A collective model for female labour supply with nonparticipation and taxation

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Abstract

This paper presents a collective discrete-choice model for female labour supply. Preferences of females and the intrahousehold allocation process are both econometrically identified. The model incorporates nonparticipation and nonlinear taxation. It is applied to Belgian microdata and is used to evaluate two revenue-neutral versions of the 2001 Tax Reform Act. We find small positive behavioural responses to the reforms. The reforms are not unambiguously welfare improving. Generally, the first revenue-neutral reform (the actual reform and a household lump-sum tax) is more beneficial to females in couples than the second (the actual reform and a proportional decrease of household disposable incomes).

Key words: collective household models, labour supply, tax reform.
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1 Introduction

Evaluations of the impact of tax reforms on employment and hours of work are usually cast in the unitary framework, which assumes that households, even if they consist of several individuals, behave as if they were single decision-making units. Recent examples of such tax reform evaluations include Hoynes (1996) and Blundell et al. (1999). One important deficiency of the unitary approach, from a welfare economic point of view, is that it is not able to say anything about the intrahousehold allocation of welfare. Apps and Rees (1988) and Brett (1998) have shown, however, that normative welfare analyses cannot, in general, ignore intrahousehold distributional issues. Another shortcoming of the approach is that its theoretical implications seem to be overly restrictive. These implications were consequently repeatedly rejected when confronted with household labour supply data (see Fortin and Lacroix, 1997 for some recent evidence).

A valuable alternative to the unitary approach is the collective approach to household behaviour. This approach, introduced by Chiappori (1988, 1992) and Apps and Rees (1988), takes account of the fact that multi-person households consist of several individuals who each have their own preferences. It is assumed that these individuals are involved in an intrahousehold bargaining process that results in Pareto-efficient intrahousehold allocations. The collective approach implies other behavioural restrictions than the unitary model (see, e.g., Chiappori, 1988, 1992, and Browning and Chiappori, 1998). Contrary to the unitary model's restrictions, the testable implications of the collective model turn out to be less restrictive (see references in Vermeulen, 2002a). Moreover, the specific setting of the collective model makes it possible to analyse the intrahousehold welfare distribution under some additional assumptions (see Chiappori, 1988, 1992). Clear evidence of conflicting outcomes of the unitary and collective approaches with respect to welfare evaluations of tax reforms is given in the different contributions in Laisney (2002).

Over time, many topics in the labour supply literature have been translated into a collective setting. Chiappori (1988, 1992) and Chiappori, Fortin and Lacroix (2002) derive collective restrictions and identification results with respect to individual preferences and the intrahousehold allocation process. These studies do not take into account taxation and nonparticipation. Blundell et al. (2001) derive testable implications and identification results for a collective labour supply model that allows for both nonparticipation and unobserved preference heterogeneity. Nonparticipation and nonlinear taxation are explored in Donni (2003). Under some additional assumptions, partial identification of individual preferences and the intrahousehold allocation process is possible. The model, without nonparticipation, was applied in Moreau and Donni (2002).

To the best of our knowledge, the only empirical studies that tackle both nonparticipation and nonlinear taxation are the contributions in Laisney (2002). These studies model household labour supply as a discrete-choice problem. Individuals are thus assumed to have the choice between a discrete set of labour supply options. This approach, which is rather popular nowadays, allows incorporating very general nonlinear and nonconvex tax schemes (see van Soest, 1995, Bingley and Walker, 1997, Keane and Moffitt, 1998, Blundell et al., 1999, and Gong and van Soest, 2002). In Laisney (2002), individual preferences and the intrahousehold allocation process are identified, in a piecemeal way, by means of both econometric estimation and a calibration stage.

The aim of this paper is to present a collective and *econometrically identifiable* discrete-choice model for female labour supply. The model is fairly general in that it incorporates both nonparticipation and nonlinear taxation. The focus on female choice behaviour is driven by the empirical observation that almost all men in the sample we use are employed full-time. Their contractual working hours typically reflect the number of hours that are worked in many economic sectors. The intrahousehold allocation process and the preferences of women in couples are *completely* identified by assuming that their preferences are egoistic and to some extent identical to those of single women. Egoistic preferences are more restrictive than those assumed in Laisney (2002). In the latter study, externalities within a household with respect to labour supply were allowed at the cost of a piecemeal identification procedure. Alternatively, our assumption is less restrictive than the assumption of equal preferences between singles and individuals in couples that was made in Barmby and Smith (2001) to obtain complete identification. Moreover, their model does not take into account nonlinear taxation and nonparticipation issues.

It will be shown that the model presented here allows for richer behavioural implications than the unitary model. The model is also able to say something about who gets what in the household. Consequently, normative welfare analyses can be done at the individual level, rather than at the household level. The model is applied to Belgian microdata. The sample selection is for childless individuals who are working or are voluntarily unemployed. Students, the self-employed, the involuntarily unemployed and retired people are excluded from the dataset. The model will be used as a basis for an evaluation of the impact on employment, hours and individual consumption of the Belgian 2001 Tax Reform Act, which was implemented between the years 2001 and 2004 and embodies some important changes with respect to the pre reform tax system. Since this reform is not revenue-neutral, we will actually evaluate two alternative tax reforms that preserve revenue-neutrality. The first of these reforms adds a lump-sum tax imposed on households to the actual reform. The alternative reform implies a proportional decrease of the disposable income of households after implementation of the actual reform. Although both reforms generate the same tax revenue, they may have different effects on labour supply and intrahousehold allocations.

The remainder of the paper is organized as follows. Section 2 presents the economic model that is cast in a collective framework. Section 3 briefly describes the current Belgian tax system and covers the main features of the 2001 Tax Reform Act. Section 4 discusses the data and presents model estimates. Tax reform simulation results are given in Section 5. Section 6 concludes.

2 The economic model

2.1 A sharing rule interpretation

We consider households consisting of two working-age individuals (m and f) and female singles. Labour supply of single men and of men in couples is assumed to be fixed at full-time working hours. Empirical evidence for this assumption is given in Section 4. Note that the assumption is also supported by Pencavel (1986), who concludes that male labour supply is rather insensitive to

changes in economic variables such as wages and nonlabour income. Further, it is assumed that preferences of individuals in couples are egoistic (see Chiappori, 1988). In other words, utility is derived from only own consumption and leisure.

