Where does the unitary model go wrong ? Simulating tax reforms by means of unitary and collective labour supply models. The case for Belgium.

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Abstract

A new methodology is presented to model household labour supply. The model is based on the collective approach to household behaviour and allows for both nonparticipation and nonconvex budget sets. It directly models the household allocation on the Pareto frontier. The model is used to quantify the distortions from using a standard unitary model, when the collective approach is more appropriate. This is done by comparing both positive and welfare economic aspects of the current Belgian tax reform.

Key words: collective household models, intrahousehold allocation, labour supply, tax reform.

JEL-classification: D11, D12, J22.

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1 Introduction

The so-called collective approach to household behaviour is gradually finding its way into the microeconomic literature. The approach, which was initially defined by Chiappori (1988, 1992), is an alternative to (or better a refinement of) the standard or unitary model of household behaviour. In the unitary model it is assumed that households, even if they consist of several individuals, behave as if they were single decision making units. Observable household consumption and labour supply is then assumed to be the result of the maximization of a single utility function, representing the household's rational preferences, subject to the household budget constraint. However, the implied restrictions of the unitary approach turn out to be rather restrictive and were repeatedly rejected when confronted with the data (see, e.g., Blundell, 1988 for some evidence).

The collective approach on the contrary, explicitly takes into account that multi-person households consist of individuals who may have different preferences. Among these individuals, an intrahousehold bargaining process that results in Pareto efficient outcomes is assumed to take place. It can be shown that this setting implies other theoretical restrictions on observable household behaviour than the unitary model (see, e.g., Browning and Chiappori, 1998 and Chiappori, Fortin and Lacroix, forthcoming). Interestingly enough, the restrictions of different collective models have not been rejected in several studies (see, e.g., references in Vermeulen, 2000).

Of course, in the light of the above, it is not very surprising that welfare economic analyses of policy reforms may obtain very different results depending on the choice of a particular model of household behaviour. Especially with respect to labour supply, the richer behavioural implications of the collective model may have serious consequences for policy recommendations that are based on positive and normative analyses. As to many topics of labour supply however, the collective approach is still in its infancy. Only very recently, issues of nonparticipation and nonlinear income taxation giving rise to convex budget sets have been dealt with in the literature on collective models (see Blundell et alii, 2001 and Donni, forthcoming).

The objective of this study is twofold.[1] Firstly, it tries to fill the gap somewhat in the literature on collective labour supply behaviour dealing with nonparticipation and taxation. This is done by presenting a new approach to model household labour supply in a collective setting. The approach takes account of both nonparticipation and income taxation that may result in nonconvex budget sets. Rather than being based on the derivation of structural collective labour supply functions and the subsequent econometric estimation of these, the approach focuses on the direct modelling of the household's allocation on the Pareto frontier, which determines the labour supply of the household members. While the approach followed is rather piecemeal, in the sense that it makes use of information obtained by both econometric estimations and calibration

[1] This study is joint research with research groups focusing on seven European Union countries: Belgium, Denmark, France, Germany, Italy, Spain and the United Kingdom.

methods, it might provide some insights that are useful for the derivation of structural collective models that can be econometrically estimated.

A second objective of the study is to dig deeper in the implications for policy recommendations of the two models of household behaviour. More specifically, it tries to quantify the distortions from using the unitary model when the collective model is more appropriate (see Beninger and Laisney, 2001). This is done by comparing positive and normative aspects of policy evaluations that are obtained by both representations of household behaviour. In concrete, real world microdata will be simulated by means of a deterministic collective labour supply model, and a unitary model will be estimated on this artificial dataset. This dataset can be considered as being drawn from a world where households behave according to the particular collective model. In a next step, both models are used to evaluate some real world tax reforms. In particular, the recently voted Belgian income tax reform and the introduction of a revenue neutral (from the government's perspective) negative income tax will be considered. With a sufficiently flexible unitary model, in the sense that it is able to capture a wide range of behavioural reactions, deviations between the models' predictions can only be due to the wrong assumption that households behave as if they were single decision makers. The whole exercise is based on Belgian microdata. The sample selection is for singles and couples, with or without children, and who are working or voluntarily unemployed. Students, involuntary unemployed and retired people are excluded from the dataset.

