INCOME TAXATION IN A COLLECTIVE HOUSEHOLD LABOUR SUPPLY MODEL WITH DISCRETE HOURS

by

Hans G. Bloemen[1] [2]

Department of Economics
Free University Amsterdam
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands

Preliminary and Incomplete

July 2005

Keywords: Labour supply, Household behaviour, Collective model, Taxation
JEL code: J22

Abstract

Most studies on the impact of labour income taxation on the labour supply behaviour of households use a unitary modelling approach. A discrete hours choice framework is increasingly used to model the choice of working hours by households or individuals. We extend on the empirical analysis of income taxation and hours choice by combining the collective approach for household behaviour and the discrete hours choice framework. Like in the continuous hours collective model, we are able to identify the parameters of the sharing rule, up to an additive constant, and the parameters of the utility functions. The collective approach imposes cross equation restrictions between the hours choice probabilities of husband and wife that we can test for. We use the model estimates to simulate the impact of changes in the income tax system on the hours choices of husband and wife.

[1] We are greatly indebted to Statistics Netherlands for providing the data.
[2] email: hbloemen@feweb.vu.nl, phone: +31 20 5986037, fax: +31 20 5986005

1 Introduction

The evaluation of the impact of the income tax system on the choice of working hours and the participation decision of individuals has received much attention in the empirical literature on labour supply, see e.g. Blundell and MaCurdy (1999) for an overview. Moreover, the focus has been directed increasingly towards the joint labour supply decision of couples (see e.g. Hausman and Ruud (1984), and Van Soest (1995), Hoynes (1996), Keane and Moffitt (1998), and Blundell et al. (1999). However, almost invariably the unitary model of household labour supply is used to study the impact of taxation on the labour supply of the household members. The unitary approach assumes the existence of a household utility function, and does not specify the preferences of the individual household members. Therefore, the intrahousehold allocation process is ignored. Moreover, studies on labour supply[3] that have tested for the restrictions of the unitary model, like for instance the pooling restriction, on the labour supply of household members, almost invariably reject the unitary restrictions. See e.g. Fortin and Lacroix (1997) for an extensive test of the unitary model.

Chiappori (1988, 1992) showed that the collective model of household labour supply imposes restrictions on the labour supply functions of household members that are less restrictive than the unitary model. The collective model explicitly specifies the preferences of the individual household members. The model implicitly incorporates the outcomes of a bargaining process with a Pareto efficient outcome by a sharing rule, which specifies the division of income between household members. Chiappori (1988, 1992) showed that under certain conditions, like egoistic (or caring) preferences and the absence of a public good in the household,[4] the sharing rule can be identified up to an additive constant. Moreover, the underlying individual preference parameters can be identified. However, the empirical application of the collective model is less straightforward than the unitary model, which explains why studies on household labour supply and taxes have concentrated on the unitary model, as indicated by Beninger and Laisney (2002). Until recently, applications of the collective household labour supply model

[3] In these the tax system is not incorporated explicitly.

[4] Recently, Blundell et al. (20..) showed how this latter assumption can be relaxed.

focussed on the analysis childless couples with both partners working. In the collective model it is less straightforward to incorporate the participation decision and taxation. Recently, Blundell et al. (2001) and Donni (2003) extended the identi¯cation result of the sharing rule to include the case of nonparticipation by one of the partners. Bloemen (2004) speci¯es an empirical model of collective household labour supply which allows for nonparticipation. Donni (2003) derives conditions for the implementation of a non-linear but convex budget contraint in a collective model. In particular, he shows how the parameters of the sharing rule can be recovered from the labour supply functions that are based on virtual wage rates and virtual nonlabour income. His approach is based on the availability of an explicit expression of the labour supply function (conditional on the tax bracket) and therefore can be seen as a collective version of the Hausman and Ruud (1984) approach. Vermeulen (2002) used the discrete hours choice model, comparable to the approach by Van Soest (1995), to empirically implement taxes in a collective type of model. However, he only considers couples with working husbands and assumes that the working hours by husbands can be approximated by 40 for all of them. Therefore, the identication of the sharing rule in his setup does not come from a relation between the working hours of the husband and those of the wife. Instead, he identi¯es the parameters of the sharing by ¯rst assuming that the individual preferences of single women and married women are the same,[5] and next assuming that the di®erence between single and married women is that single woman get the entire nonlabour income and married women only a share. Thus, the model is very similar to estimating an individual labour supply model allowing for a di®erence between married and single women. Beninger and Laisney (2002) also address the problem of collective household labour supply with taxation. They simulate data from a speci¯cation of the collective model and show how changes in the tax system a®ect model outcomes. This way they highlight the speci¯c properties of the collective labour supply model and emphasize the potential importance of the formulating a collective model. They compare the model

[5] In section 6 of this paper, we ¯nd a higher marginal utility of working hours for unmarried women cohabitating with a partner (two-person household without children) than for married women (in a two person household without children). Therefore, it is unlikely that the preference parameters of single women and women belonging to couples (which is an even less homogeneous group) will be the same.

outcomes with the outcomes generated by the unitary model. They also estimate a discrete hours choice model of the same type as Van Soest (1995) using the simulated collective data, to see whether the unitary model using this framework would generate comparable results as the collective model that the data were generated from. The unitary model generates substantially di®erent results than the collective model. It should be noted that there may be several causes for the di®erences between the outcomes, like the use of di®erent utility functions, the use of a discrete choice framework, as well as the speci¯cation with the logistic errors.[6] For instance, Beninger and Laisney (2002) ¯nd that the model underestimates the probability of nonparticipation, which was also found in the original model, even when it is extended with ¯xed cost of work.

So empirical evaluations of the impact of taxes on household members using the collective framework are still scarce. One way to proceed would the speci¯cation of a continuous horus labour supply functions for the household members and implementing the result by Donni (2003). This requires the incorporation of the Hausman-algorithm (see, for instance, Hausman 1981) to determine the virtual wage rates and non-labour income in the estimation procedure. An additional complication that arises in the context of the collective model is the treatment of corner solutions (zero working hours) and the problem of statistical coherency, as was shown in Bloemen (2004).

However, the literature on the empirical analysis of labour supply and taxes has moved away from the Hausman (1981) approach in favour of the discrete choice approach, as used by, for instance, Van Soest (1995). Originally the neoclassical labour supply model formed the basis for the empirical analysis of labour supply. This way of modelling labour supply and taxes requires the solution of the optimal working hours, de¯ned as the hours at which the budget constraint and the indi®erence curve are tangent. An empirical implmentation is feasible if the budget constraint is convex and if an explicit functional form for the labour supply function, evaluated in virtual nonlabour income and virtual wage rates, exists. Implementation gets increasingly complicated if nonconvexities in

[6] As far as I can see there has never been a similar simulation study to analyze the properties of the model by Van Soest (1995) in the ¯rst place, for instance by simulating data by a neoclassical unitary model and next estimating the discrete choice hours model with the logistic errors, to see whether it is really that °exible such that it can approximate any underlying utility speci¯cation.

the budget constraint appear, in particular the more °exible are the speci¯ed labour supply functions.[7] Modelling the simultaneous choice of the labour supply of household members, say husband and wife, in the presence of income taxation, further complicates the implementation.

Due to the aforementioned problems with nonvex budget constraints, a discrete choice approach of modelling labour supply behaviour, as described in Van Soest (1995), became very popular. Van Soest (1995) models the labour supply behaviour of couples as a discrete choice problem. Only speci¯c, discrete numbers of working hours can be chosen. By choosing a log-quadratic (so called \°exible") utility function with additive errors distributed according to the extreme value distribution, the choice probabilities (de¯ned over a discrete choice set of working hours) are logistic probabilities. This way of modelling avoids the need to locate the tangency point of indi®erence curve and budget constraint, it avoids the need to have an explicit expression of the labour supply function in terms of the virtual wage rate and the virtual nonlabour income, it avoids the need to a priori impose concavity of the utility function. Nonconvexities of the budget constraint are easily dealt with because the whole approach based on comparing utility levels and comparing utility levels is exactly what we need if we want to incorporate nonconvexities in the budget constraint. Because if its ease of implementation the approach has been widely applied to the measuring the impacts of the tax system on the labour supply behaviour of individuals and households.

Note that the approach is based on discretizing the range of working hours in certain intervals. However, since the underlying utility function chosen is a continuous utility function, it is clear that a more re¯ned discretization makes it more complex to approximate the empirical distribution function of the more re¯ned hours range. One of the consequences of the continuous utility function is that the discrete choice model usually fails to predict zero working hours correctly. To deal with this, often `¯xed cost of work' are included. In fact a function for ¯xed cost of work is speci¯ed, and it is combined with the budget of working and nonworking individuals. Thus, the discrete hours choice framework is very convenient for modelling the impact of complex budget

[7] See e.g. Bloemen and Kapteijn 2003.

sets on the labour supply behaviour of individuals. However, we should keep in mind that the framework is widely adopted for pragmatic reasons. Di®erent ways of modelling the impact of taxes may be very complicated. Nevertheless new alternatives based on the neo-classical model still receive attention. The workby Heim (2003) is an example of such an alternative.

In the present paper we adopt the discrete choice hours approach as a framework to model the labour supply behaviour of households, and we formulate a collective version of the discrete hours choice model. As noted before, Vermeulen (2002) also speci¯ed a discrete hours choice model with taxes, but he uses only information on the labour supply of women to estimate the model parameters. In fact he identi¯es a sharing rule from di®erences in labour market outcomes for married and single women, while he assumes that at the individual level married and single women have the same preferences. In this paper, we use a dataset on childless couples from the Dutch Socio Economic Panel (SEP) for the years 1990-1999. We model the individual preferences of both the husband and the wife. We show that, given our parametrization, we can identify the sharing rule, up to an additive constant, and the parameters of the individual utility functions of husband and wife. The collective model imposes parameter restrictions between the choice probabilites of husband and wife. We estimate an unrestricted version of the model, that does not impose the restrictions implied by the collective model, and a resctriction version, which allows us to test for the validity of the restrictions imposed by the collective framework. Parameter estimates of the sharing rule are obtained as outcomes of the estimation process, which provides us insights into the intrahousehold allocation process. For nonworking individuals wages are not observed. Therefore, we also estimate the wage distributions of men and women, correcting for participation.

The organization of the paper is as follows. In section 2 we formulate the collective version of the discrete hours choice model. In section 3 we present the econometric speci¯cation of our model. We specify the utility function of husband and wife, the error structure, the sharing rule, and the wage distribution. Moreover, we present the identi¯cation results of the sharing rule and preference parameters and we show which cross-restrictions are imposed on the choice of men and women by the collective sharing rule representation. In section 4 we brie°y discuss the Dutch income tax system. Section 5 provides descriptive statistics of the data. Section 6 contains the results of estimation. Section 7 simulation results with tax reforms are presented. Section 8 concludes.