Preferences of females are represented by the following well-behaved direct utility function:

$$u^f = v^f\left(c^f, l^f, \mathbf{d}^f\right), \tag{1}$$

where c^f denotes the female's private consumption of a Hicksian aggregate commodity, l^f is leisure and $\mathbf{d}^f$ is a vector of demographic characteristics (e.g., a variable indicating whether the female is single or living in a couple, age and education level). Budget constraints for female singles and couples are respectively equal to

$$c^f \leq y + w^f \ell^f - \tau^f\left(w^f \ell^f, y, \mathbf{d}^f\right) \tag{2}$$

and

$$c^m + c^f \leq y + w^m \ell^m + w^f \ell^f - \tau^c\left(w^m \ell^m, w^f \ell^f, y, \mathbf{d}^m, \mathbf{d}^f\right) = x, \tag{3}$$

where w^i denotes individual i's gross hourly wage rate, ℓ^i is individual i's labour supply ($\ell^i = T - l^i$, where T is total time available), c^m is the male's private consumption, y is nonlabour or other income and τ^f and τ^c are tax functions that capture the income tax, which generally depends on earned incomes, other income and demographic characteristics. Finally, denote total household means by x.[1]

The core assumption in the collective approach is that individuals in couples choose Pareto-efficient allocations (see Chiappori, 1988, 1992). It is a well-known result that if preferences are of the egoistic type and budget constraints are linear, then any Pareto-efficient allocation can be represented as a two-stage budgeting process. In the first stage, household members divide total household nonlabour income among themselves. In the second step, each individual maximizes her or his own utility subject to an individual budget constraint resulting from the first-stage allocation. This result has been generalized by Donni (2003) to a setting with nonparticipation and nonlinear taxation giving rise to convex budget sets. In our model with fixed male labour supply, Pareto-efficiency of intrahousehold allocations amounts to the following maximization problem:

$$\max_{c^f, l^f} v^f\left(c^f, l^f, \mathbf{d}^f\right) \tag{4}$$

subject to

$$c^f \leq \phi\left(x, \mathbf{z}\right),$$

where ϕ is a function determining the part of total household consumption x that is transferred to the woman in the couple.[2] Following Chiappori (1988), we call ϕ the *sharing rule*. In general, this sharing rule will depend on a number of variables $\mathbf{z}$ that influence an individual's bargaining power in the household. In Chiappori (1988, 1992), individual wages and other income act as such variables. In a setting with nonlinear income taxation, however, these variables seem to be less adequate. Our empirical exercise will make use of a variable that has already proved useful in the different contributions in Laisney (2002). It captures the *earning capacity* of the female in the household. The variable is defined as the difference between total household consumption when the female works full-time and total household consumption when she does not participate in the labour

market. This variable thus incorporates elements related to her productivity and elements related to the nonlinear tax system.[3]

How can we now identify efficiently both preferences of females, as represented by v^f, and the sharing rule, as represented by ϕ? Note that in labour supply datasets, only *total* household consumption (net income) is observed, and not the private consumption levels c^m and c^f. This rules out a direct estimation of females' preferences by means of the variables c^f and ℓ^f, via a discrete-choice model, for instance.

One possibility to identify preferences and the sharing rule is to make use of observed labour supply behaviour of single women (in addition to couples' behaviour). Note that preferences of singles can easily be identified by means of standard techniques, since the unitary approach is fully applicable to them. In Barmby and Smith (2001), for example, preferences of individuals in couples are identified by assuming that their preferences equal those of singles. As will be shown below, we do not have to go that far to identify both preferences and the sharing rule. However, our assumption to obtain *complete* identification is more restrictive than the approach followed by Chiappori (1988, 1992) and Donni (2003). The latter studies make use of only the information in a couples dataset to identify the sharing rule up to an additive constant and preferences up to a translation (i.e., incomplete identification).

2.2 Empirical specification of the model

We opt for a discrete-choice model for female labour supply. This approach, which was introduced by van Soest (1995), assumes that individuals can choose between a limited number of labour supply options. The specific setting allows incorporating very general (e.g., nonlinear and noncontinuous) tax schemes. The optimization problem consists of comparing the different utility levels associated with each of the available hours choices and choosing the one that yields the highest utility.

Let us assume that females have J labour supply choices, each associated with a particular consumption level. Preferences of females are assumed to be representable by a restricted version of the quadratic direct utility function (see Stern, 1986). The utility that female i derives from labour supply choice j is given by

$$\begin{aligned} u_{ij}^f &= v^f\left(c_{ij}^f, l_{ij}^f, \mathbf{d}_i^f\right) + \varepsilon_{ij} \qquad (5)\\ &= \beta_{\ell\ell}\left(\mathbf{d}_i^f\right)\cdot\left(\ell_{ij}^f\right)^2 + \beta_{c\ell}\cdot\ell_{ij}^f c_{ij}^f + \beta_c\cdot c_{ij}^f + \beta_\ell\left(\mathbf{d}_i^f\right)\cdot\ell_{ij}^f + \varepsilon_{ij}, \end{aligned}$$

where $\ell_{ij}^f = T - l_{ij}^f$ and ε_{ij} is an unobserved preference component that is assumed to be distributed as a type I extreme value random variable. The preference parameters $\beta_{\ell\ell}\left(\mathbf{d}_i^f\right)$ and $\beta_\ell\left(\mathbf{d}_i^f\right)$ are assumed to be heterogeneous across individuals, and are of the following form:

$$\beta_{\ell\ell}\left(\mathbf{d}_i^f\right) = \beta_{\ell\ell 0} + \boldsymbol{\beta}'_{\ell\ell 1}\mathbf{d}_i^f + \upsilon_{\ell\ell i} \qquad (6)$$

and

$$\beta_\ell\left(\mathbf{d}_i^f\right) = \beta_{\ell 0} + \boldsymbol{\beta}'_{\ell 1}\mathbf{d}_i^f + \upsilon_{\ell i}. \qquad (7)$$

Following Train (1998), an extra source of unobserved preference heterogeneity across individuals is introduced via the disturbances $\upsilon_{\ell\ell i}$ and $\upsilon_{\ell i}$. These are assumed to be mean zero normally distributed and independent of each other: $(\upsilon_{\ell\ell i}, \upsilon_{\ell i}) \backsim N_2\left(0, 0, \sigma^2_{\upsilon_{\ell\ell}}, \sigma^2_{\upsilon_\ell}, 0\right)$.