The paper is structured as follows. In the next section, the elements of the current Belgian tax-benefit system are presented that are important for the study at hand. The third section discusses the tax reforms that will be focused on in the simulation exercise. Section 4 presents a new approach to model household labour supply behaviour that is based on the collective setting. A flexible unitary model and some econometric issues are presented in section 5. Data and estimation results are given in sections 6 and 7. The eighth section deals with the simulation results. Concluding remarks are presented in section 9.

2 The Belgian tax-benefit system

2.1 The Belgian personal income tax system

2.1.1 Introduction

In what follows we focus on simplified personal income tax systems for 1997 and 2000. There are two main reasons for this simplification. Firstly, precise information on items like capital redemptions due to mortgage loans, payments to group insurance contracts, contributions to private pension funds, etc. is lacking in the dataset that will be used in the exercise. These items however, have an effect on the tax liability of households. Tax liabilities that are calculated by means of the information in the dataset can at best be seen as estimates of paid income taxes. Secondly, because of the specific characteristics of the selected samples of households, we can safely focus on tax rules applicable on labour incomes and ignore tax rules on incomes coming from pensions, unemployment benefits and the like. Since capital income is separately taxed for the majority of households, it can be argued that we do not have to take into account this type of income to calculate taxes on labour income. Of course, capital income taxes have an effect on the level of net nonlabour income.

The focus on the years 1997 and 2000 has the following reason. Every year, nominal variables in the Belgian tax system (e.g., standard deductions and tax brackets) are adapted to keep real government revenue constant. If one would start from the tax system of 1997 for the pre-reform situation and simulate the future Belgian tax reform e.g., then one would not only simulate changes in the tax system itself, but also changes that come from inflation adaptations of the nominal values in the system. Therefore, structural labour supply models are estimated on data subjected to the 1997 tax system, whereas data for the baseline simulation (i.e., the pre-reform situation) are derived for the 2000 tax system. Tax reforms are then immediately applied to these data for 2000.

Since there are some important differences in the taxation of singles and that of married couples, both tax systems are discussed separately in what follows. Note finally that cohabiting individuals are taxed like singles.

2.1.2 A simplified tax system for singles

Tax scheme In the simplified tax scheme for singles, four main components are taken into account to calculate the tax liability. 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. This simplified tax system can be represented as follows.

Table 1: A simplified taxation scheme

Gross labour income	$w\ell$
Taxable labour income	$X = w\ell\,(1 - t_s) - D\,(w\ell\,(1 - t_s))$
Gross tax liability	$T_g = s\,(X)$
Net tax liability	$T_n = T_g - C$
Net labour income	$I = w\ell\,(1 - t_s) - T_n$

Gross yearly labour income is denoted by $w\ell$ (wage rate w times hours worked ℓ under the assumption that the former does not change with the latter). Standard deductions that depend on labour income are denoted by D, s is the marginal tax rate scheme that converts taxable labour income into gross tax liability, C are tax credits and t_s is the marginal tax rate associated with social security contributions. In this simplified taxation scheme, the tax credit consists of three components: (1) the tax credit related to the basic exemption of taxation, (2) the tax credit related to family size and (3) the negative tax credit related to the temporary crisis surcharge. In what follows, the assumptions on the different taxation scheme components will be discussed.

Social security contributions of employees In general, every employee is subjected to a marginal tax rate of 13.07% associated with social security contributions (i.e., t_s=0.1307).