The budget constraint is nonlinear due to the income tax system. One way to interpret the discrete choice model is to see it as an approximation to a continuous hours utility maximization problem. Using the discrete choice problem in the context of a collective labour supply model has consequences for the shape of the sharing rule. In Chiappori (1992) the sharing rule depends only on the wage rates of husband and wife and the household's nonlabour income, and not explicitly on working hours. In a continous choice framework optimal working hours are represented by the labour supply function, which in turn depends on the wage rates and nonlabour income.[8] In a discrete choice framework working hours by the partners will enter the sharing rule explicitly. Like in Blundell at al. (2002) a combination of a discrete choice framework with the collective model and the assumption of Pareto e±ciency implies that the double indi®erence assumption holds: if the husband (wife) is indi®erent between two di®erent hours levels, the wife (husband) is also indi®erent. This is particularly important for the choice at zero working hours and one of its implications is that the sharing rule depends also depends on the wage rate of a nonworking partner, as was shown in Blundell et al. (2002). Donni (2003) assumes that the budget constraint is convex, possibly after convexication. This excludes an important source of a nonconvexity in the budget constraint, namely the presence of an income source that depends on the state of nonemployment, like a welfare bene¯t. Inclusion of this type of state dependent nonlabour income places further restrictions on the sharing rule. In general, the determination of a utility maximum in case of a nonconvex budget constraint calls for the comparison of the household welfare function. Thus, in general the utility maximization problem is not separable in a two stage problem in which ¯rst the share of household income for each partner is determined and next the individuals maximize an individual choice problem subject to their income share. The two stage problem is only possible if additional structure is placed on the parameters of the utility function and the sharing rule such that the individual decision is consistent

[8] See, for instance, Chiappori (1992), footnote 8.

with the Pareto efficiency of the household. The latter implies again a double indifference assumption which now also implies the incorporation of the state dependent nonlabour incomes of the two partners. Thus, the sharing rule not only depends on the wage rates but also on the benefit incomes of the partners.

2 The model

2.1 The collective framework

In this section we formulate the collective discrete choice model for working hours. By formulating a discrete choice model we follow the literature on labour supply and taxes in which the specification of discrete choice models for working hours is common practice nowadays. A drawback of the formulation of a discrete choice model is that it loosens the link with the neoclassical theoretical framework for modelling labour supply behaviour. The model does not really provide a reason why individuals choose from a discrete set of working hours, which was also noted by Van Soest (1995). Demand side restriction could be the underlying reason. However, demand side restrictions are not modelled explicitly in this framework.[9] Estimates of wage elasticities will usually be lower than in a continuous choice model, especially if the choice set consists of a limited number of working hours and if the sample size is small. This need not be a problem if in reality the choice of different amounts of working hours is actually restricted. Arguments in favour of the discrete choice model are that in practice workers usually are faced by contractual working hours and cannot select any real number of working hours, and that the more refined the choice set becomes, the closer the solution of a discrete choice will be to a continuous choice of working hours. Moreover, empirically the discrete choice model fits the empirical distribution of working hours much better. Apart from that we have already noted that the convenience of the discrete choice model to incorporate complex tax systems is the main reason for the fact that this model has been applied so widely. However, the fact that the choice set of hours is discrete also means that the details of the nonlinear budget constraint are not fully incorporated. For instance, where the

[9] Examples of models that model demand side restrictions explicitly are Dickens and Lundberg (1993) and Bloemen (2002).

contiuous hours neoclassical model of labour supply has implications for optimal labour supply in kink points of the budget set, the discrete hours model will not lead to any predictions with respect to kink points, since only the utility levels at fixed hours levels are considered. Van Soest (1995) defends this by saying what really matters are the income brackets and if there is sufficient variation in different income values in the sample, this will provide sufficient detail of the budget constraint in the estimation of the model.

Throughout we will consider a two-member household consisting of husband and wife. The consumption level and the working hours are denoted by $(C_m; h_m)$ for the husband and $(C_f; h_f)$ for the wife. Utility of each household member is defined over the consumption and working hours, and we denote it by $U_j(C_j; h_j); j = m; f$. We assume that preferences are egoistic, and that there are no public goods in the household.[10] We assume that individuals divide their total time in leisure time and working hours. Thus we do not consider time that is spent on household production.[11] The gross wage rates of husband and wife, and the household's nonlabour income are denoted by w_m, w_f, and y respectively. Individuals may choose their working hours out of the set $S \equiv \{h^1; \ldots; h^H\}$,[12] in which H represents the number of choice possibilities. We assume that the tax system is known and that the after tax income is a function of the working hours and the gross wage rates of husband and wife, and of the household's non-labour income. Therefore, we denote the after tax income of the household as $g(h_m; h_f; w_m; w_f; y)$. We assume that there is a benefit b_j for household member j which is only obtained if j is not employed. Note that in a unitary household labour supply model, the discrete choice approach can take any kind of non-convexity in the budget constraint due to the tax and social security system. For instance, there may be a benefit income that is only obtained if a household member is not employed, and the net household income need

[10] Recently, Chiappori et al. (2002) relaxed the assumption of the absence of public goods. However, identification of the model parameters requires information of the households' expenditures on the public good.

[11] Chiappori (1997) incorporates household production in the collective labour supply model. Unfortunately, time spent on household production by separate household members is seldom ever observed.

[12] In section 4, in which we describe the data, we will be more specific about the hours values in the choice set.

not necessarily be increasing in the working hours of husband and wife.

Note that Donni (2003) imposes restrictions on the tax system. For instance, he assumes that the function g(:) is increasing in the working hours, the gross wage rates, and the nonlabour income of husband and wife. More speci¯c, he imposes convexity of the budget constraint. This is partly due to the continuous hours framework, in which a convex budget set ensures the existence of a unique tangency point of indi®erence curve and budget constraint. But is should be noted that the collective framework complicates the solution in the presence of a nonconvex budget set even further, also in the presence of the discrete hours framework. Usually in a collective household labour supply model it is assumed that the problem can be split up into two stages. A ¯rst in which the income sharing is determined, and a second in which each individual determines his/her working hours conditional on the income share.

In general, the determination of a utility maximum in case of a nonconvex budget constraint calls for the comparison of the household welfare function as a whole. Thus, in general the utility maximization problem is not separable in a two stage problem in which ¯rst the share of household income for each partner is determined and next the individuals maximize an individual choice problem subject to their income share. The two stage problem is only possible if additional structure is placed on the parameters of the utility function and the sharing rule such that the individual decision is consistent with the Pareto e±ciency of the household. This is comparable to the problem discussed by Blundell et al. (2002) in a collective model in which the husband makes a discrete choice between working 40 hours a week or not working at all. They show that Pareto e±ciency implies that the double indi®erence assumtpion should hold: if the husband (wife) is indi®erent between two di®erent hours levels, the wife (husband) is also indifferent. This excludes discrete jumps in utility in the utility level of the husband (wife) at points at which the wife (husband) is indi®erent between working or not. It is clear that this places restrictions on the parameters of the sharing rule in relation to the parameters of the utility function. This also shows that discontinuities in the budget (e.g. due to labour market related bene¯ts, or tax credits for the employed) more than other (continuous) convexities in the budget set, impose restrictions on the sharing rule. In the next section we show the implications of double indifference for our specification in more detail. For the moment we concentrate on the impact of taxes on labour income and we do not deal with employment state related benefits.

We assume that for each combination of $(h_m; h_f; w_m; w_f; y)$ there exist virtual wage rates $\omega_j = \omega_j(h_m; h_f; w_m; w_f; y); j = m; f$, and a virtual nonlabour income $\mu = \mu(h_m; h_f; w_m; w_f; y)$ such that $g(h_m; h_f; w_m; w_f; y) = \omega_m h_m + \omega_f h_f + \mu$.

Let $\bar{u}_m(w_m; w_f; y)$ denote the utility level that is at least available to the husband. This utility level can be interpreted as the outcome of some bargaining process that leads to Pareto efficient allocations. Note that we assume here that the outcome of the bargaining process depends on gross wage rates and nonlabour income. More general specifications are possible. Now we may write the choice problem of the household members according to the collective model as follows:[13,14]

$$\begin{gathered} \max_{h_m \in S; h_f \in S; C_m; C_f} U_f(C_f; h_f) \\ U_m(C_m; h_m) \geq \bar{u}_m(w_m; w_f; y) \\ C_m + C_f = g(h_m; h_f; w_m; w_f; y) \\ S = \{h^1; \ldots; h^H\} \end{gathered} \tag{1}$$

First, note how the choice of working hours by one partner affect the choice of the other. If the husband decides to choose a higher level of working hours, then this affects the total household budget and consequently the choice of working hours by the wife. Suppose that the husband's net labour income increases as the result of the increase in his working hours. Then the impact on the working hours of the wife depends on the division of this additional income over male and female consumption. If part of the additional income is transferred to the wife and if the wife's leisure is a normal good, she may reduce her working hours. If, however, the additional income is spent entirely on the consumption of the husband, or if the consumption of the wife will be reduced, the wife's working hours may stay the same or increase. Consequently, the interaction of the working hours

[13] Note that we have normalized the total time endowment to 1 here.

[14] Note that there are alternative representations of the same maximization problem. By writing down the Lagrangian we may obtain the `household welfare function' which is additive in the utility levels of both husband and wife.

of husband and wife depends on the way husband and wife share the total household income, which depends both on their relative bargaining power and on their preferences. In the unitary model, the additonal income raised by the increase in working hours would be pooled and added to the household income. Only preferences of husband and wife will determine how it contributes to the consumption of both household members.

2.2 Discrete choice, Pareto e±ciency and double indi®erence

The discrete choice framework may impose additional restrictions on the household's income sharing rule. Blundell et al. (2001) formulate a collective model of household labour supply in which the wife can choose from a continuous range of working hours, but the husband's choice is restricted to choosing to work 40 hours a week or not to work at all, and show that Pareto e±ciency of the underlying decision problem requires the \double indi®erence" condition. This condition states that if the husband is indi®erent between working (40 hours a week) or not working, the wife is also indi®erent: the wife's utility level is not a®ected if the husband's working hours would jump from 40 hours a week to nonparticipation or back if the husband himself is indi®erent between these two hours levels. If the wife's utility level could be a®ected, then there were scope for a Pareto improvement, which is in contradiction with the Pareto e±ciency of the household allocation problem. If the husband changes working hours discetely his labour income is a®ected as well. If the husband is indi®erent between the two levels of workiong hours, then the change in consumption generated by the change in income exactly o®sets the change in utility that is due to the change in working hours. If part of the income change were transferred to the wife, her utility would rise and we would have a Pareto improvement which implies that we are not in a Pareto e±cient situation. The implication is that at the reservation wage, the additional income raised by the husband by an increase in working hours should be assigned entirely to the husband. Note that this relationship only holds for reservation wage rates, at which the husband is indi®erent between the di®erent levels of working hours. At other wages levels, this condition need (and will) not hold, but the condition places restrictions on the relation between the preferences and the income sharing rule. If the choice set of working hours is discrete for a variety of hours levels and di®erent hours levels imply di®erent income levels, the double indi®erence condition should be satis¯ed for any pair of choices of working hours of husband and wife. However, if we consider the discrete choice set as an approximation for the continuous hours choice, discrete `jumps' in income due to `jumps' in working hours get smaller and smaller the more re¯ned is the discretization of the hours choice set. However, if there are discontinuities in the budget constraint, due to the properties of the tax and social security system, then the imposition of double indi®erence becomes more fundamental.