Necessary elements for the application of a discrete-choice model are the individual consumption levels c^f_{ij} associated with the different labour supply choices. For single females, these consumption levels are observed, given gross wage rates (observed for participants, estimated for nonparticipants; cf. infra), other income, individual characteristics and the tax system. As already mentioned, private consumption levels of women in couples are *not* observed. We know, however, that the female's private consumption at the j'th labour supply choice c^f_{ij} equals the share of total household consumption x_{ij} that is allocated to her by means of the sharing rule ϕ. Let us assume that this sharing rule is of the following form:

$$\phi\left(x_{ij}, z_i\right) = \left(1 + \kappa_1 + \kappa_2 z_i\right) \cdot x_{ij}, \tag{8}$$

where z_i is the female's earning capacity, and κ_1 and κ_2 are parameters that are to be estimated.[4] Note that $0 < 1 + \kappa_1 + \kappa_2 z_i < 1$. By making use of a dummy variable s_i, which indicates whether female i is single ($s_i = 0$) or living in a couple ($s_i = 1$), we can define a budget constraint that is simultaneously applicable to both single females and those in couples:

$$c^f_{ij} = \left(1 + \kappa_1 s_i + \kappa_2 s_i z_i\right) \cdot x_{ij}. \tag{9}$$

Substituting equation (9) for c^f_{ij} in equation (5), we obtain the following 'collective' female utility function with observable regressors:

$$\begin{aligned} u^f_{ij} \quad = \quad & \beta_{\ell\ell}\left(\mathbf{d}^f_i\right) \cdot \left(\ell^f_{ij}\right)^2 + \beta_{c\ell} \cdot \ell^f_{ij} \cdot \left(1 + \kappa_1 s_i + \kappa_2 s_i z_i\right) \cdot x_{ij} \\ & + \beta_c \cdot \left(1 + \kappa_1 s_i + \kappa_2 s_i z_i\right) \cdot x_{ij} + \beta_\ell\left(\mathbf{d}^f_i\right) \cdot \ell^f_{ij} + \varepsilon_{ij}. \end{aligned} \tag{10}$$

Application of this structural form in a random-parameters logit model results in the direct identification of the parameters $\beta_{\ell\ell}\left(\mathbf{d}^f_i\right)$, $\beta_{c\ell}$, $\beta^*_{c\ell 1} = \beta_{c\ell}\kappa_1$, $\beta^*_{c\ell 2} = \beta_{c\ell}\kappa_2$, β_c, $\beta^*_{c1} = \beta_c\kappa_1$, $\beta^*_{c2} = \beta_c\kappa_2$ and $\beta_\ell\left(\mathbf{d}^f_i\right)$. By means of these estimates, we can derive the sharing rule parameters:

$$\kappa_1 = \frac{\beta^*_{c\ell 1}}{\beta_{c\ell}} = \frac{\beta^*_{c1}}{\beta_c} \tag{11}$$

and

$$\kappa_2 = \frac{\beta^*_{c\ell 2}}{\beta_{c\ell}} = \frac{\beta^*_{c2}}{\beta_c}. \tag{12}$$

Equations (11) and (12) imply two testable restrictions of this collective labour supply model. The underlying idea is that the female's private consumption can change only via the sharing rule that allocates total household consumption to both household members. Since the female's private consumption occurs twice in the given functional form, the sharing rule should twice have the same effect on female consumption. Note that these restrictions are implied by the specific functional form rather than by the collective approach as such.

It is also clear from equations (10), (11) and (12) that the equality of the preference parameters $\beta_{c\ell}$ and β_c for single women and females in couples is necessary and sufficient for the identification of both female preferences and the sharing rule. Without it, preferences and the sharing rule cannot be disentangled. Nevertheless, there is much room for preference variation between singles and females in couples with respect to the parameters $\beta_{\ell\ell}\left(\mathbf{d}_i^f\right)$ and $\beta_\ell\left(\mathbf{d}_i^f\right)$. Marginal rates of substitution between consumption and leisure may well differ, implying that the above assumption does not seem to be overly restrictive.[5]

Apart from the above collective restrictions, the model implies the standard unitary restrictions on the female's utility function. These restrictions boil down to the utility function (5) being (strictly) quasi-concave, monotonically increasing in consumption c^f and monotonically decreasing in labour supply ℓ^f. This implies the following restrictions on the parameters for all $\left(c^f, \ell^f\right)$:

$\beta_{c\ell}\ell^f + \beta_c > 0$ (monotonicity restriction w.r.t. consumption)

$2\beta_{\ell\ell}\left(\mathbf{d}^f\right)\ell^f + \beta_{c\ell}c^f + \beta_\ell\left(\mathbf{d}^f\right) < 0$ (monotonicity restriction w.r.t. labour supply)

$\beta_{c\ell}\left[2\beta_{\ell\ell}\left(\mathbf{d}^f\right)\ell^f + \beta_{c\ell}c^f + \beta_\ell\left(\mathbf{d}^f\right)\right] - \beta_{\ell\ell}\left(\mathbf{d}^f\right)\left[\beta_{c\ell}\ell^f + \beta_c\right] > 0$ (quasi-concavity restriction).

Note that the last two restrictions depend on the unobserved disturbances coming from the assumed preference heterogeneity across individuals. One possibility is a test of these restrictions for the expected value of the parameters $\beta_{\ell\ell}\left(\mathbf{d}^f\right)$ and $\beta_\ell\left(\mathbf{d}^f\right)$.

3 The Belgian tax-benefit system and the 2001 Tax Reform Act

3.1 The Belgian tax-benefit system

The empirical exercise focuses on a simplified tax-benefit system. One simplification is that the dataset used lacks information on many items that affect the tax liability of households. Examples of such items are contributions to private pension funds and capital redemptions due to mortgage loans. The selected sample for the empirical exercise also allows us to safely restrict attention to tax rules that are applicable to labour incomes and to ignore rules on incomes coming from, e.g., pensions and unemployment benefits. Also child benefits do not have to be taken into account, since we focus on childless households. We will sketch only the tax system that applies to the selected sample. A more elaborate discussion of the Belgian tax-benefit system can be found in Vermeulen (2002b).

