>(1.03)</td>
<td>(0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>- 7.98</td>
<td>5.65</td>
<td>- 0.75</td>
<td>194</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(4.11)</td>
<td>(2.31)</td>
<td>(0.32)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a)$ Standard errors in parentheses

$^b)$ 1 is the lowest level of education
Table A3.2: Participation-equations\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>constant</th>
<th>log(age)</th>
<th>\text{[log(age)]}^2</th>
<th>number of children younger than 6</th>
<th>log likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>men</strong></td>
<td>-2.1</td>
<td>0.20</td>
<td>-0.0030</td>
<td></td>
<td>-7.66</td>
</tr>
<tr>
<td></td>
<td>(0.4)</td>
<td>(0.02)</td>
<td>(0.0002)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>women</strong></td>
<td>1.4</td>
<td>-0.04</td>
<td>-0.00002</td>
<td>-0.55</td>
<td>-11.69</td>
</tr>
<tr>
<td></td>
<td>(0.3)</td>
<td>(0.02)</td>
<td>(0.0002)</td>
<td>(0.04)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Standard errors in parentheses.
Table A3.3: Wage-equations\(^a,b)\)

**log wage-equation for men**

<table>
<thead>
<tr>
<th>level of education</th>
<th>constant</th>
<th>log(age)</th>
<th>([\text{log(age)}]^2)</th>
<th>(\lambda_1^c))</th>
<th>(R^2)</th>
<th>number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-13.87</td>
<td>9.02</td>
<td>-1.24</td>
<td>0.25</td>
<td>0.115</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>(6.23)</td>
<td>(3.56)</td>
<td>(0.51)</td>
<td>(0.29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-21.05</td>
<td>12.96</td>
<td>-1.77</td>
<td>0.41</td>
<td>0.289</td>
<td>292</td>
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<td></td>
<td>(5.46)</td>
<td>(3.14)</td>
<td>(0.45)</td>
<td>(0.27)</td>
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</tr>
<tr>
<td>3</td>
<td>-16.34</td>
<td>10.24</td>
<td>-1.38</td>
<td>0.51</td>
<td>0.151</td>
<td>574</td>
</tr>
<tr>
<td></td>
<td>(5.71)</td>
<td>(3.24)</td>
<td>(0.46)</td>
<td>(0.29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-20.20</td>
<td>12.11</td>
<td>-1.59</td>
<td>0.26</td>
<td>0.261</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>(7.75)</td>
<td>(4.37)</td>
<td>(0.62)</td>
<td>(0.32)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**log wage-equation for women**

<table>
<thead>
<tr>
<th>level of education</th>
<th>constant</th>
<th>log(age)</th>
<th>([\text{log(age)}]^2)</th>
<th>(\lambda_1^c))</th>
<th>(R^2)</th>
<th>number of observations</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>8.21</td>
<td>5.81</td>
<td>-0.80</td>
<td>0.14</td>
<td>0.117</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>(3.40)</td>
<td>(1.95)</td>
<td>(0.28)</td>
<td>(0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-18.01</td>
<td>11.50</td>
<td>-1.62</td>
<td>0.14</td>
<td>0.302</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>(3.23)</td>
<td>(1.88)</td>
<td>(0.27)</td>
<td>(0.19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-8.59</td>
<td>6.00</td>
<td>-0.82</td>
<td>0.17</td>
<td>0.191</td>
<td>327</td>
</tr>
<tr>
<td></td>
<td>(2.57)</td>
<td>(1.49)</td>
<td>(0.21)</td>
<td>(0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-7.73</td>
<td>5.74</td>
<td>-0.81</td>
<td>0.41</td>
<td>0.149</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>(5.63)</td>
<td>(3.19)</td>
<td>(0.44)</td>
<td>(0.13)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Standard errors in parentheses
\(^b\) 1 is the lowest level of education
\(^c\) See Heckman (1976)
Appendix 4: Estimation Results

Table A4.1: Estimation results for the extended model\(^{a)}\)