Standard deductions We assume that the only deductions consist of the standard expenses.[2] The scheme associated with the latter is the following (where the amounts in the left column are gross labour incomes minus social security contributions in euro).[3]

Table 2: Standard expenses (in euro; 1997 above, 2000 below)

$w\ell\,(1-t_s)$	lower bound	rate
0-4,090.24	0	20%
4,090.24-8,180.49	818.05	10%
8,180.49-13,634.14	1,227.07	5%
13,634.14-54,536.58	1,499.76	3%
0-4,164.61	0	20%
4,164.61-8,354.01	832.92	10%
8,354.01-13,906.83	1,251.86	5%
13,906.83-55,470.32	1,529.50	3%

Marginal tax rates scheme The marginal tax rates that are applicable on taxable labour income are shown in Table 3.

Tax credits After application of the marginal tax rates scheme to the taxable labour income X, the gross tax liability T_g is obtained. The net tax liability T_n is obtained by subtracting the appropriate tax credits. As already mentioned, we focus on three such items. The first tax credit is that related to the basic exemption from income taxation. For a single, this exemption equals 5,032.24 euro for 1997 and 5,205.76 euro for 2000. If taxable labour income is higher than this amount, a tax credit is thus obtained of 1,258.60 euro in 1997. Secondly, there is the tax credit related to family size: the exemption from income taxation depends on the number of dependent children.[4] The extra exemption (apart from that related to the basic exemption) is shown in Table 4. A single with two dependent children, e.g., has an exemption from income taxation of 7,759.07 euro for 1997. Assuming that her taxable income is higher than this amount, the appropriate tax credit equals 2,014.13 euro (6,271.71*0.25+(7,759.07-6,271.71)*0.3).

[2]Individuals are also allowed to declare their real professional expenses. However, information on these expenses is completely lacking in the dataset.

[3]1 euro equals 40.3399 BEF.

[4]Note that the tax credit C is not allowed to be higher than the gross tax liability in current legislation (i.e., no negative income tax).

Table 3: Marginal tax rates (bands in euro; 1997 above, 2000 below)

X	lower bound	rate
0-6,271.71	0	25%
6,271.71-8,304.43	1,567.93	30%
8,304.43-11,849.31	2,177.74	40%
11,849.31-27,268.29	3,595.70	45%
27,268.29-40,902.43	10,534.24	50%
40,902.43-59,990.23	17,351.31	52.5%
$\geq 59,990.23$	27,372.40	55%
0-6,395.65	0	25%
6,395.65-8,477.96	1,598.91	30%
8,477.96-12,097.20	2,223.60	40%
12,097.20-27,838.44	3,671.30	45%
27,838.44-41,745.27	10,754.86	50%
41,745.27-61,229.70	17,708.27	52.5%
$\geq 61,229.70$	27,937.60	55%

Table 4: Exemption related to dependent children (in euro)

Number of children	Extra exemption
1	1,065.94
2	2,726.83
3	6,172.55
4	9,965.32
per extra child above 4	+ 3,792.77
1	1,115.52
2	2,850.78
3	6,395.65
4	10,337.16
per extra child above 4	+ 3,941.51

Finally, there is a negative tax credit related to the crisis surcharge: after application of the other tax credits, an extra tax rate of 3% is applied to the resulting tax liability.

2.1.3 A simplified tax system for couples

Tax scheme Tax liabilities (including social security contributions) for married couples are calculated by means of the following main components of the taxation scheme for couples: (1) social security tax, (2) standard deductions, (3) applicability of the marital quotient, (4) marginal tax rates and (5) standard tax credits.

Social security contributions In general, gross labour incomes of both spouses are subjected to a marginal tax rate associated with social security contributions of 13.07% (cf. singles' case).

Standard deductions As was also the case for the taxation of singles, it is assumed that both spouses make use of the standard expenses scheme (cf. Table 2).

Marital quotient Once the social security contribution and the standard expenses have been subtracted from the gross labour incomes, it can be checked whether a couple is allowed to make use of the marital quotient. Via the marital quotient, part of the taxable labour income of one of the spouses can be transferred to the other spouse and taxed separately. In our framework, couples are allowed to make use of the marital quotient if the taxable labour income of the spouse with the lowest earnings does not exceed 30% of joint taxable labour income. The part that is shifted to the spouse with lowest earnings equals 30% of joint taxable labour income, minus the own taxable labour income of that spouse. This part cannot exceed 7,362.44 euro (1997) and 7,511.17 euro (2000) however.