The simplified tax scheme for the year 2000 that is used for the sample of single women consists of four main components. These are (1) the social security tax that is to be paid by employees, (2) the standard deductions, (3) the marginal tax rate scheme and (4) the standard tax credits. The social security tax is equal to a constant rate of 13.07%, which is applied to gross labour income. In a next step, standard expenses are deducted from labour income net of social security contributions at a decreasing marginal rate ranging from 20% on the first 4,165 euro to 3% on the bracket up to 55,470 euro. After these

standard deductions, the marginal tax rate scheme is applied to taxable labour income. This marginal tax rate scheme consists of seven marginal tax rates, ranging from 25%, applied to the first 6,400 euro, to 55% for the taxable labour income above 61,230 euro. This operation results in the gross tax liability. Net tax liability is obtained by subtracting the appropriate tax credits. The first tax credit is that related to the basic exemption from income taxation. For a single, this exemption equals about 5,200 euro. If taxable labour income is higher than this exemption, a credit of about 1,300 euro is obtained. Next to this tax credit is the tax credit related to family size. Since the households in the selected sample are childless, this credit can be ignored in the empirical exercise. Finally, there is a negative tax credit related to the temporary crisis surcharge.[6] After application of the other tax credits, an extra tax rate of 3% is applied to the resulting tax liability.

The tax scheme for married couples differs from the above tax scheme in two respects. First of all, married individuals can make use of the so-called 'marital quotient' if some conditions are satisfied. This tax rule allows shifting a part of the taxable labour income of one of the spouses to the other. In our simplified tax scheme, couples are allowed to make use of this marital quotient if the taxable labour income of the spouse with the lowest earnings does not exceed 30% of the joint taxable labour income. The part that is shifted to the spouse with the lowest earnings equals 30% of joint taxable labour income, minus the own taxable labour income of that spouse (with a maximum of about 7,500 euro, however). A second main difference between the tax scheme for singles and couples is the basic exemption that is related to the tax credit. This exemption equals about 4,140 euro for each spouse.

3.2 The 2001 Tax Reform Act

In August 2001, the new Tax Reform Act was proclaimed. This reform was scheduled for implementation over the period 2001 to 2004, and implies some relatively sweeping changes of the current tax system. According to the government, the cost of this reform is estimated at 3.25 billion euro, or 10.7% of the amount generated in 2001 by the personal income tax system net of the temporary crisis surcharge (see Reynders, 2000). Worthy of note for the selected sample in the empirical exercise are four main measures.

The first important alteration in the current tax system is the introduction of a refundable tax credit for the lowest labour incomes. A tax credit of about 620 euro will be given to individuals with a labour income (after deduction of social security contributions and deductions for professional expenses) between about 3,700 and 12,400 euro. Eligible working individuals who either do not pay taxes or pay less taxes than this credit receive an extra income equal to the difference between the credit and the taxes paid. Individuals that participate in the labour market and earn less or more than the above-mentioned boundaries may be eligible for a reduced tax credit. The government, through this in-work tax credit, aims to improve work incentives by making work pay and to boost the income position of some working individuals.

A second feature of the tax reform is the broadening of the middle tax brackets and the lowering of the two highest marginal tax rates from 52.5% and 55% to 50%. This measure is introduced to relieve the fiscal pressure on respectively the middle and the highest incomes.

A third measure equalizes the tax exemption of married individuals and singles. The current system features different tax exemptions for married individuals and (possibly cohabiting) singles. This exemption is to be brought up to the higher singles' level.

Finally, the marital quotient will also be applicable to unmarried individuals with a cohabitation contract.

The tax reform described above is not revenue-neutral. We will therefore add two alternative tax parameters to the actual reform in order to preserve revenue-neutrality. Note that the choice of how revenue-neutrality is obtained is not entirely innocent in a model focusing on spouses' bargaining over intrahousehold allocations; the latter may well differ over different tax systems generating the same revenue. The first revenue-neutral reform receiving our focus is the actual reform complemented with a lump-sum tax at the household level. This lump sum is defined in such a way that the same tax revenue on couples is generated as in the pre reform situation. The alternative reform that we focus on decreases couples' disposable incomes after application of the actual reform by the same percentage, such that equal tax revenue is preserved. Of course, both the lump-sum tax and the percentage decrease in disposable income cannot be determined beforehand (due to the behavioural reactions). Both tax parameters will be obtained by means of a trial-and-error procedure in the tax reform simulations.

4 Data and empirical results

4.1 Data

The data are drawn from the 1992 and 1997 Socio-Economic Panel (SEP) of the Center for Social Policy (University of Antwerp). This panel is representative of the Belgian population and is primarily used for research into poverty issues, the effectiveness of social security and welfare distribution.[7]

Two samples are selected for the empirical exercise. The first consists of female singles without children, aged between 25 and 55 (inclusive), and who are employed or voluntarily unemployed. Students, the self-employed, the unemployed and retired people are excluded from the dataset. The second sample consists of married or de-facto couples subject to the same sample selection as single females. To minimize the impact of measurement error, individuals with wages below or above the 1st and 99th percentiles of the wage distribution were also excluded. The sample sizes are, respectively, 128 and 340 for female singles and couples. Note that hourly gross wage rates are unobserved for individuals who do not participate in the labour market. These wages are estimated by means of Heckman's two-step estimation procedure (see Vermeulen, 2002b for more detailed results).

Table 1 provides summary statistics on both selected samples. Histograms on average weekly contractual hours of singles and individuals in couples are given in Figures 1-4.[8] As is clear from Figures 2 and 4, the labour supply of men is highly concentrated around 38 hours. Only a small fraction of men have a contractual labour supply that deviates from this mode. Moreover, there are no men who are not working in the selected sample. This fleshes out the assumption made earlier that all men work full-time. Labour supply of women has a larger variance. Figures 1 and 3 clearly show that an important fraction of

the females do not participate in the labour market. This fraction is higher for women in couples than for singles. A not unimportant fraction of the females are working part-time, with peaks around 20 and 30 hours.

In the empirical exercise, we assume that women have the following discrete-choice set: $\ell^f \in \{0, 20, 30, 38\}$.[9] For each of these weekly hours choices, the corresponding household net income (i.e., total household consumption) is calculated. This net income depends on the individuals' gross hourly wages, the household's nonlabour income and the tax system.