<table>
<thead>
<tr>
<th>(\lambda)'s fixed</th>
<th>(\lambda)'s fixed, (\eta_{mf} = \eta_{fm} = 0)</th>
<th>(\lambda)'s fixed, (\eta_{mf} = \eta_{fm} = 0)</th>
<th>no habit formation</th>
<th>wage predictions on actual wages only</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\lambda_{mm})</td>
<td>(\lambda_{ff})</td>
<td>(\lambda_{mm})</td>
<td>(\lambda_{ff})</td>
<td>(\lambda_{mm})</td>
</tr>
<tr>
<td>(\lambda_{mf})</td>
<td>(\lambda_{fm})</td>
<td>(\lambda_{mf})</td>
<td>(\lambda_{fm})</td>
<td>(\lambda_{mf})</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>0.1507</td>
<td>0.1515</td>
<td>0.0597</td>
<td>0.0597</td>
</tr>
<tr>
<td>(\beta_m)</td>
<td>-0.0008</td>
<td>-0.0008</td>
<td>-0.0015</td>
<td>-0.0015</td>
</tr>
<tr>
<td>(\beta_f)</td>
<td>-0.0027</td>
<td>-0.0027</td>
<td>-0.0009</td>
<td>-0.0009</td>
</tr>
<tr>
<td>(\gamma_m)</td>
<td>0.1048</td>
<td>0.1062</td>
<td>0.2985</td>
<td>0.3031</td>
</tr>
<tr>
<td>(\gamma_f)</td>
<td>1.2844</td>
<td>1.2832</td>
<td>1.0754</td>
<td>1.0744</td>
</tr>
<tr>
<td>(\pi_m)</td>
<td>2.2085</td>
<td>2.2085</td>
<td>1.0890</td>
<td>1.0370</td>
</tr>
<tr>
<td>(\pi_f)</td>
<td>-1035.01</td>
<td>-1033.90</td>
<td>-855.73</td>
<td>-793.50</td>
</tr>
<tr>
<td>(\delta_{m0})</td>
<td>80.81</td>
<td>80.47</td>
<td>123.31</td>
<td>124.12</td>
</tr>
<tr>
<td>(\delta_{f0})</td>
<td>178.50</td>
<td>178.80</td>
<td>37.67</td>
<td>37.74</td>
</tr>
<tr>
<td>(\theta)</td>
<td>72654.90</td>
<td>72869.95</td>
<td>65149.11</td>
<td>66099.29</td>
</tr>
<tr>
<td>(\eta_{mm})</td>
<td>0.2073</td>
<td>0.2100</td>
<td>0.2013</td>
<td>0.2249</td>
</tr>
<tr>
<td>(\eta_{ff})</td>
<td>1 (u.b.)</td>
<td>1 (u.b.)</td>
<td>1 (u.b.)</td>
<td>1 (u.b.)</td>
</tr>
<tr>
<td>(\eta_{mf})</td>
<td>0.2051</td>
<td>0.2579</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\eta_{fm})</td>
<td>0.0024</td>
<td>0.0025</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\xi_m)</td>
<td>1 (u.b.)</td>
<td>1 (u.b.)</td>
<td>1 (u.b.)</td>
<td>0.8917</td>
</tr>
<tr>
<td>(\xi_f)</td>
<td>0.9909</td>
<td>0.9911</td>
<td>0.9889</td>
<td>0.9885</td>
</tr>
<tr>
<td>(\lambda_{mm})</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>(\lambda_{ff})</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(\lambda_{mf})</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(\lambda_{fm})</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(\sigma_m)</td>
<td>6.01</td>
<td>6.00</td>
<td>6.05</td>
<td>6.05</td>
</tr>
<tr>
<td>(\sigma_f)</td>
<td>12.58</td>
<td>12.64</td>
<td>12.82</td>
<td>12.82</td>
</tr>
<tr>
<td>(\sigma_{vm})</td>
<td>7071.00</td>
<td>7070.12</td>
<td>2548.67</td>
<td>2385.77</td>
</tr>
<tr>
<td>(\sigma_{vf})</td>
<td>4711.57</td>
<td>4712.37</td>
<td>2408.12</td>
<td>2230.02</td>
</tr>
<tr>
<td>(\rho)</td>
<td>-0.0738</td>
<td>-0.0727</td>
<td>-0.0325</td>
<td>-0.0269</td>
</tr>
<tr>
<td>(\log likelihood)</td>
<td>-4115.46</td>
<td>-4115.01</td>
<td>-4127.19</td>
<td>-4126.13</td>
</tr>
</tbody>
</table>