2.3 The sharing rule representation

In this section we formulates the sharing rule representation of the decision problem (1). The discrete choice nature of decision problem also has implications for the sharing rule. The decision problem (1) implies that the decision problem for the husband depends explicitly on the working hours h_f of the wife, since di®erent working hours of the wife imply a di®erent budget for the husband. Moreover, decisions are made on basis of comparing utility levels for di®erent levels of working hours.

Now if the husband's working hours are equal to $h_m \in S$, then the husband's consumption level is de¯ned by

$$u_m(C_m; h_m) = \psi_m(w_m; w_f; y) \qquad (2)$$

If $V_m(\cdot; h_m)$ is the inverse of the mapping $u_m(\cdot; h_m)$, [15] and if we make explicit that in a discrete choice framework the wife's working hours h_f enter the decision of trhe husband, we may write

$$C_m = V_m(\psi_m(w_m; w_f; y); h_m) = \Psi(w_m; w_f; h_m; y) \qquad (3)$$

Equation (3) shows that the consumption of the husband depends on the gross hourly rates w_m and w_f of husband and wife, on the household's nonlabour income y, and, due to the discrete choice nature of our decision problem, it also depends explicitly on the working hours h_m and h_f of husband and wife.

[15] Conform Blundell et al. (2001).

To express consumption in terms of virtual wage rates and virtual nonlabour income, we assume that there exists a function $\rho(\omega_m;\omega_f;h_m;\mu)$ such that

$$\omega_m h_m + \rho(\omega_m;\omega_f;h_m;\mu) = \psi(w_m;w_f;h_m;y) \tag{4}$$

in which $\omega_m;\omega_f$ and μ are the virtual wage rates and nonlabour income defined earlier. The virtual wage rates and the nonlabour income are, in general, functions of $(w_m;w_f;h_m;h_f;y)$, the gross wage rates, working hours, and the household's nonlabour income. Note that in this notation the wife's share is $\mu - \rho = \mu(w_m;w_f;h_m;h_f;y) - \rho(w_m;w_f;h_m;h_f;y)$. Note that the sharing rule $\rho(.)$ describes for each combination of working hours, wage rates and nonlabour income how the household income is divided between husband and wife. The collective discrete hours decision problem can be represented by two individual decision problems, conditional on the sharing rule. Partner j in the household chooses his or her working hours by solving the following problem:

$$\max_{h_j \in S} u_j(C_j;h_j)$$

$$\text{subject to } C_j = \omega_j h_j + \rho_j(\omega_m;\omega_f;h_m;\mu)$$

$$\omega_j = \omega_j(w_m;w_f;h_m;y);\ \mu = \mu(w_m;w_f;h_m;y) \tag{5}$$

$$\rho_m = \rho;\ \rho_f = \mu - \rho$$

$$j = m;f$$

Note that the decision problem described in (5) somehow resembles a repeated game. Both partners know the sharing rule and incorporate what the other partner will do in response to their choice of working hours.[16]

2.4 Choice probabilities and identification of the sharing rule

In the continuous hours context Chiappori (1988) derives the identification of the sharing rule (up to an additive constant). He shows that the impacts of wage rates and nonlabour income on the sharing rule are nonparametrically identified. With a sample

[16] Chiappori et al. (2002) emphasized, among others, in their empirical application the importance of having `stable' households in the sample, in which the partners know each other for quite some years, which makes it more likely that the hypothesis of efficiency in the intrahousehold decision process is satisfied.

of observations on working hours, wage rates, and nonlabour income of working couples, we can identify the impacts of wage rates and nonlabour income on each partner's working hours. The identiifcation of the sharing rule stems from restrictions that the collective framework imposes on the way these variables a®ect working hours: the husband's (wife's) wage rate a®ects the working hours of the wife (husband) only through the sharing rule, whereas the shares of husband and wife add-up to nonlabour income. Exploiting these restrictions, the impact of wage rates and nonlabour income on working hours can be decomposed into their impact on the sharing rule and their impact on working hours through the individual labour supply equation. Now that we are working with a discrete choice framework, the original identi¯cation result cannot be directly applied anymore. However, it is not hard to point at similarities between the identi¯cation in the continuous hours model and the discrete choice model. In a discrete choice framework, instead of measuring the impact of wage rates and nonlabour income on (expected) working hours, we measure the impact of these variables on the choice probabilities of di®erent categories of working hours. The collective model then predicts that the other partner's wage rate enters the choice probability of a speci¯c number of working hours by the sharing rule, and places restrictions on the way in which nonlabour income enters the choice probabilities. Consequently, for a formal proof of (nonparametric) identi¯cation we would have to proof that information on the empirical frequency distribution of di®erent hours categories, wage rates, and nonlabour income, together with the restrictions of the impact of the latter variables on the choice probabilities implied by the collective model can be used to identify the e®ects of the wage rates and nonlabour income on the sharing rule. It is beyond the scope of this applied paper to answer the question whether it is possible to proof nonparametric identi¯cation. Instead, we will choose functional forms for the utility function and the distribution of stochastics, and we will show that from the reduced form parameters that measure the e®ects of wage rates and nonlabour income on the choice probabilities, we can recover the parameters that measure the e®ects of these variables on the sharing rule.

3 Econometric specification

3.1 The error structure

As has become common practice in discrete choice models of labour supply with taxes, we assume that each utility level of a given number of working hours contains an additive error term that is distributed according to the extreme value distribution. Suppose that the observed numbers of working hours of husband and wife are h_m^k and h_f^l respectively, with $k, l \in \{1, \ldots, H\}$. We denote the utility of husband and wife by

$$u_m(C_m^{kl}; h_m^k) = u_m^{kl}(\eta_m) + \varepsilon_m^k$$
$$u_f(C_f^{lk}; h_f^l) = u_f^{lk}(\eta_f) + \varepsilon_f^l \qquad (6)$$
$$k, l \in \{1, \ldots, H\}$$

The superscripts kl and lk denote that the values of the variables depend on h_m^k and h_f^l, whereas η_m and η_f (which are possibly correlated with each other to allow for household specific elements) may represent unobserved heterogeneity that affects preferences but is not specific to the hours category chosen. For the additive error terms ε_m^k and ε_f^l we make the following assumptions: (i) $\varepsilon_j^r; j = m, f; r = 1, \ldots, H$, are indedepentently and identically distributed according to the extreme value distribution; (ii) $E(\varepsilon_j^r | h_m, h_f, w_m, w_f, y) = 0; j = m, f; r = 1, \ldots, H$.

The combination of working hours h_m^k and h_f^l is observed if two conditions are met simultaneously. For the wife, we have

$$u_f^{lk}(\eta_f) + \varepsilon_f^l > u_f^{sk}(\eta_f) + \varepsilon_f^s; s \neq l; s = 1, \ldots, H \qquad (7)$$

whereas for the husband

$$u_m^{kl}(\eta_m) + \varepsilon_m^k > u_m^{rl}(\eta_m) + \varepsilon_m^r; r \neq k; r = 1, \ldots, H \qquad (8)$$

From (8) and (7) and the assumptions about the additive errors we may write

$$p(h_m = h_m^k, h_f = h_f^l | w_m, w_f, y, \eta_m, \eta_f) = \frac{\exp(u_m^{kl}(\eta_m))}{\sum_{r=1}^{H} \exp(u_m^{rl}(\eta_m))} \frac{\exp(u_f^{lk}(\eta_f))}{\sum_{s=1}^{H} \exp(u_f^{sk}(\eta_f))} \qquad (9)$$

For the regularity of the joint probability distribution of working hours of husband and wife it is required that the underlying conditions for observing an hours combination

$(h_m^k, h_f^l), k, l = 1, \ldots, H$ are exclusive and exhaustive: for given values of $\epsilon_j^r, j = m, f; r = 1, \ldots, H$ the working hours (h_m^k, h_f^l) is the unique combination of male and female working hours that satisfies (7) and (8) simultaneously. In other words, there is no other pair of working hours $(h_m^r, h_f^s); r \neq k, s \neq l$ which also satisfies (7) and (8) simultaneously. Note that this condition is not a priori, like in the individual or unitary discrete hours model. Whether the outcome is unique depends on the way working hours of one partner enter the other partner's utility function. A sufficient condition for regularity is that the utility of the husband (wife) is monotonous in the working hours of the wife (husband).[17]

An example in which a unique solution is guaranteed can be constructed: if (i) the marginal utility of consumption is strictly positive, (ii) leisure is a normal good, (iii) the tax system for the household income is convex, and (iv) there is income pooling. In this situation the optimal working hours of the husband (wife) are monotonously decreasing in the working hours of the wife (husband).

The collective framework does not impose income pooling, while most tax systems exhibit nonconvexities. Therefore, uniqueness of the model outcome may impose restrictions on the parameters of the sharing rule.

The statistical consequence of a nonunique solution is that summing (9) over k and l results in an expression that exceeds one. This is the known as the problem of incoherency.

Finding parameter conditions that are sufficient for coherency are usually very strong since they hold for every observation in the data. A different way of dealing with statistical coherency is to spread the additional probability mass evenly over the different hours combinations: if p_{kl} represents the probability in (9) we normalize every probability by dividing by $\sum_{l=1}^{J} \sum_{k=1}^{H} p_{kl}$. This way, the normalized probabilities add-up to one but the underlying economic model is not necessarily coherent, but we need not impose strong restrictions and we can check afterward if the model is coherent.[18]

[17] From a game-theoretic perspective (7) and (8) may be interpreted as best response functions. There is a unique Nash equilibrium if the best response functions have one unique intersection. It is clear that by construction (7) and (8) will generate at least one intersection, but additional assumption have to made to restrict the solution to one intersection.

[18] If the model is coherent then $\sum_{l=1}^{J} \sum_{k=1}^{H} p_{kl} = 1$.

3.2 The wage equation

For individuals who do not work, or individuals who do work but have missing information on wages, the gross wage rate is not observed. We formulate the following equation for the gross wage rate:

$$\ln w_j = \eta_j' x_j + v_j; \; j = m, f \quad (10)$$

In (10) η_j is the parameter vector measuring the impact of the observed characteristics x_j on the gross wage rate, whereas v_j is a random error. We assume that v_j follows a normal distribution with mean zero and covariance τ_j^2. For each household member we specify a selection equation for the labour market state with an error term that is jointly normally distributed with the error term in the wage equation (10).[19] We estimated the parameters of the wage equation and the selection equation jointly with maximum likelihood. Note that the selection equation should include the variables included in the utility function. Since the choice of one partner may also depend on the wage of the other, we also include all the covariates of the partner's wage equation in the selection equation.