[Table 1 about here]

[Figure 1 about here]

[Figure 2 about here]
[Figure 3 about here]

[Figure 4 about here]

4.2 Empirical results

The second column of Table 2 reports unrestricted estimates of the model for female labour supply (see equation (10)).[10] According to a likelihood ratio test, the conditional logit model (in other words, the model without unobserved preference heterogeneity with respect to $\left(\ell^f\right)^2$ and ℓ^f) cannot be rejected. Twice the difference between the log likelihood of the unrestricted model and the log likelihood of the restricted model equals 0.15. This test statistic is to be compared to the critical value $\chi^2_{0.05}(2) = 5.99$.

Let us now turn our attention to the explanatory variables that are specific to the collective approach. Two variables related to the sharing rule are significantly estimated at the 5% significance level. Important with respect to the collective model described above is the fact that a Wald test cannot reject the restrictions (11) and (12). The test statistic equals 2.74 and is lower than the critical value $\chi^2_{0.05}(2)$. The unitary monotonicity and quasi-concavity restrictions were tested by checking whether they are satisfied for all observations in the sample.[11] Contrary to the above collective restrictions, results are not quite satisfactory. Monotonicity with respect to consumption is not satisfied for the 38 hours choice. The marginal utility of labour is positive for 74% of the labour supply choices checked. The concavity restriction is not satisfied for 94% of the labour supply choices.[12] Since these unitary rejections are problematic from a policy evaluation point of view, we re-estimated the model with monotonicity with respect to consumption and the collective restrictions imposed.[13] The estimation results are reported in the third column of Table 2. Quite interestingly, the number of correctly predicted labour supply choices increased rather dramatically. Moreover, the imposed restrictions cannot be rejected by means of a likelihood ratio test; the test statistic of 6.99 is lower than the critical value $\chi^2_{0.05}(3) = 7.82$.

Using the estimated coefficients and equations (11) and (12), we can derive the sharing rule parameters κ_1 and κ_2. These are respectively equal to -0.82341 and 0.00047, with corresponding standard errors of 0.14595 and 0.00010. This

implies the following sharing rule for the j'th hours choice of individual i (see equation (8)):

$$\phi(x_{ij}, z_i) = (0.17659 + 0.00047 \cdot z_i) \cdot x_{ij}. \tag{13}$$

The share of total household consumption that is shifted to the female in a couple is thus positively, and significantly, related to her earning capacity. This sharing rule enables us to estimate the private consumption assigned to the female, given her earning capacity and total household consumption (see next section).

[Table 2 about here]

5 Policy simulations

This section evaluates the Belgian 2001 Tax Reform Act. More specifically, we will concentrate on the measures defined in this reform that are applicable to the couples in our selected sample. As has already been mentioned, a main advantage of the collective approach is that it makes it possible to identify gainers and losers from the tax reform at the individual level, rather than at the household level. In other words, intrahousehold distributional issues can be considered.

We simulated the tax reform by calculating the pre- and post reform hours choices that are most likely given the estimated model parameters and the household's budget set (i.e., net incomes for all four hours choices) for all females in couples. In general, two types of behavioural responses to the tax reform will come into play. The first effect is due to the fact that the tax reform implies a change of the household budget set. In other words, for each labour supply choice, a different net income is obtained after the tax reform. The impact of the reform on the individuals' labour supply and consumption will depend on the standard interaction between income and substitution effects. This is not the end of the story, however, since the reform may also imply a change of the bargaining position of the individuals in couples, which is captured by the sharing rule. This alteration entails an impact on both the magnitude and the allocation of total household consumption to the household members. It implies an extra behavioural effect on top of the standard effects that are incorporated in the unitary approach.

Note that we do not focus on the actual reform here, but on two alternative reforms that complement the tax reform with either a lump-sum tax on couples or a proportional decrease of couples' disposable incomes in order to preserve revenue-neutrality (see Section 3.2). As already mentioned earlier, a trial-and-error procedure was followed to determine the latter additional tax parameters. It turns out that a lump-sum tax of 22 euro per week (or 1144 euro per year) is needed to make the actual tax reform revenue-neutral for the couples in the selected sample. The same tax revenue can be generated if one decreases couples' disposable incomes after the actual tax reform by about 3.65%.

Table 3 gives some summary statistics based on the pre- and post reform simulations for couples. As is clear from the table, both alternative revenue-neutral tax reforms are associated with very small positive behavioural responses: the average labour supply of females in couples is increased by about 0.07%. Both reforms also imply a slight increase of the average household consumption or net

income. The impact of the reforms on the individual consumption levels differs, however. If the actual tax reform is made revenue-neutral by adding a lump-sum tax at the couples' level, then the average individual consumption of women in couples increases slightly, whereas the average male consumption decreases slightly. The reverse picture emerges if we focus on the second revenue-neutral reform. If, next to the actual reform, households are also faced with a proportional decrease in disposable income, then the average weekly consumption of females in couples decreases by about two euro while the average consumption of males increases by about the same amount. It is also striking that the average individual consumption of women (both before and after the reform) is much lower than that of males. This lower consumption is compensated to some extent, since women in couples work, on average, ten hours less per week than their partners. Going somewhat further than a purely positive description of the aggregate impact of the reform, under strong measurability and interpersonal comparability assumptions the utility of women is slightly increased on average for the first reform, while it is decreased for the second revenue-neutral reform. Note that these results clearly show that intrahousehold distributional issues may be important. Although both alternative tax reforms generate the same tax revenue as in the pre reform situation, and entail similar labour supply responses, the impact on intrahousehold allocations is quite different. It seems that women are better off, on average, if the actual tax reform is complemented with a lump-sum tax, than when a proportional decrease of the disposable income is added (see also further).

[Table 3 about here]

Tables 4 and 5 show simulated labour supply responses to both tax reforms for females in couples. As is clear from the tables, responses are rather moderate. Most of the females in couples remain in the status quo position (i.e., 98.5% are on the diagonal in Table 4, while 99.4% do not change labour supply according to Table 5). Interestingly, only females who worked full-time or did not participate before the reform react; no changes occur for part-time working females. Note also that both reforms imply a very small increase in labor force participation.