\(^{a)}\) u.b.: upper bound, l.b.: lower bound
Table A4.2. Estimation results for the basic and the extended model and receivers of any benefits are omitted

without rationing

<table>
<thead>
<tr>
<th>basic model</th>
<th>extended model</th>
<th>endogeneous variable: preferred hours</th>
<th>endogeneous variable: actual hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>-0.0314</td>
<td>0.0485</td>
<td>-0.0003</td>
</tr>
<tr>
<td>( \beta_m )</td>
<td>-0.0015</td>
<td>-0.0015</td>
<td>-0.0015</td>
</tr>
<tr>
<td>( \beta_f )</td>
<td>-0.0002</td>
<td>-0.0008</td>
<td>-0.0002</td>
</tr>
<tr>
<td>( \gamma_m )</td>
<td>0.3121</td>
<td>0.3160</td>
<td>0.3100</td>
</tr>
<tr>
<td>( \gamma_f )</td>
<td>2.3574</td>
<td>0.9048</td>
<td>2.2941</td>
</tr>
<tr>
<td>( \eta_m )</td>
<td>1.2586</td>
<td>1.1914</td>
<td>1.3765</td>
</tr>
<tr>
<td>( \pi_f )</td>
<td>-41.18</td>
<td>-817.94</td>
<td>-41.03</td>
</tr>
<tr>
<td>( \delta_{m0} )</td>
<td>129.74</td>
<td>127.26</td>
<td>129.43</td>
</tr>
<tr>
<td>( \delta_{f0} )</td>
<td>35.88</td>
<td>36.27</td>
<td>35.36</td>
</tr>
<tr>
<td>( \theta )</td>
<td>62379.26</td>
<td>67065.42</td>
<td>62563.23</td>
</tr>
</tbody>
</table>

| \( \eta_{mm} \) | 0 | 0.2116 | 0 | 0.2125 | 0 | 0.6183 |
| \( \eta_{ff} \) | 0 | 1 (u.b.) | 0 | 1 (u.b.) | 0 | 1 (u.b.) |
| \( \eta_{mf} \) | 0 | 0 | 0 | 0 | 0 | 0 |
| \( \eta_{fm} \) | 0 | 0 | 0 | 0 | 0 | 0 |
| \( \xi_m \) | - | - | 1 (u.b.) | 1 (u.b.) | - | 0.5722 |
| \( \xi_f \) | - | 0.9889 | - | 0.9896 | - | 0.9962 |
| \( \lambda_{mm} \) | - | - | - | - | - | 1 |
| \( \lambda_{ff} \) | - | 1 | - | 1 | - | 1 |
| \( \lambda_{mf} \) | - | - | - | - | - | - |
| \( \lambda_{fm} \) | - | - | - | - | - | - |
| \( \sigma_m \) | 6.30 | 6.04 | 6.32 | 6.04 | 6.91 | 6.19 |
| \( \sigma_f \) | 21.28 | 12.78 | 21.29 | 12.87 | 23.66 | 12.43 |
| \( \sigma_{vm} \) | - | - | - | - | - | - |
| \( \sigma_{vf} \) | - | - | - | - | - | - |
| \( \rho \) | -0.0279 | -0.0135 | -0.0865 | -0.0726 | 0.0065 | 0.0135 |
| \( \log \) | -4282.21 | -4019.05 | -4281.78 | -4020.19 | -4385.54 | -4036.37 |

likelihood

\[ a) \text{ u.b. := upper bound, l.b. := lower bound} \]
Appendix 5: The stability of the model