3.3 The utility function

Empirical applications of the discrete choice hours model with taxation generally specify a utility function that is (log)-quadratic in its arguments. Even though a quadratic specification is as parametric as any other specification, the general opinion is that a quadratic utility function is flexible and may approximate any arbitrary utility function. A more obvious advantage of the quadratic specification is that a priori we do not have to impose any regularity conditions on the utility function. Since we base our model on the collective approach, we have to fill out the sharing rule in the utility function. In order to reduce the number of reduced form parameters (explained later on), and to keep the function as a whole manageable, we represent preferences by the following quadratic direct utility function:

$$u_j^{kl} = (\beta^j_{0,hh} + \beta^{j\prime}_{hh} z_j + \beta^j_{\gamma} \gamma_j)(h_j^k)^2 + \beta^j_{ch} h_j^k C_j^{kl} + \beta^j_c C_j^{kl} + (\beta^j_{0h} + \beta^{j\prime}_{h} z_j + \gamma_j) h_j^k; \; j = m, f \quad (11)$$

[19] Similar approaches are followed by Van Soest (1995) and Keane and Moffitt (1998).

In (11) z_j represents a vector of observable tast shifters that may influence the impact of working hours on the level of utility, whereas $\beta^j_{0;hh}; \beta^j_{hh}; \beta^j_{ch}; \beta^j_{c}, \beta^j_{0;h}$ and β^j_{h} are the parameters of the utility function. The utility function contains an unobserved taste shifter ε_j. We allow for correlation between the unobserved taste shifter of husband and wife, and we assume that it is normally distributed:

$$\begin{pmatrix} \varepsilon_m \\ \varepsilon_f \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}; \begin{pmatrix} \sigma^2_{\varepsilon;m} & \sigma_{\varepsilon;mf} \\ \sigma_{\varepsilon;mf} & \sigma^2_{\varepsilon;f} \end{pmatrix}\right) \tag{12}$$

We denote the density function of random preferences by $f(\varepsilon_m; \varepsilon_f; \Sigma_\varepsilon)$, where Σ_ε represents the covariance matrix.

Regularity conditions impose restrictions on the utility function. First, it is increasing in consumption if

$$\beta^j_{ch} h^k_j + \beta^j_c > 0; \forall k \in \{1; ...; H\}; j = m; f \tag{13}$$

Second, utility is decreasing in working hours if, for a given level of consumption C_j

$$2(\beta^j_{0;hh} + \beta^{j}_{hh}{}'z_j + \beta^j_{\varepsilon}\varepsilon_j)h^k_j + \beta^j_{ch}C_j + (\beta^j_{0h} + \beta^{j}_{h}{}'z_j + \varepsilon_j) < 0; \forall k \in \{1; ...; H\}; j = m; f \tag{14}$$

Finally, the utility function is strictly quasi-concave if

$$\begin{aligned} \beta^j_{ch}\Big[2(\beta^j_{0;hh} + \beta^{j}_{hh}{}'z_j + \beta^j_{\varepsilon}\varepsilon_j)h^k_j + \beta^j_{ch}C_j + (\beta^j_{0h} + \beta^{j}_{h}{}'z_j + \varepsilon_j)\Big] + \\ - 2(\beta^j_{0;hh} + \beta^{j}_{hh}{}'z_j + \beta^j_{\varepsilon}\varepsilon_j)(\beta^j_{ch}h^k_j + \beta^j_c) > 0 \end{aligned} \tag{15}$$

The regularity conditions (13), (14), and (15) can be verified once the utility parameters have been estimated.

3.4 Specification of the sharing rule

In the previous section we have noticed that the sharing rule in this discrete choice setting is not only a function of the (virtual) wage rates of husband and wife and the (virtual) nonlabour income of the household, but is also a function of the working hours of both partners and their benefit income while unemployed.[20] Accordingly, we specify

[20] In their model of restricted choice by the husband, Blundell et al. (2001) actually specify two separate sharing rules for the two choice opportunities (0 or 40 hours) of the husband. Here we a priori impose more restrictions between the HxH different hours choice opportunities of husband and wife by including working hours of husband and wife as a variable affecting the share.

the following sharing rule:

$$\rho(\omega_m, \omega_f, h_m, h_f, \mu) = \alpha_0 + \alpha_1 \omega_m h_m + \alpha_2 \mu + \alpha_3 D + \alpha_4 h_m + \alpha_5 \mu^2 \tag{16}$$

Note that we included the virtual labour income $\omega_j h_j, j = m, f$ to express the direct impact of working hours on the budget. The variable D is a factor that represents the relative bargaining power of husband and wife, and we specify

$$D = \frac{\omega_m}{\omega_m + \omega_f} \tag{17}$$

Recall that $\rho = \rho_m$, the husband's share, while the wife's share follows from (16) as $\rho_f = \mu - \rho_m$. Moreover, by the budget constraint, $C_j = \omega_j h_j + \rho_j, j = m, f$. Note that income pooling is satisfied if $1 + \alpha_1 = \alpha_2$.

By filling out the budget constraint in the utility function, we obtain the impact of the sharing rule on the utility level. Since the sharing rule enters both the utility function of husband and wife, the model imposes cross equation constraints between the husband's and wife's utility levels. After filling out the husband's budget constraint in his utility function, we may write his utility level in `reduced form' as

$$\begin{aligned} u^{kl}_m = {} & \gamma^m_1 h_m \omega_m h_m + \delta^m_1 \omega_m h_m + \gamma^m_2 h_m \mu + \gamma^m_3 h_m D + \gamma^{*m}_4 h^2_m + \\ & + \gamma^m_5 h_m \mu^2 + \delta^m_2 \mu + \delta^m_3 D + \delta^{*m}_4 h_m + \delta^m_5 \mu^2 + \\ & + (\beta^j_{hh}{}' z_j + \beta^j_0 \gamma_j)(h^k_j)^2 + (\beta^j_h{}' z_j + \gamma_j) h^k_j \end{aligned} \tag{18}$$

The parameters in (18) can be expressed in the parameters of the utility function (11) and the parameters of the sharing rule (16):

$$\begin{aligned} \gamma^m_l &= \beta^m_{ch} \alpha_l, \quad l = 2, 3, 5 \\ \gamma^m_1 &= \beta^m_{ch}(1 + \alpha_1); \quad \delta^m_1 = \beta^m_c (\alpha_1 + 1) \\ \gamma^{*m}_4 &= \beta^m_{ch} \alpha_4 + \beta^m_{0,hh} \\ \delta^m_l &= \beta^m_c \alpha_l, \quad l = 2, 3, 5 \\ \delta^{*m}_4 &= \gamma^{*m}_0 = \beta^m_{ch} \alpha_0 + \beta^m_{0h} + \beta^m_c \alpha_4 \end{aligned} \tag{19}$$

Note that the parameters γ^m_l all refer to the cross effects of working hours with the sharing rule, e.g., parameter γ^m_3 measures the impact of the cross effect of male working hours with the wage rate fraction D, which is the third parameter entering the sharing rule, and consequently $\gamma_3^m = \beta_{ch}^m \alpha_3$. Similarly, the parameters δ_l^m measure the direct effect of the level of the sharing rule on the utility level, e.g. δ_3^m measures the effect of the third variable entering the sharing rule, with $\delta_3^m = \beta_c^m \alpha_3$. Note that income pooling imposes the parameter restrictions $\gamma_1^m = \gamma_2^m$ and $\delta_1^m = \delta_2^m$.

For the wives, the utility function becomes

$$u_f^{kl} = \beta_{ch}^f \omega_f h_f^2 + \gamma_0^{*f} h_f + \gamma_1^f h_f \omega_m h_m + \beta_c^f \omega_f h_f + \gamma_2^f h_f \mu + \gamma_3^f h_f D + \gamma_4^f h_f h_m +$$

$$+ \gamma_5^f h_f \mu^2 + \delta_1^f \omega_m h_m + \delta_2^f \mu + \delta_3^f D + \delta_4^f h_m + \delta_5^f \mu^2 + \quad (20)$$

$$+ \beta_{0;hh}^f h_f^2 + (\beta_{hh}^{j\prime} z_j + \beta_\nu^j \nu_j)(h_j^k)^2 + (\beta_h^{j\prime} z_j + \nu_j) h_j^k$$

with

$$\gamma_l^f = -\beta_{ch}^f \alpha_l;\ l = 1;3;4;5$$

$$\gamma_2^f = \beta_{ch}^f (1 - \alpha_2)$$

$$\delta_l^f = -\beta_c^f \alpha_l;\ l = 1;3;4;5 \quad (21)$$

$$\delta_2^f = \beta_c^f (1 - \alpha_2)$$

$$\gamma_0^{*f} = -\beta_{ch}^f \alpha_0 + \beta_{0h}^f$$

Income pooling imposes the parameter restrictions $\gamma_1^f = \gamma_2^f$ and $\delta_1^f = \delta_2^f$. The parameters $\gamma_l^m; \delta_l^m; l = 1;2;3;5; \gamma_4^{*m}$, and δ_4^{*m} can be considered as the unrestricted, reduced form parameters of the utility function. Similarly, for the women we have the reduced form parameters $\gamma_l^f; \delta_l^f; l = 1;3;4;5; \gamma_4^{*f}; \delta_4^{*f}$. Note that in (18) only the parameters of variables that vary with the number of working hours h_m are identified, since the choice of working hours depends on differences in utility values of different levels of working hours. Note that δ_2^m, δ_3^m and δ_5^m are identified since the virtual wage rates and the virtual non-labour income of the household depend by the tax system on male working hours. In the utility function of the wives (20) the parameter δ_4^f is not identified so we may normalize $\delta_4^f = 0$. Note that the structural parameters $\beta_{ch}^f; \beta_c^f$, and $\beta_{0;hh}^f$ enter the reduced form utility function of the wives directly.

Thus, we have 23 unrestricted parameters in the reduced form utility functions of husband and wives. The underlying structural parameters are $\beta_{ch}^j; \beta_c^j; \beta_{0;hh}^j; \beta_{0h}^j; j = m; f$

and the parameters of the sharing rule $\alpha_l; l = 0; \ldots; 5$.[21]

These are 14 parameters in number. Now the question is: can we recover the structural parameters uniquely from the reduced form parameters? This is basically the same question as was addressed by Chiappori (1988, 1992) for the case of continuous labour supply with positive working hours. Only, here we restrict ourselves to a specific functional form for the utility function. Note that the number of reduced form parameters (23) is much larger than the number of structural parameters (14). So if we are able to express the structural parameters in terms of the reduced form parameters there must be a sufficient number of restrictions between parameters to ensure that the solution found is unique.