[Table 4 about here]

[Table 5 about here]

Let us finally concentrate on the number of gainers and losers from the tax reforms. Contrary to studies based on unitary models, which can only concentrate on households as a whole, the collective approach allows us to apply a welfare analysis at the level of individuals. Tables 6 and 7 show the numbers of gainers and losers from the tax reforms for individuals in couples. As is clear from the tables, both revenue-neutral tax reforms imply a different impact on the welfare levels for different households.[14] Although the reforms imply a strict Pareto improvement for many couples, a considerable number of couples are characterized by both household members strictly losing with respect to their pre reform situation. There are also many households in which the female is better off after the reform, while the partner is worse off (or vice versa). When we compare both revenue-neutral tax reforms, we can see that the first

reform (actual reform and lump sum tax) is associated with fewer couples where both individuals gain from the reform than the second reform (actual reform and percentage decrease of the households' disposable incomes); these numbers are respectively equal to 95 and 129. The first tax reform further implies a higher number of women who have a (weakly) increased utility level than the second tax reform (239 versus 189 females who are better off). A reverse picture emerges for males. In the first reform, 138 males in couples are better off after the reform, while this is the case for 186 males for the second reform.

[Table 6 about here]

[Table 7 about here]

Once again, although both alternative reforms generate the same tax revenue and almost the same post reform labour supply for females, the impact on individual welfare levels is quite different. Women are, on average, better off when a lump-sum tax is added to the actual reform in order to preserve revenue-neutrality, than when the actual reform is complemented with a proportional decrease of the household's disposable income. The main reason for this result can be found by examining the impact of the reforms on the earning capacity of females (which positively affects their consumption share). The lump-sum component in the first revenue-neutral reform has no effect on earning capacity. The percentage decrease of the household's disposable income, however, does impact this distribution factor. *Ceteris paribus*, the earning capacity will be higher for the first reform than for the second. This is reflected in a lower female consumption share for the latter reform. Since labour supply remains constant for most females, this lower consumption share is thus associated with a lower utility level.

6 Conclusion

This paper presents a new methodology to estimate a discrete-choice model for female labour supply. The model is cast in the collective setting and is fairly general in that it allows for both nonparticipation and nonlinear taxation. Identification of the model is obtained by assuming that some, but not all, preference parameters of single females and those in couples are identical; marginal rates of substitution between consumption and leisure may well differ. By means of this (not very restrictive) assumption, both females' preferences and the rule governing the sharing of total household consumption, as a function of the earning capacity of the female, are econometrically identifiable. This feature is rather important, since it allows us to consider intrahousehold distributional issues, in addition to standard interhousehold ones.

The model is applied to Belgian microdata and is used to evaluate the 2001 Tax Reform Act. This tax reform incorporates some important changes of the pre reform tax system. Since the actual reform is not revenue-neutral, we considered two alternative reforms. The first adds a lump-sum tax at the household level to the actual reform in order to preserve revenue-neutrality. The second reform keeps tax revenue constant by a proportional decrease of the household's disposable income after implementation of the actual reform.

Two types of theoretical restrictions are implied by the specific model we use. A first restriction is linked to the collective setting and is not rejected by the data. The model also implies some standard unitary restrictions on the identified female preferences. The latter restrictions, however, are rejected when confronted with the data. As to the sharing rule, the earning capacity of females has a significantly estimated positive impact on the share in total household consumption that is shifted to women.

The impact of both revenue-neutral tax reforms on hours and participation is moderate. About 1.5% of the females in couples change labour supply after implementation of the first reform, while this is the case for only 0.6% of the females with respect to the second reform. Neither tax reforms imply an unambiguously positive impact on the individuals' welfare levels. For some households, the tax reforms are a strict Pareto improvement. Other couples, however, are characterized by both individuals strictly losing from the reforms. In a considerable number of households, one individual is better off after the reforms, while their partner is worse off. Although the impact on labour supply is similar for both revenue-neutral reforms, they affect the individuals' welfare in a different way. Generally, the tax reform in which the actual reform is complemented with a lump-sum tax is more beneficial to females, than the reform in which a proportional decrease in the household's disposable income is added. This can be explained by the differential impact of the reforms on female earning capacity. Note that such results, which refer to the intrahousehold allocation of welfare, cannot be obtained in the standard unitary approach to household labour supply.

Although the obtained results are not entirely satisfactory due to the rejection of some behavioural restrictions, the approach shows its relevance in analysing changes in fiscal policy. The study has its limitations, however. To increase its empirical relevance, the model should be generalized so that it can deal adequately with external effects and the presence of children in the household. A second limitation of the study is that it does not take into account elements of household public consumption. A large share of total household means, after all, is spent on goods with a public consumption component, such as rent or heating. Two recent studies that deal with household public consumption in a different way are Lewbel, Chiappori and Browning (2001) and Chiappori, Blundell and Meghir (2002). Finally, the model does not incorporate household production, which implies that an individual's time endowment can only be allocated to market time and pure leisure (see Apps and Rees, 1996, 1997, and Chiappori, 1997). The increasing availability of time budget studies may allow a more realistic empirical modelling of household labour supply.

Endnotes

[1] Due to the lack of adequate data, the above model has an important weakness: it does not incorporate household production (see Apps and Rees, 1996, 1997, and Chiappori, 1997). The simple dichotomy between market time and leisure may be a questionable assumption in modelling couples' labour supply decisions. The increasing availability of time budget studies may enhance the empirical modelling of household labour supply taking account of household production.

[2] Strictly speaking, the function ϕ must give rise to a convex individual budget set. If the tax function τ^c is increasing and convex in female labour supply, then this requirement is satisfied if ϕ is increasing and concave in the household's net income x (see also Donni, 2003).

[3] This variable also depends on the male's productivity. It is, for example, easily seen that, *ceteris paribus*, a female's earning capacity decreases if her husband's gross income increases in a joint tax system with progressive marginal rates.

[4] Each variable that affects the bargaining power of the individuals in a household but does not affect preferences can be taken up in the sharing rule (such variables are usually called 'distribution factors'). See Browning and Chiappori (1998) and Chiappori, Fortin and Lacroix (2002) for some examples. It may be difficult, however, to find good distribution factors. Contrary to Chiappori, Fortin and Lacroix (2002), an index capturing divorce laws or laws on alimony cannot be used for Belgium, since all regions have the same legislation on divorce and alimony.

[5] More generally, the above approach requires that single women and females in couples have the same *type* of preferences (e.g., preferences that can be represented by a quadratic direct utility function). The parameters that completely define these preferences, however, may differ between both categories of women. In the estimation process, the utility function that represents preferences is normalized such that parameters associated with individual consumption are equal.