To investigate the stability of the model we write the equations (2.1) - (2.2) and (3.14) - (3.15) in matrix notation:

\[
\tilde{\mathbf{h}} = (\mathbf{\beta} \times \mathbf{W} + \mathbf{I}_{2N}) \cdot \mathbf{\delta} + \sum_{j=1}^{7} (\gamma_j \times \mathbf{x}_j) + \mathbf{\epsilon} \quad \text{(A.5.1)}
\]

\[
\mathbf{\delta} = \delta_0 \times \mathbf{1}_N + (\mathbf{E}_1 \times \mathbf{Z} \times \mathbf{I}_N) \cdot \mathbf{h}(-1) + (\mathbf{E}_1 \times (\mathbf{I}_N - \mathbf{Z}) \times \mathbf{V} + \mathbf{E}_2 \times \mathbf{V}^{t_{1j}}) \cdot \mathbf{h}(-1) \quad \text{(A.5.2)}
\]

where \( h = (h_{m1} \ldots h_{mN} h_{f1} \ldots h_{fN})^T \), \( N \) := total number of households

\[
\tilde{\mathbf{h}} = (\tilde{h}_{m1} \ldots \tilde{h}_{mN} \tilde{h}_{f1} \ldots \tilde{h}_{fN})^T
\]

\[
\mathbf{\beta} = (\mathbf{\beta}_m \mathbf{\beta}_f)
\]

\[
\mathbf{W} = \begin{pmatrix}
\mathbf{w}_{m1} & 0 & \mathbf{w}_{f1} & 0 \\
0 & \mathbf{w}_{mN} & 0 & \mathbf{w}_{fN}
\end{pmatrix}
\]

\[
\mathbf{\delta} = (\delta_{m1} \ldots \delta_{mN} \delta_{f1} \ldots \delta_{fN})^T
\]

\[
\mathbf{\gamma}_1 = \begin{pmatrix}
\gamma_m \\
\alpha
\end{pmatrix} \quad \mathbf{\gamma}_2 = \frac{1}{2} \begin{pmatrix}
\mathbf{\beta}_m \gamma_m \\
\mathbf{\beta}_f \gamma_m
\end{pmatrix} \quad \mathbf{\gamma}_3 = \begin{pmatrix}
\mathbf{\alpha} \\
\mathbf{\gamma}_f
\end{pmatrix} \quad \mathbf{\gamma}_4 = \frac{1}{2} \begin{pmatrix}
\mathbf{\beta}_m \mathbf{\gamma}_f \\
\mathbf{\beta}_f \mathbf{\gamma}_f
\end{pmatrix}
\]

\[
\mathbf{\gamma}_5 = \begin{pmatrix}
\mathbf{\beta}_m \alpha \\
\mathbf{\beta}_f \alpha
\end{pmatrix} \quad \mathbf{\gamma}_6 = \begin{pmatrix}
\mathbf{\beta}_m \\
\mathbf{\beta}_f
\end{pmatrix} \quad \mathbf{\gamma}_7 = \begin{pmatrix}
\mathbf{\beta}_m \theta \\
\mathbf{\beta}_f \theta
\end{pmatrix}
\]

\[
\mathbf{x}_1 = (\mathbf{w}_{m1} \ldots \mathbf{w}_{mN})^T
\]

\[
\mathbf{x}_2 = (\mathbf{w}_{f1} \ldots \mathbf{w}_{fN})^T
\]

\[
\mathbf{x}_3 = (\mathbf{w}_{m1} \ldots \mathbf{w}_{mN})^T
\]

\[
\mathbf{x}_4 = (\mathbf{w}_{f1} \ldots \mathbf{w}_{fN})^T
\]

\[
\mathbf{x}_5 = (\mathbf{w}_{m1} \mathbf{w}_{f1} \ldots \mathbf{w}_{mN} \mathbf{w}_{fN})^T
\]
\[
\begin{align*}
\mathbf{x}_6 &= (u_1 \ldots u_N)^T \\
\mathbf{x}_7 &= (1 \ldots 1)^T \Delta 1_N^T \\
\delta_0 &= \begin{pmatrix} \delta_m^0 \\ \delta_f^0 \end{pmatrix} \\
\mathbf{E}_1 &= \begin{pmatrix} \eta_{mm} & 0 \\ 0 & \eta_{ff} \end{pmatrix} ; \quad \mathbf{E}_2 &= \begin{pmatrix} \eta_{fm} & 0 \\ 0 & \eta_{ff} \end{pmatrix} \\
\mathbf{Z} &= \begin{pmatrix} \zeta_m & 0 \\ 0 & \zeta_f \end{pmatrix} \\
\mathbf{V} &= \begin{pmatrix} 0 & V_{11} & \ldots & V_{1N} \\ V_{21} & 0 & \ldots & V_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ V_{N1} & V_{N2} & \ldots & 0 \end{pmatrix} \quad \mathbf{V}^{ij} = \begin{pmatrix} V_{ij}^{11} & \ldots & V_{ij}^{1N} \\ \vdots & \ddots & \vdots \\ V_{ij}^{N1} & \ldots & V_{ij}^{NN} \end{pmatrix}
\end{align*}
\]