It is straightforward to see that we can identify $\beta^f_{ch}; \beta^f_c$ and $\beta^f_{0;hh}$ as these enter the reduced form utility function directly. Subsequently, we have solved the remaining structural parameters in terms of the reduced form parameters and we have found the following expressions:

$$\beta^m_{ch} = \frac{\beta^f_{ch}\gamma^m_1}{\beta^f_{ch} - \gamma^f_1} \tag{22}$$

$$\beta^m_{c} = \frac{\beta^f_{ch}\delta^m_1}{\beta^f_{ch} - \gamma^f_1} \tag{23}$$

$$\beta^m_{0;hh} = \gamma^{*m}_4 + \frac{\gamma^m_1\gamma^f_4}{\beta^f_{ch} - \gamma^f_1} \tag{24}$$

$$\alpha_j = -\frac{\gamma^f_j}{\beta^f_{ch}}; j = 1; 3; 4; 5 \tag{25}$$

$$\alpha_2 = 1 - \frac{\gamma^f_2}{\beta^f_{ch}} \tag{26}$$

Apart from finding expressions for the structural parameters in terms of the reduced form parameters, we have found the following parameter restrictions:

$$\frac{\gamma^m_1}{\delta^m_1} = \frac{\gamma^m_l}{\delta^m_l}; l = 2; 3; 5 \tag{27}$$

---

[21] Needless to say, the utility function also contains the parameters β^j_h and $\beta^j_{hh}; j = m; f$. However, since these parameters measure the effects of the taste shifters and enter the reduced form utility functions (18) and (20) directly identification of structural parameters is not an issue. We concentrate the discussion of identification on the parameters that do enter the structural utility functions and the the sharing rule, but do not enter the reduced form utility functions explicitly.

$$\frac{\beta^f_{ch}}{\beta^f_c} = \frac{\gamma^f_l}{\delta^f_l}; l = 1; 2; 3; 5 \qquad (28)$$

$$\gamma^f_1 \gamma^m_l - \gamma^m_1 \gamma^f_l = \beta^f_{ch} \gamma^m_l; l = 2; 3; 5 \qquad (29)$$

Note that there is a difference between the three subsets of restrictions in (27), (28) and (29). The restrictions in (27) impose restrictions on the reduced form parameters of the utility function of the husband, but do not contain cross equation constraints between husband and wife. Similarly, the restrictions in (28) only impose restrictions on the reduced form utility function of the wife. Empirical applications of the collective model that only make use of data on, say, women, therefore test the restrictions in (28). The restrictions in (29) contain the collective restrictions that link the behaviour of husband and wife. These contain the more interesting implications of the collective framework. By modelling both the behaviour of wife and husband, instead of estimating a model that compares married women with single women, we address these cross equation restrictions between husband and wife.

In (22) to (26) (together with $\beta^f_{ch}; \beta^f_c$ and $\beta^f_{0;hh}$), 11 of the 14 structural parameters are expressed in terms of reduced parameters. There are three structural parameters that cannot be expressed in terms of the reduced form parameters: these are the parameters $\alpha_0; \beta^m_{0h}$ and β^f_{0h}, one of which is the intercept of the sharing rule. Note that these parameters enter the reduced form parameters δ^{*m}_4 and γ^{*f}_0. So there are only two reduced form parameters to identify these structural parameters. There are 10 restrictions in (27)-(29) that do not involve the parameters δ^{*m}_4 and γ^{*f}_0. Moreover, these latter two parameters do not enter the expressions for the structural parameters that we can recover. Summarizing, with 21 of the 23 reduced form parameters we can uniquely recover 11 structural parameters and 10 parameter restrictions (10+11=21). The 3 remaining structural parameters cannot be identified from the 2 remaining reduced form parameters. The parameters that cannot be identified are the intercept of the sharing rule and the intercepts of the taste shifters in the utility functions of husband and wife. The result corresponds to the identification in a continuous hours model: Chiappori (1988, 1992) derived the by now well-known result that that parameters of the sharing rule can be identified up to their level.

3.5 Implications of double indi®erence

Blundell et al. (2002) showed the consequences of Pareto e±ciency if the husband can only choose to work fourty hours a week or not to work at all: if the husband earns the reservation wage, at which he is indi®erent between working and not working, the wife should be indi®erent as well. So at the husband's reservation wage, the husband's labour market state should not e®ect the wife's utility level: the discrete change in income, that arises from switching labour market states, should not a®ect the wife's utility level, and since the husband's income a®ects the wife's utility level by the sharing rule, this implies that, at the reservation wage, the sharing rule should assign the income di®erence between the labour market states entirely to the husband. Blundell et al. (2002), though, stress that this condition only holds at the reservation wage, and need not to hold outside the participation frontier.

We now illustrate what will be the implication of double indi®erence in the context of the discrete choice model with a sharing rule as speci¯ed in (16). Let us consider two levels of working hours from the choice set, h^k and $h^{k'}$. Let us assume that we can de¯ne a gross hourly wage $\gamma^{kk'}_m$ at which the husband is indi®erent between working h^k hours and working $h^{k'}$ hours. Let $\gamma^{kk'}_{mk}$ and μ^k denote the associated virtual wage rate and nonlabour income at hours h^k, and, similarly, for hours $h^{k'}$ we have the virtual wage rate $\gamma^{kk'}_{mk'}$ and virtual nonlabour income $\mu^{k'}$. The sharing rule evaluated at these values may be denoted by ρ^k_m and $\rho^{k'}_m$. Thus, by de¯nition we have

$$u_m(\gamma^{kk'}_{mk} h^k_m + \rho^k_m, h^k_m) = u_m(\gamma^{kk'}_{mk'} h^{k'}_m + \rho^{k'}_m, h^{k'}_m) \quad (30)$$

with

$$\rho^k_m = \rho^k_m(\gamma^{kk'}_{mk}, \omega^k_f, h^k_m, h_f, \mu^k) \text{ and } \rho^{k'}_m = \rho^{k'}_m(\gamma^{kk'}_{mk'}, \omega^{k'}_f, h^{k'}_m, h_f, \mu_{k'}) \quad (31)$$

Note that in (31) we have also incorporated the possibility that the wife's virtual wage rate is a®ected by the working hours of the husband.[22]

Now double indi®erence implies that none of the di®erence in the income goes to the wife, which is equivalent to saying that the wife is indi®erent between the husband

[22] As we show will show in section 4, this may happen in practice in the Dutch tax system since deductibilities may be transferred to the other partner.

working h_m^k hours or working $h_m^{k'}$ hours. For the wife's consumption this means

$$\omega_f^k h_f + \rho_f(\gamma_{mk}^{kk'}; \omega_f^k; h_m^k; h_f; \mu^k) = \omega_f^{k'} h_f + \rho_f(\gamma_{mk'}^{kk'}; \omega_f^{k'}; h_m^{k'}; h_f; \mu^{k'}) \qquad (32)$$

For the sharing rule specification (16) this implies the restriction

$$\begin{aligned}&(\alpha_1 - 1)(\omega_f^k - \omega_f^{k'})h_f + \alpha_2(\gamma_{mk}^{kk'} h_k - \gamma_{mk'}^{kk'} h_{k'}) + (\alpha_3 - 1)(\mu^k - \mu^{k'}) + \\ &+ \alpha_4(D^k - D^{k'}) + \alpha_5(h_m^k - h_m^{k'}) + \alpha_7((\mu^k)^2 - (\mu^{k'})^2) = 0; \forall k; k' = 1; \ldots; H\end{aligned} \qquad (33)$$

First note that the restriction (33) only holds at the point at which the individual is indifferent between hours levels h_m^k and $h_m^{k'}$, which all happens with zero probability due to the appearance of random variation in preferences.

Next, we consider two cases. First, suppose that the budget constraint is continuous. Then the differences at the left hand side of (33) will all disappear if h_m^k approaches $h_m^{k'}$. In this case, double indifference is not a fundamental issue, but caused by the fact that we approximate continuous hours by discrete hours. As long as the sharing rule specification is continous in working hours itself and the hours categories specified are not too wide, we may say that the sharing rule specification (16) includes (does not a priori preclude) double indifference.

A more fundamental problem appears if the budget constraint is discontinuous. This can very well happen if there exists a benefit income for the non-working, if there exist fixed costs of work, or if there exists a standard tax deduction for employed individuals. Suppose that $h_m^{k'} = 0$ and that the discontinuity in the budget set is incorporated in $\mu^{k'}$. Then discontinuities in the sharing rule will not disasppear, even if h_m^k approaches $h_m^{k'}$. Thus we will have to extend the sharing rule with the additional terms $\mu_k - \mu_{k'}$ and $(\mu_k)^2 - (\mu_{k'})^2$ for all working hours $h_m^k; k = 1; \ldots; H$. This, in turn, is equivalent to including $\mu_{k'}$ and $(\mu_{k'})^2$ as a separate term in the sharing rule. Including these terms does not imply that double indifference is imposed, but that double indifference is not a priori excluded by the specification.

3.6 Fixed cost of work

Previous studies that use the discrete hours framework reveal that the discrete choice model, once the parameters have been estimated, typically fails to predict the sample fraction of non-working individuals (see Van Soest, 1995, and the remarks in Beninger and Laisney, 2002). This had led to the practice of introducing fixed cost of work (see, for instance, Van Soest and Das, 2001). Fixed cost of work are not directly observed, but parametrized by allowing for a fixed discrete difference in the consumption level between labour market states. Suppose that the fixed cost of work of household member j $(j = m; f)$ is F_j. To introduce fixed cost we will assume that the income available for consumption is $C_j = \omega_j h_j + \rho_j - F_j I(h_j > 0); j = m; f$. Note that we assign the fixed cost of household member j completely to the consumption of household member j and not to the partner. This is motivated by the double indifference story, which implies that the sharing rule should be a continuous function of the amounts of fixed cost of both partners (i.e. the amounts should enter the sharing rule for both working and non-working individuals). But if the amounts are fixed, and if there are no variables that affect fixed costs of work and not the marginal utility of working hours, we cannot identify fixed costs of work from the sharing rule, as the sharing rule is identified up to an additive constant only. Therefore, the fixed cost of work only enter the individual consumption levels.

Adding fixed cost solves at least part of the misprediction of the fraction of non-working in the discrete choice hours model. We want to emphasize that it is an ad hoc solution, but it has become common practice in the literature on discrete hours models.[23]

In our specification, the emphasis is more on incorporating the collective framework and therefore we do not want to pay too much attention to the fixed cost specification[24] and we want to keep them as simple as possible and assume that the fixed costs are constant, but may take different values for men and women.[25]

As a final remark we note that it can easily be verified that adding fixed costs of work by adding two parameters F_m and F_f only adds two parameters in the reduced form

[23] In different contexts, alternatives for a fixed cost are imaginable. For instance, Bloemen (2003) specifies a search model for unemployed job searchers, that includes working hours as a job characteristic. In that framework, unemployment benefits as well as job offer restrictions gives a very natural explanation for observing someone with zero working hours, apart from the choice explanation. The need for adding ad hoc fixed cost is not very strong in such a framework.

[24] For this reason, Vermeulen (2002) does not include fixed costs at all

[25] Fixed cost are often assumed to vary with household composition and the number of children, but as we look at couples without children, our sample is homogeneous in this respect.

utility function, so it does not affect the number of restrictions to be tested.