[6] The objective of this tax, which was introduced in 1993, was to generate extra means to meet the budget and debt criteria of the Maastricht Treaty.

[7] This study does not make use of the 'panel' structure of the data. The reason for this choice is that the SEP was subject to substantial attrition between 1992 and 1997. Many new households entered the data set in 1997, while only a very small number of households were observed in both waves of the SEP.

[8] The sample of single males is subject to the same sample selection rules as those for single females.

[9] Observed hours ℓ_0^f (see Figures 1 and 3) were allocated to the elements of the discrete choice set as follows: $\ell^f = 0$ if $\ell_0^f = 0$; $\ell^f = 20$ if $\ell_0^f \in]0, 25]$; $\ell^f = 30$ if $\ell_0^f \in]25, 35]$ and $\ell_0^f = 38$ if $\ell_0^f > 35$.

[10] Estimates are obtained by means of simulated maximum likelihood. The number of randomly drawn values for $\upsilon_{\ell\ell i}$ and $\upsilon_{\ell i}$ equals 100.

[11] The restrictions were tested for all four labour supply choices, taking into account the corresponding consumption levels, for each observation (both singles and women in couples). This amounts to checking the restrictions for $4 \times 468 = 1872$ labour supply choices. Strictly speaking, restrictions that involve the consumption level c^f (notably, the monotonicity restriction with respect to labour supply and the quasi-concavity restriction) should be satisfied for *all* nonnegative consumption levels.

[12] The model was also applied to the subsample of single women (to which the unitary approach should be fully applicable). Monotonicity with respect to consumption was rejected for the 38 hours labour supply choice. Monotonicity with respect to labour was rejected for 25% of the labour supply choices checked. Concavity was rejected in 87% of the cases. One reason for these results might be that the model does not take into account fixed costs of work. Information on these costs, however, is lacking in the dataset that we use.

[13] Monotonicity with respect to consumption is imposed by means of the linear restriction $\beta_c = -\beta_{c\ell} \cdot 38$. This implies that the collective restrictions can be imposed by the restrictions $\beta^*_{c1} = -\beta^*_{c\ell 1} \cdot 38$ and $\beta^*_{c2} = -\beta^*_{c\ell 2} \cdot 38$. Note that monotonicity with respect to labour supply and quasi-concavity cannot be imposed without losing the flexibility of the behavioural model.

[14] The male's utility level is represented by his individual consumption.

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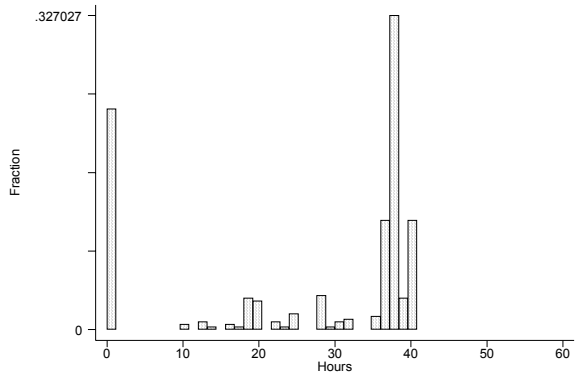

Figure 1: Contractual working hours per week for women in couples

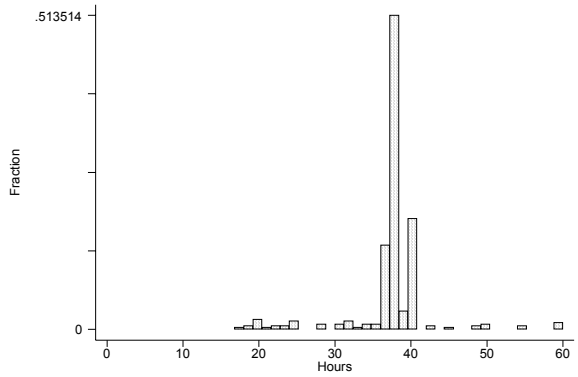

Figure 2: Contractual working hours per week for men in couples

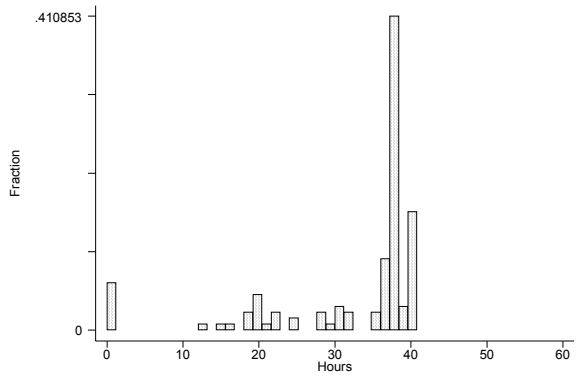

Figure 3: Contractual working hours per week for single women

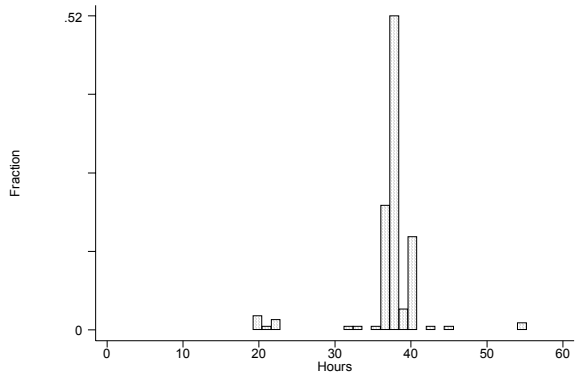

Figure 4: Contractual working hours per week for single men

Table 1: Descriptive statistics

	Couples		Single females	
Variable	Mean	Std. dev.	Mean	Std. dev.
Dummy for labour market participation female	0.77	0.42	0.94	0.24
Dummy for labour market participation male	1	0		
Dummy 1 for schooling female	0.54	0.50	0.43	0.50
Dummy 2 for schooling female	0.25	0.44	0.32	0.47
Dummy 3 for schooling female	0.06	0.24	0.16	0.36
Dummy 1 for schooling male	0.57	0.50		
Dummy 2 for schooling male	0.24	0.43		
Dummy 3 for schooling male	0.08	0.28		
Dummy 1 for region	0.24	0.43	0.30	0.46
Dummy 2 for region	0.04	0.21	0.19	0.39
Age female	36.68	9.72	38.17	9.98
Age male	38.63	9.70		
Number of years employed female	12.26	9.24	15.10	9.59
Number of years employed male	18.47	10.89		
Hourly gross wage rate female	11.66	3.93	13.01	5.56
Hourly gross wage rate male	14.65	5.88		
Contractual working hours per week female	26.76	15.94	32.51	10.76
Contractual working hours per week male	37.99	2.06		
Weekly consumption-based nonlabour income	40.09	109.58	57.92	55.07

Notes: Dummy for labour market participation: 1 = working. Dummy 1 for schooling: 1 = secondary school (primary school benchmark). Dummy 2 for schooling: 1 = non academic higher education. Dummy 3 for schooling: 1 = academic higher education. Dummy 1 for region: 1 = Walloon Region (Flemish Region benchmark). Dummy 2 for region: 1 = Brussels Capital Region. Monetary values are in euro.