\[i, j := m(\text{male}) \text{ or } f(\text{female})\]

\[I_N := (N \text{ by } N) \text{ identity matrix.}\]

It is assumed that in the long run preferred number of hours, actual number of hours and actual number of hours one period lagged are equal.

Substituting (A.3.2) into (A.3.1) then yields

\[
\begin{align*}
\mathbf{h} &= \{I_{2N} - G(E_1 Z x I_N + (E_1 (I_N - Z)) x V^{ij} + E_2 x V^{ij})\}^{-1} \{G(\delta_0 x 1_N) + \Sigma (\gamma_1 x x_1 + \epsilon)\} \\
& \quad \text{for } i = 1^n \\
& \quad \text{(A.5.3)}
\end{align*}
\]

where \(G := \beta x W + I_{2N}\)

\[H := G(E_1 Z x I_N + E_1 (I_N - Z) x V^{ij} + E_2 x V^{ij}).\]
Stability of the model is guaranteed when it can be shown that the eigenvalues of \( H \) lie within the unit circle. By Gershgorin's Theorem\(^1\) we are able to specify an upper and lower bound for the eigenvalues.

**Gershgorin's Theorem.** Each eigenvalue of the \( K \times K \) matrix

\[
A = [a_{ij}]
\]

lies in some interval

\[
I_i = [a_{ii} - \varepsilon_i, a_{ii} + \varepsilon_i],
\]

\( i = 1, \ldots, K \) where

\[
\varepsilon_i = \sum_{j \neq i} a_{ij}
\]

By applying this theorem to the \( 2N \times 2N \) matrix \( H \) and assuming that each wage rate is less than or equal to 50 (guilders per hour)\(^1\), we obtain the union of all \( 2N \) intervals for the estimated parameters, presented in table 6.4: \([0.799, 0.9976]\). So the model is shown to be stable.

---

1) (Econometrica, vol. 52, no. 4 (1984)).

1) This corresponds to about \$17.


<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Title</th>
<th>Month</th>
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<tbody>
<tr>
<td>2.</td>
<td>P. Kort</td>
<td>Aanpassingskosten in een dynamisch model van de onderneming</td>
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<td>3.</td>
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<td>Optimale besturing en dynamisch ondernemingsgedrag</td>
<td>maart</td>
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<td>4.</td>
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<td>Toepassing van de regressieschatter in de accountantscontrole</td>
<td>mei</td>
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<td>5.</td>
<td>J. Kriens, R.H. Veenstra</td>
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<td>juni</td>
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<tr>
<td>6.</td>
<td>A. van den Elzen, D. Talman</td>
<td>A new strategy-adjustment process for computing a Nash equilibrium in a noncooperative more-person game</td>
<td>juli</td>
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<td>7.</td>
<td>W. van Eijs, W. de Freytas, T. Mekel</td>
<td>Automatisering, Arbeidstijd en Werkgelegenheid</td>
<td>juli</td>
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<td>H. Gremmen</td>
<td>Macro-economisch computerspel, Beschrijving van een model</td>
<td>okt.</td>
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<td>10.</td>
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<td>Inefficiency of credible strategies in oligopolistic resource markets with uncertainty</td>
<td>okt.</td>
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<tr>
<td>11.</td>
<td>J. Moors</td>
<td>Some tossing experiments with biased coins.</td>
<td>dec.</td>
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<tr>
<td>12.</td>
<td>F. van der Ploeg</td>
<td>The effects of a tax and income policy on government finance, employment and capital formation</td>
<td>dec.</td>
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