3.7 Likelihood contributions

We will apply the method of simulated maximum likelihood to estimate the model parameters.[26] We may distinguish the likelihood contributions for various types of observations, depending on the labour market state and the available information. Typically, we will use information on all households for which we observe the labour market state, the background characteristics, and the non-labour income. So we will not throw away information on working individuals with missing wages or working hours. First, consider a household in which both spouses are working, and in which we observe wages (w_m, w_f) and working hours (h_m, h_f). We draw R random values for random preferences $(\nu_{r,m}, \nu_{r,f}), r = 1, \ldots, R$ from its distribution (12). Let $p(h_m, h_f | w_m, w_f, \nu_m, \nu_f)$ be short hand notation for the probability in (9). Then the likelihood contribution for this household can be written as

$$p(h_m, h_f, w_m, w_f) = \frac{1}{R} \Sigma_{r=1}^{R} p(h_m, h_f | w_m, w_f, \nu_{r,m}, \nu_{r,f}) \tag{34}$$

Suppose now that the husband works, with working hours h_m and wage rate w_m, while the wife does not work $(h_f = 0)$, or she works $(h_f > 0)$ but information on her wage rate is missing. Then we may draw R wage rates $w_{r,f}$ $(r = 1, \ldots, R)$ from the distribution of female wage rates[27] and formulate the following likelihood contribition:

$$p(h_m, h_f, w_m) = \frac{1}{R} \Sigma_{r=1}^{R} p(h_m, h_f | w_m, w_{r,f}, \nu_{r,m}, \nu_{r,f}) \tag{35}$$

Equivalently, we may formulate the likelihood contribution if the wife works h_f hours at wage rate w_f, and the husband does not work or has missing information wages:

$$p(h_m, h_f, w_f) = \frac{1}{R} \Sigma_{r=1}^{R} p(h_m, h_f | w_{r,m}, w_f, \nu_{r,m}, \nu_{r,f}) \tag{36}$$

If both husband and wife are not working, or if both are working, with observed working hours, and unobserved wage rates, we draw wage rates $(w_{r,m}, w_{r,f})$ from the distribution

[26] See e.g. Börsch-Supan and Hajivassiliou (1993) for a comprehensive description of this method.
[27] Recall from sectiom 3.2 that we obtain parameter estimates of the wage distribution in a first step.

of wage rates and we have the likelihood contribution

$$p(h_m, h_f) = \frac{1}{R}\sum_{r=1}^{R} p(h_m, h_f | w_{r,m}, w_{r,f}, \gamma_{r,m}, \gamma_{r,f}) \qquad (37)$$

Now suppose that the wife works h_f hours at a wage rate of w_f, while the husband is working but information on working hours and wages are missing. Then from (9) we can formulate the probability that the husband's hours are positive. Consequently, we may formulate the likelihood contribution as

$$p(h_m > 0, h_f, w_f) = \frac{1}{R}\sum_{r=1}^{R} p(h_m > 0, h_f | w_{r,m}, w_f, \gamma_{r,m}, \gamma_{r,f}) \qquad (38)$$

A similar likelihood contribution exists for working couples with missing observations on the wife's working hours, or missing information on the working hours of both partners.

We can use the likelihood ratio test to test various parameter restrictions, like the parameter retrictions implied by the sharing rule representation and the income pooling.

4 The income tax system in the Netherlands

In the years 1997 and 1998 the rules of the Dutch income tax system were basically the same. There are, though, year to year differences in marginal tax rates and standard deductibles. For household labour supply decisions it is important to note that in the Dutch tax system individual incomes are taxed. Every individual has a standard deductible:[28] the marginal tax rate for any income below this amount is zero. There is some relation between the income taxation of two partners in a household. Only if a household member earns an income that is below the standard deductible, s/he can transfer the amount of the standard deductible to her/his partner, who can add it to his/her deductible. This raises household income if the partner earns more than the deductible. Transferring the deductible, if the income situation within the household allows it, is the common practice among households in the Netherlands. In 1998 the deductible was split up into a small nontranferable deductible[29] and the transferable deductible. In both years there are three tax brackets for the income net of the deductible.[30] The marginal tax rate

[28] The Dutch terminology in the law is the “basisaftrek”.
[29] The so called “bovenbasisaftrek”.
[30] The “belastbare som”.

for the ¯rst bracket varies from year to year, because it partly consists of premiums for social welfare. The marginal tax rate for the two higher brackets remained at 50% and 60% throughout the years. Table 1 shows the standard deductibles throughout the years 1997-1998. As an example, consider the year 1997 and suppose that the wife earns less than 7102 guilders a year.[31] Then she may transfer the full deductible amount of 7102 to her husband. She will then have a deductible of zero, whereas the deductible for her husband will be 14204 guilders. The advantage for the household income as a whole is (i) that the complete deductible amount of 7102 is exploited[32] and (ii) if the husband is in the second or third tax bracket there is an additional gain since on the margin the husband's income is taxed at a higher rate than the wife's income as the tax system is progressive. Van Soest and Das (2001) plotted the impact of transferring the deductible to the other partner on the budget constraint for the year 1998. The shape of the budget constraint shows a nonconvex kink at low numbers of working hours, but the nonconvexity is not particularly large.

5 The data

We use data from the Socio-Economic Panel (SEP). The SEP is a household survey collected by Statistics Netherlands. We use data for the years 1997 to 1999. In this period, households were interviewed on a yearly basis, every May. The income in a given survey wave refers to the previous calendar year: the income information in the survey is based on the income information that individuals used for the tax administration for the previous year, which typically has to be ¯nished and returned to the tax authorities by april. For this reason, we link data from two subsequent waves to get the complete information for one year. Consequently, for each individual we use information for the years 1997 and 1998.

For each year, we selected couples living together (either married or unmarried) without children, in which the male is in the age range of 22 to 60 and the female is no older than 60. We excluded households in which either husband or wife reports to be self-

[31] Note that someone can never deduct more than the value of her/his income.
[32] If the wife's income is 6000 guilders, she can only deduct these 6000.

employed. Furthermore, we require the availability of information on the labour market state of both household members, the non-labour income, and information on the level of schooling and the sector of education. We use information on hourly wage rates and working hours of both partners, but we will also use information on individuals with missing working hours and wage rates.[33] The pooled dataset contains 1385 observations (in which the observation unit is the two-member household).

Table 3 contains descriptive statistics for the pooled data. Note that 85.4% of the male respondents is employed and 72.2% of their female partners. In interpreting these numbers we should recall that we selected couples without children. Therefore, the percentages of males and females working are relatively high in our sample. At the household level we see that in 65.9% of the households both spouses are working and in 19.6% of the households the husband works, while the wife does not. For 8.2% of the households none of the members is working, whereas in only 6.4% of the households only the wife works.

Note that on average the males in the sample are higher educated than the females. We have also information about the direction, or sector, of education and here we see some typical di®erences between males and females. There are few women with a technical type of education whereas the majority of the men followed a technical education. The majority of women is educated for the service sector. There are also more women without specialization in education. The mean age for males is about 2 years higher than for females, which is quite common for married couples.

Mean weekly working hours for males are about 40, whereas females work 31 hours a week on average. The male hourly wage rate is more than 2 guilders higher than the wage rate of females. The non-labour income includes interest income, income out of real estate, rent subsidy, income out of life insurance (\lijfrente"), gifts by family, dividend income and income out of pro¯ts and scholarships. In the survey it is measured on a yearly basis and in table 1 it is converted to guilders per week. The average is about 37 guilders a week, and there is quite some variation in it, with some households reporting much higher amounts, and some households reporting not to have received any

[33] In the estimation, likelihood contributions will be adjusted accordingly.

non-labour income.

We have classified working hours into intervals of 6 hours. Zero working hours is treated as a separate class. The midpoints of the interval is the value of hours that we use for computing utility levels and the like. If h^k denotes the classified midpoint value and h is the observed value, then we classify h as follows:

$$
\begin{aligned}
h^k &= h^0 = 0 \text{ if } h = 0 \\
h^k &= 6k - 3 \text{ if } 6(k-1) < h \leq 6k;\ k = 1, \ldots, 10 \qquad (39) \\
h^k &= h^{11} = 63 \text{ if } h > 63
\end{aligned}
$$

By choosing these hours classes we made some considerations. We wanted to have the amounts of working hours of 38 and 40, that are both often considered as the institutional amount of full time hours in the Netherlands, in one class, the full-time hours class. Moreover, we wanted to have amounts of part-time hours that institutionally occur more often, like 20 and 32, in separate classes. We also wanted to have working weeks of 60 hours a week in a separate class than working more than 60 hours a week, which determines our final class. We use the same classes for men and women. On the one hand, mens' working hours are more contentrated around full time hours, so we might have used a rougher classification of working hours, but we did not want to use an asymmetry in this respect between men and women. Van Soest (1995) also has used classes with 6 hours, although the bounds of his classes were slightly different. He concluded that the classes were sufficiently refined.

6 Estimation results

We have estimated several versions of the model, which differ by the parameter restrictions that are imposed. The parameters of interest are the structural parameters: the parameters of the utility functions of husband and wife in (11) and the parameters of the sharing rule in (16). The model specification in terms of the reduced form parameters in (18) and (20) is in the first place important for the testing of the various restrictions imposed by the sharing rule representation.

We first estimated the structural model parameters without imposing any of the regularity conditions in (13)-(15). Note that the regularity condition (13) can easily imposed on the parameters, whereas the remaining two regularity conditions can be checked afterwards. For none of the partners the estimated parameter values satisfied regularity condition (13) (positive marginal utility of consumption). Therefore, we re-estimated the model. Note that (13) is satisfied for all $h \geq 0$ if $\beta_c^j > 0$ and in addition, if $\beta_{ch}^j < 0$, $\beta_{ch}^j h_j^H + \beta_c^j > 0$, all for $j = m; f$. For men, we found $\beta_{ch}^m < 0$ whereas the condition $\beta_{ch}^H h_m^H + \beta_c^m > 0$ was binding, whereas for women we found $\beta_{ch}^f > 0$ whereas the condition $\beta_c^f > 0$ was binding. Thus, we again re-estimated the model imposing $\beta_c^m = -\beta_{ch}^m h^H$ for men, and imposing $\beta_c^f = \beta_{ch}^f h^1$ for women,[34] such that (13) is satisfied for both men and women in the relevant range of working hours. Summarizing, it turns out that the flexible specification of the utility function does not satisfy the most elementary regularity condition that states that utility is increasing in consumption. This regularity condition needs to be imposed. This is in particular important if we want to use the model for policy simulations with interpretable results.

We tested the restrictions in (27), (28), and (29). Table 4 shows the likelihood values of various specifications. Specification 1. indicates the reduced form parametrization of the utility function in (18) and (20). Specfication 2. is the structural parametrization in terms of the parameters of the sharingule (16) and the utility functions in (11), but we did not impose positive marginal utility of consumption, as discussed above. Therefore, specification 2. is specification 1. with the restrictions (27), (28), and (29) imposed. The likelihood ratio test statistic takes the value ..., wherease the critical value at the 5% level is .... Thus, the restrictions are ....