Table 2: Parameter estimates of the female labour supply model

Variable	Unrestricted est.	Restricted est.
$\left(\ell^f\right)^2$	17.694 (3.106)	19.314 (3.116)
$\sigma_{v_{\ell\ell}}$	0.263 (0.739)	0.107 (0.469)
$\left(\ell^f\right)^2 \times$ education dummy 1	2.324 (1.362)	2.045 (1.353)
$\left(\ell^f\right)^2 \times$ education dummy 2	0.084 (1.667)	0.123 (1.637)
$\left(\ell^f\right)^2 \times$ education dummy 3	4.573 (3.310)	4.174 (2.879)
$\left(\ell^f\right)^2 \times$ region dummy 1	0.733 (1.071)	0.918 (1.071)
$\left(\ell^f\right)^2 \times$ region dummy 2	-0.407 (1.881)	-0.409 (1.859)
$\left(\ell^f\right)^2 \times$ dummy couple	-11.937 (3.021)	-12.591 (3.041)
$\left(x \times \ell^f\right)$	-2.759 (0.489)	-3.114 (0.480)
$\left(x \times \ell^f\right) \times$ dummy couple	1.917 (0.550)	2.564 (0.494)
$\left(x \times \ell^f\right) \times$ dummy couple $\times$ earning capacity	$-5.58\times10^{-7}(7.94\times10^{-7})$	$-1.46\times10^{-6}(2.59\times10^{-7})$
c^f	91.099 (22.523)	118.332 (18.252)
$x\times$ dummy couple	-105.679 (33.190)	-97.436 (18.775)
$x\times$ dummy couple $\times$ earning capacity	0.073 (0.063)	$0.056\ (9.82\times10^{-6})$
ℓ^f	-246.156 (92.383)	-330.379 (77.873)
σ_{v_ℓ}	3.523 (16.729)	2.450 (14.346)
$\ell^f\times$ education dummy 1	-43.392 (50.534)	-35.655 (50.407)
$\ell^f \times$ education dummy 2	161.965 (76.989)	147.019 (75.105)
$\ell^f \times$ education dummy 3	55.825 (179.637)	74.064 (153.146)
$\ell^f\times$ region dummy 1	-20.215 (45.373)	-26.916 (44.969)
$\ell^f\times$ region dummy 2	51.272 (87.693)	50.672 (86.265)
$\ell^f\times$ dummy couple	632.225 (174.151)	438.164 (79.691)
Log likelihood	-288.026	-291.522
Correctly predicted observations	64%	79%

Notes: Estimates are obtained by simulated maximum likelihood. All parameter estimates and standard errors (between brackets) are multiplied by 1000. Education dummy 1: 1 = secondary schooling (primary schooling benchmark). Education dummy 2: 1 = non academic higher education. Education dummy 3: 1 = academic higher education. Region dummy 1: 1 = Walloon Region (Flemish Region benchmark). Region dummy 2: 1 = Brussels Capital Region. Dummy couple: 1 = couple (single woman is benchmark). Earning capacity is the difference between the household's disposable income when the female is working full time and when she does not participate. Prediction of the labour supply for an observation is obtained by selecting the hours choice with the highest probability.

Table 3: Summary statistics couples pre reform versus post reform situation

	Pre reform	Post reform 1	Post reform 2
Mean labour supply females	27.50	27.52	27.52
Mean gross earnings couple	889.13	889.25	889.35
Mean income tax	354.35	354.35	354.35
Mean income tax rate	0.399	0.399	0.389
Mean household consumption	578.49	578.59	578.58
Mean individual consumption females	168.87	169.16	166.68
Mean individual consumption men	409.62	409.43	411.90
Mean utility females	17.80	17.81	17.75
Mean consumption share females	0.2919	0.2924	0.2881

Note: Monetary values are in euro per week; labour supply is in hours per week. Post reform 1 is the actual tax reform with a lump-sum tax of 22 euro at a household level added. Post reform 2 is the actual tax reform complemented with a proportional decrease of 3.65 percent of the couple's disposable income.

Table 4: Pre reform versus post reform 1: labour supply of females in couples.

	0	20	30	38	Total
0	90	1	0	1	92
20	0	6	0	0	6
30	0	0	1	0	1
38	0	2	1	238	241
Total	90	9	2	239	340

Note: Rows are pre reform labour supply, columns post reform. Post reform 1 is the actual tax reform with an additional lump-sum tax of 22 euro at a household level.

Table 5: Pre reform versus post reform 2: labour supply of females in couples

	0	20	30	38	Total
0	91	0	0	1	92
20	0	6	0	0	6
30	0	0	1	0	1
38	0	1	0	240	241
Total	91	7	1	241	340

Note: Rows are pre reform labour supply, columns post reform. Post reform 2 is the actual tax reform complemented by a proportional decrease of 3.65 percent of the couple's disposable income.

Table 6: Gainers and losers of tax reform 1

	f(-)	f(0)	f(+)
m(-)	58	88	56
m(0)	0	0	0
m(+)	43	35	60

Note: Tax reform 1 is the actual tax reform with an additional lump-sum tax of 22 euro at a household level. The variables m and f refer to, respectively, the utility level of males and females in couples. The labels (-), (0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.

Table 7: Gainers and losers of tax reform 2

	f(-)	f(0)	f(+)
m(-)	94	54	6
m(0)	0	0	0
m(+)	57	79	50

Note: Tax reform 2 is the actual tax reform complemented by a proportional decrease of 3.65 percent of the couple's disposable income. The variables m and f refer to respectively the utility level of males and females in couples. The labels (-), (0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.