As discussed before, we imposed the restrictions $\beta_c^m = -\beta_{ch}^m h_m^H$ and $\beta_c^f = \beta_{ch}^f h_f^1$ to obtain a positive marginal utility of consumption (13). Imposing these restrictions in addition to the collective restrictions is labelled specifcation 3. This adds two restrictions to specification 2. The likelihood ratio test statistic for testing the restrictions imposed by specification 3. against specification 1. is ....

If we take for granted that we have to impose positive marginal utility of consump-

[34] Recall that h^H and h^1 indicatee the largest number and the lowest numbwe of working hours from the discrete choice set, respectively.

tion, as the sharing rule specification only gives interpretable results if the utility function satisfies monotonicity, we are interested in testing the additional restrictions provided by the sharing rule resprentation, once monotonicity of the utility function is imposed. First, note that for positive marginal utility of consumption we impose $\beta^f_c = \beta^f_{ch} h^1$ on the woman's utility function. Thus, the 4 restrictions in (28) disappear. Next, imposing $\beta^m_c = -\beta^m_{ch} h^H$ on the man's utility function implies that the restrictions in (27) are imposed and cannot be tested anymore. So the 3 restrictions in (29) remain to be tested. As explained before there is a difference between the restrictions (27) and (28) on the one hand, and (29) on the other hand. The restrictions (27) and (28) are implied by the specification of the utility functions: they do not impose cross restrictions between husband and wife, but restrictions between the parameters of the utility function of a given partner, and here we see that we get the same restrictions if we impose a regularity condition on utility. The parameter restrictions (29) are much more fundamental for testing the collective model. They are cross restrictions between the preference parameters of husband and wife and are of similar form as the collective restrictions obtained with a continuous hours collective model. In terms of the reduced form parameters, imposing $\beta^m_c = -\beta^m_{ch} h^H$ and $\beta^f_c = \beta^f_{ch} h^1$ implies the restrictions $\gamma^f_l = -\delta^f_l h^1; l = 1;3;4;5$ and $\gamma^m_l = -\delta^m_l h^H; l = 1;2;3;5$. Comparing the likelihood value of this variant (variant 4. in table 4) with the structural model in which both monotonicity and the sharing rule specification is imposed (i.e. testing restrictions (29) gives a likelihood ratio test statistic of ..., which implies that the collective restrictions (29) are .... since the critical value at the 5% level is ....

The tables 4 through 7 show the parameter estimates of specification 3. Table 7 contains the taste shifters. They are hard to interpret by themselves, but their impact may become clear once we realize how they affect the marginal utility of working hours. We may say that the base parameters of the marginal utility of working hours are $\beta^j_{0;hh}$ and $\beta^j_{0h}; j = m; f$ (see table 5). These indicate the base effect of the marginal utility of working hours for someone belonging to the base group (man and woman have the highest education level and are not married). From the estimates we can see that the base reaches a peak at a certain level of working hours (i.e. if $\beta^j_{0;h} + 2\beta^j_{0;hh} = 0$). From the estimates in table 7 we can determine how this peak in utility shifts for di®erent taste shifters. For instance, if the peak in utility shifts to the left, we may say that at the same level of income that person can reach a higher utility level at lower working hours than the base. This way we determined that a man with the lowest education level tends to work more than a higher educated man, a man whose wife has the lowest level of education tends to work less than a man with the highest level of education, whereas a man whose wife as an intermediate education level works more, and married men work more than unmarried cohabitants. For women we ¯nd that the marginal utility of working hours decreases if she is married to a low educated man, which gives a strong incentive not to work. The incentive to work rises the more educated the woman is, and married woman tend to work less than unmarried cohabitants.

We have also checked the regularity conditions (14) and (15). Note that if (14) is not satis¯ed the individual may have a strong preference towards working. Also note that as far as the comparison of the utility levels of the two labour market states runs through the ¯xed cost, and in table 5 we can see that the ¯xed cost of work have a positive value, which is in accordance with the idea that working a®ects the utility level negatively. Therefore assumption (14) in a model speci¯cation with ¯xed cost of work mainly addresses the comparison of positive value of working hours. Finally note that we cannot completely identify the sharing rule from the marginal utility of working hours. In section 3 we showed that the parameters $®_0; ¯^m_{0h}$ and $¯^f_{0h}$ cannot be identi¯ed separately, and therefore we have normalized $®_0 = 0$. A violation of (14) may therefore be attributed to the impact of the location of the sahring rule. Assumption (14) is satis¯ed for 42% of the men and for 60% of the women.

In a discrete choice framework concavity of the utility function is not important for locating the utility maximum since the utility is maximized by choosing the highest level of utility. Note that also here $¯^m_{0h}$ and $¯^f_{0h}$ enter the condition, so again violation may be attributed to the location of the sharing rule. Condition (15) is nevertheless satis¯ed for the vaste majority of men (76%) and women (65%).

6.1 The results of the sharing rule

Table 6 shows the results of the sharing rule. The marginal effect of the husband's virtual wage rate on the share is $\alpha_1 h_m + \alpha_4 \omega_f/(\omega_m + \omega_f)^2 = 3.0 h_m - 408\omega_f/(\omega_m + \omega_f)^2$. Thus, we see too opposing effects: the effect that runs through a higher labour income increases the share but a higher virtual wage rate relative to the wive's virtual wage rate decrease the share. The latter may indicate that the husband transfers money to the wife if his relative virtual wage rate increase, such that she may reduce working hours and spend more time on household activities. In total, since the effect depends on male working hours, we may say that men who work more hours have a higher bargaining power within the household. Since the total effect depends on the data, we computed the percentage of households with a positive effect, which is 80.8%. This is about 4% below the percentage of employed men in the sample, so for most employed men we find a positive effect. Since the wife's wage rate enters via the wage fraction, a higher virtual wage rate compared to the husband's leads to a lower share. An interpretation from the point of view of the husband's wage rate has already been given. A different interpretation is that a wife with a higher wage rate can take care of herself and gets less money from the husband. Summarizing, the interpretation of the effect of the fraction D has much to do with care and division of tasks within the household. Note that the wage fraction will not change if the virtual wage rates of husband and wife change with the same percentage. That may happen if marginal tax rates are changed with some percentage, or if in collective wage bargaining all wage rise with the same percentage. Thus, the wage fraction captures effects of unilateral within household changes in the wage rate of one partner, e.g. due to promotion.

The marginal effect of the husband's working hours on the share is given by $3.0\omega_m - 34.9$. It is rising in ω_m, but note that a higher value of working hours may lead to a lower virtual wage rate if a higher tax bracket is reached. We checked the sample and found that the total effect is positive for 90.5% of the observations. Gaining more power over the household income therefore creates an additional incentive for men to work. Finally, the marginal effect of non-labour income itself is $4.3 - 2 \times 0.0049\mu$. It is positive for 91%

of the observations. It shows that for most households the husband receives a higher income the higher is the non-labour income, but the more money goes to the wife the wealthier is the household. Since the wife receives non-labour income minus the share, she recieves 1 ¡ 4:3 + 2 £ 0:0049¹ if the non-labour income increases. This is positive for 19.5% of the households. Summarizing, the husband seems to be the person how has most power over the household's non-labour income.

6.2 Elasticities

We have computed `average elasticities'. We did this by increasing the wages of, say, men, by 1% and we checked what happened to the total of expected working hours of men and women in the sample. The results are in table 8. First, note that the quantitative impact is very small. Bext we see that the total working hours of both men and women decrease if the male wage rate increases. For men, the income e®ect dominates and the they use the increase in the wage rate to decrease working hours. Women reduce their working hours in response to an increase in the husband's wage rate. If the wife's wage rate increases, we see that the response of the husband's working hours is very small: the man's choice of working hours is not very responsive to the wife's wage. The woman's working hours increase upon an increase in her wage. Overall we can say that women's working hours are more responsive to change in wage rates.

6.3 Simulation: from proportional taxation to the °at tax

Table 1: The Dutch tax system: standard deductible amount and marginal tax rate 1st bracket

Year	transferable amount	nontransferable amount	marginal tax rate 1st bracket
1997	7102	0	37.3%
1998	8207	410	36.35%

Amounts in Dutch Guilders
Marginal tax rates of the 2nd and 3rd bracket: 50% and 60%

Table 2: Bracket bounds for income minus standard deductible

Year	upper bound 1st bracket = lower bound 2nd bracket	upper bound 2nd bracket = lower bound 3rd bracket
1997	45960	97422
1998	47184	103774

Table 3: descriptive statistics of the pooled data: 1385 observations

Variable	Husband		Wife
Employment status			
Employed	85.4%		72.2%
Not Employed	14.6%		17.8%
Education level			
Primary	6.5%		10.7%
Lower vocational	15.0%		21.2%
Intermediate	50.3%		44.5%
Higher Vocational	20.2%		17.9%
University degree	7.4%		5.6%
Education sector			
Technical	33.1%		5.4%
Economic/administrative	26.6%		25.6%
General (not specialized)	16.1%		28.4%
Services	24.1%		40.4%
Weekly working hours			
# Observations	n=1120		n=941
Mean	40.7		31.3
(Standard deviation)	(8.5)		(11.5)
Hourly gross wage rates			
# Observations	n=1033		n=860
Mean (Guilders)	30.3		25.4
(Standard deviation)	(10.1)		(8.4)
Age			
Mean	41.5		39.4
(Standard deviation)	(12.1)		(12.4)
Household level variables			
Non-labour income			
Household level, weekly			
Mean (guilders)		36.8	
Standard deviation		(103.3)	
Employment status			
Both partners working		65.9%	
Husband working, wife not		19.6%	
Wife working, husband not		6.4%	
Both not working		8.2%	
Marital status			
Married		67.2%	

Table 4: Likelihood values and Likelihood ratio test statistics

Specification	Likelihood value	LR test statistic	alternative model spec.	degrees of freedom	$\chi^2_{0.05}(r)$
1. Reduced form, unrestricted	....				
2. Sharing rule representation	....	....	1.	..	....
3. Shar. rule repr.	....	.....	2.	..	.....
and monotonicity		...	4.	.	...
4. Reduced form with with monotonicity	....	.....	1.	...	....

Table 5: Estimates of the `structural' parameters

	Husband, j = m		Wife, j = f	
parameter, variable	estimate	std. err.	estimate	std. err.
$\beta^j_{0,hh}$, h_j^2	-0.0071*	0.0037	-0.0044*	0.0023
β^j_{ch}, $h_j C_j/1000$	-0.019*	0.010	0.033**	0.017
β^j_c, $C_j/1000$	1.22*	-0.66	0.10**	0.05
β^j_{0h}, h_j	0.52*	0.27	0.24	0.17
F_j, Fixed Cost	1531*	867	887	2760

**: significant at 5% level, *: 10% level

Table 6: Estimates of the sharing rule

parameter, variable	estimate	std. err.
α_1, $\omega_m h_m$	3.0**	1.5
α_2, μ	4.3**	2.1
α_3, D	-408	1299
α_4, h_m	-34.9*	18.8
α_5, $\mu^2/1000$	-4.9*	2.8

**: significant at 5% level, *: 10% level

Table 7a: Estimates of the `structural model'
The tast shifters: parameters ¯$^{j}_{hh}$

	Husband, j = m		Wife, j = f	
parameter, variable	estimate	std. err.	estimate	std. err.
ln(age husband/17)	-0.07**	0.01	0.031**	0.010
ln(age husband/17) squared	0.06**	0.01	-0.017**	0.006
ln(age wife/17)	0.035**	0.012	-0.059**	0.009
ln(age wife/17) squared	-0.021**	0.009	0.044**	0.006
education level husband 1	0.0089**	0.0020	0.0038**	0.0010
education level husband 2	0.0024*	0.0013	0.0003	0.0009
education level husband 3	0.0005	0.0009	0.00015	0.00062
education level wife 1	-0.0001	0.0017	0.0026	0.0014
education level wife 2	-0.012**	0.002	0.0011	0.0009
education level wife 3	-0.0074**	0.0010	-0.0021**	0.0007
married	-0.0021**	0.0011	0.0018**	0.0008
¯$^{j}_{0}$	-0.013**	0.0001	-0.014**	0.0003

**: signi¯cant at 5% level, *: 10% level

Table 7b: Estimates of the `structural model' parameters
The tast shifters: parameters ¯^j_h

	Husband, j = m		Wife, j = f	
parameter, variable	estimate	std. err.	estimate	std. err.
ln(age husband/17)	5.75**	1.10	-1.97**	0.59
ln(age husband/17) squared	-4.52**	0.77	1.01**	0.35
ln(age wife/17)	-2.68**	0.92	4.38**	0.58
ln(age wife/17) squared	1.65**	0.64	-3.29**	0.39
education level husband 1	-0.69**	0.16	-0.27**	0.06
education level husband 2	-0.18**	0.10	-0.025	0.054
education level husband 3	-0.04	0.07	-0.021	0.039
education level wife 1	-0.02	0.13	-0.23**	0.08
education level wife 2	0.90**	0.12	-0.11**	0.05
education level wife 3	0.56**	0.07	0.11**	0.04
married	0.18**	0.08	-0.14**	0.05
¾$_j$	1.6**	0.1	0.59**	0.05
¾$_{mf}$	0.16**	0.03		

**: signi¯cant at 5% level, *: 10% level

Table 8: Wage elasticities of labour supply

Wage:	Hours men	Hours women
Wage husband	-0.018	-0.086
Wage wife	-0.0083	0.067

A The wage equation

The parameters estimates of the wage equations in (10) are obtained in a first step. The parameters of the wage equation are estimated simultaneously with a selection equation for the labour market state. Let d_j be an indicator taking the value 1 if household member j is employed and taking the value 0 if not. The selection equation is

$$\begin{aligned} d_j^* &= m_j' \theta_j + l_j;\ j = m; f \\ d_j &= \iota(d_j^* > 0) \end{aligned} \qquad (40)$$

The error terms of the wage equation (10) and the selection equation (40) is assumed to be distributed according to the bivariate normal distribution:

$$\begin{pmatrix} l_j \\ v_j \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}; \begin{pmatrix} 1 & \rho_{vl;j}\tau_j \\ \rho_{vl;j}\tau_j & \tau_j^2 \end{pmatrix}\right);\ j = m; f \qquad (41)$$

in which $\rho_{vl;j}$ represents the correlation coefficient between the error term of the wage equation v_j and the error in the selection equation l_j. The parameters $\eta_j; \theta_j; \rho_{lv;j}$, and τ_j are estimated simultaneously by maximum likelihood.

Table A.1 contains the maximum-likelihood estimates of the parameters of the participation equation and table A.2 contains the estimates of the wage equations of both husband and wife. In the wage equation we included a quadratic in the individual's age, dummy variables for the level of education, dumy variables for the type, or sector, of education, and time dummies. Note that the selection equation may be interpreted as an appriximation of the `reduced form' employment equation that follows from the structural model. In the employment equation we include all the variables that appear as taste shifters in the utility function, which are the age of both partners, the level of education of both partners, and the marital status. Since the participation decision also depends on the wage of the partner, we also include the sector dummies of the partner in the employment equation. Because of the `reduced form' nature of the selection equation it is hard to interpret the values of the estimates, and we do not devote much time discussing them. Nevertheless we may point at some interesting interactions of the partner's education on the employment status. We see that men with the lowest level of education have a lower probability of being employment, and we see that men with wives who have any of the middle three education levels have a higher probability of being employed than men whose wives have either the lowest education level or university level. For the female employment status we do not ¯nd a signi¯cant impact of the husband's level of education, but we do see that her probability of being in employment increases monotonically with her own level of education. Since the employment equation is reduced form, we do not know whether this increasing pattern is due to the wage or due to preferences. The correlation coe±cient for the correlation between the errors of the employment and wage equation are signi¯cant for both husband and wife, showing the relevance of incorporating selectivity in the estimation of the parameters of the wage equation.

Table A.2 shows the estimates of the wage equations. Both the wage equation of the husband and of the wife show an increasing pattern in the level of education, and both men and women with an economic/administrative or a general type of education have higher wages than men and women working ing technical or service sector.

Table A1: ML Estimates of the employment equations

	Husband		Wife	
Variable	estimate	std. err.	estimate	std. err.
intercept	-0.70	0.63	1.09*	0.58
log(age husband/17)	7.49**	2.00	-1.19	1.63
log(age husb./17) squared	-4.98**	1.12	0.54	0.94
log(age wife/17)	-2.18	1.72	4.01**	1.24
log(age wife/17) squared	1.17	1.01	-3.33**	0.78
Education level husband 1	-0.91**	0.42	-0.53**	0.21
Education level husband 2	-0.46	0.35	-0.42**	0.20
Education level husband 3	-0.27	0.34	-0.28*	0.18
Education level husband 4	-0.24	0.36	-0.34*	0.18
Education level wife 1	0.07	0.26	-0.90**	0.32
Education level wife 2	0.53**	0.25	-0.63**	0.30
Education level wife 3	0.56**	0.25	-0.33	0.29
Education level wife 4	0.34	0.26	-0.44	0.31
Married	-0.04	0.12	-0.11	0.12

Table A1: ML Estimates of the employment equations (ctd.)

	Husband		Wife	
Variable	estimate	std. err.	estimate	std. err.
Sector Technical husband	0.07	0.13	0.04	0.09
Sector Econ./adm. husband	0.01	0.13	0.15	0.09
Sector General husband	0.25	0.21	0.12	0.14
Sector Technical wife	0.02	0.18	-0.18	0.22
Sector Econ./adm. wife	0.14	0.12	0.28*	0.14
Sector General wife	0.14	0.12	0.17	0.12
1998	0.04	0.09	-0.06	0.09
$\rho_{vl;m}$	-0.975**	0.013	—	—
$\rho_{vl;f}$	—	—	-0.96**	0.02

**: significant at 5% level, *: 10% level

Table A2: ML Estimates of the Wage equations

	Husband		Wife	
Variable	estimate	std. err.	estimate	std. err.
intercept	3.38**	0.23	3.02**	0.20
log(age/17)	-0.19	0.55	0.47	0.47
log(age/17) squared	0.58	0.33	0.16	0.32
Education level 1	-0.27	0.14	-0.15	0.14
Education level 2	-0.34**	0.12	-0.15	0.13
Education level 3	-0.24**	0.12	-0.14	0.12
Education level 4	-0.13	0.13	-0.03	0.14
Technical	-0.005	0.058	0.13	0.11
Econ./adm.	0.047	0.061	-0.016	0.069
General	-0.002	0.074	0.062	0.072
1998	-0.010	0.042	-0.016	0.050
¿m	0.49**	0.01	|	|
¿f	|	|	0.60**	0.02

**: signi¯cant at 5% level, *: 10% level

References

Beninger, D. and F. Laisney (2002), Comparison between Unitary and Collective Models of Household Labor Supply with Taxation, working paper.

Bloemen, H.G. (2003), Job Search, Hours Restrictions, and Desired Hours of Work, Free University, Amsterdam.

Bloemen, H.G. (2004), Am Empirical Model of Collective Household Labour

Supply with Nonparticipation, Discussion Paper, TI 2004-010/3, Tinbergen Institute, Amsterdam.

Bloemen, H.G. and A. Kapteijn (2003), The Estimation of Utility Consistent Labor Supply Models by Means of Simulated Scores, Research Memorandum ALERT 2003-19, Free University, Amsterdam.

Blundell, R, P.A. Chiappori, T. Magnac and C. Meghir (2001), Collective Labor Supply: Heterogeneity and Nonparticipation, working paper WP01/19, The Institute for Fiscal Studies, London.

Blundell, R, A. Duncan, J. McCrae and C. Meghir (1999), Evaluating inwork bene¯t reform: the working families tax credit in the UK, mimeo, London, Institute for Fiscal Studies.

Blundell, R, and T. MaCurdy (1999), Labor supply: a review of alternative approaches, in: O. Ashenfelter and D. Card (eds.), Handbook of Labor Economics, Vol. 3, pp. 1559{1695.

Chiappori, P.A. (1988), Rational Household Labor Supply, Econometrica, Vol. 56, pp. 63{89.

Chiappori, P.A. (1992), Colective Labor Supply and Welfare, Journal of Political Economy, Vol. 100, pp. 437{467.

Chiappori, P.A. (1997), Introducing Household Production in Collective Models of Labor Supply, Journal of Political Economy, Vol. 105, No. 1, pp. 191{209.

Chiappori, P.A, R. Blundell and C. Meghir (2002), Collective Labor Supply with Children, working paper.

Chiappori, P.A, B. Fortin and G. Lacroix (2002), Marriage Market, Divorce Legislation, and Household Labor Supply, Journal of Political Economy, Vol. 110, no. 11, pp. 37{72.

Donni, O. (2003), Collective Household Labor Supply: Nonparticipation and Income Taxation, Journal of Public Economics, Vol. 87, pp. 1179{1198.

Fortin, B. and G. Lacroix (1997), A test of the Unitary and COllective Models of Household Labor Supply, Economic Journal, Vol. 107, pp. 933{955.

Heim, B. T. (2003), Structural estimation of family labor supply with taxes: estimating a continuous hours model using a direct utility speci¯cation, mimeo, Duke Univesity.

Hoynes, H. (1996), Welfare transfers in two-parent families: labor suplpy and welfare participation under ADDC-UP, Econometrica, Vol. 64. pp. 295{332.

Keane, M, and R. Mo±t (1998), A structural model of multiple welfare program participation and labor supply, International Economic Review, Vol. 39, No. 3, pp. 553{589.

Van Soest, A.H.O. (1995), Structural Models of Family Labor Supply: A Discrete Choice Approach, Journal of Human Resources, Vol. 30, No. 1, pp. 63{88.

Van Soest, A.H.O. and M. Das (2001), Family Labor Supply and Proposed Tax Reforms in the Netherlands, De Economist, Vol. 149, No. 2, pp. 191{218.

Vermeulen, F. (2002), A Collective Model for Female Labour Supply with Nonparticipation and Taxation.