Marginal tax rates scheme Once the marital quotient has been applied, the resulting incomes are taxed separately via the marginal tax rates scheme of Table 3.

Tax credits After calculation of the gross tax liabilities of both spouses, net tax liabilities can be obtained by taking into account the appropriate tax credits. For married couples, the following rules are to be applied. First, there is a tax credit related to the basic exemption from income taxation. This exemption equals 3,966.30 euro (1997) and 4,139.82 euro (2000) for each spouse. Second, there is the tax credit related to family size. The therewith associated exemption from income taxation is the same as that in the case of singles (see Table 4). This extra exemption is given to the spouse with the highest labour income. Note that if the exemption from income taxation is higher than the income of one of the spouses, then the rest of the exemption can be shifted to the other spouse. Finally, there is the negative tax credit related to the crisis surcharge. After application of the other tax credits, an extra tax rate of 3% is applied on the resulting tax liability.

2.2 A concise overview of the Belgian social security system[5]

2.2.1 Overview

The Belgian social security system is financed by contributions of employees (cf. supra), contributions of employers and self-employed people and part of the tax revenue. The system consists of eight broad branches: (1) health insurance (involves benefits to cover part of the costs of medical help and medicines), (2) benefits for people unfit for work (due to illness or accidents), (3) maternity benefits (benefits for women in the weeks before and after delivery), (4) pensions (benefits for retired people), (5) unemployment benefits (benefits for people who are involuntarily unemployed or who are exempted from searching for work; e.g. early retired individuals), (6) family benefits (child benefits, maternity premiums and adoption premiums), (7) professional risks (benefits for individuals that were involved in accidents related to work) and the (8) branch which considers the yearly vacation. Apart from these eight branches, the social security system also includes the benefits for persons with a handicap, the subsistence minimum and so-called social work. This consists of material and immaterial help for people depending on the subsistence minimum (e.g., free legal advice). Some social benefits are not included in the social security system in a technical sense. The most important ones are scholarships, access facilities to social dwellings and the provision of social loans with a lowered interest rate and subsidies to pay the rent on loans.

2.2.2 Which items are important for the research project ?

Not every item of the above social benefit system is equally important from the exercise's point of view. Since the research project does not focus on consumption, the health insurance item (branch (1) above) is not applicable to the project. Due to the specific sample, also the items (2) benefits for people unfit to work, (3) maternity benefits, (4) pensions, (5) unemployment benefits and (7) professional risks can be left out of consideration (apart from taking up some of these in the nonlabour income). As to item (8), amounts received for yearly vacation are subjected to the usual tax system. In this sense, these do not belong to the social security system as such, but are taken into account to calculate the personal income tax. The only component of the main branches of the social security system that is important for the exercise is that of the family benefits.

[5]Source: *Beknopt overzicht van de Sociale Zekerheid in België* (1998), joint publication of several administrative bodies (http://socialsecurity.fgov.be/overzicht/1998/index.htm).

They encompass child benefits, maternity premiums and adoption premiums. The most important ones are the child benefits. In general they do not depend on the income of the rightful claimants, remain untaxed and do not affect the personal income tax (i.e., they are simply added to the household's nonlabour income). The amounts received depend on the rank and ages of the children, the professional status (employed, unemployed with unemployment benefits and retired) of the rightful claimant and some other aspects (orphans and children with a handicap). In Table 5 monthly child benefits (amounts per child) in the ordinary regime are shown.

Table 5: Monthly child benefits in ordinary regime (in euro; 1997 above, 2000 below)

	Age of the child			
	0-5	6-11	12-15	16+
First child	65.77	88.62	100.67	102.58
Second child	121.69	144.55	156.59	158.50
Third child and other children	181.68	204.54	216.58	218.49
First child	69.81	81.95	88.32	91.15
Second child	129.15	153.40	166.19	176.25
Third child and other children	192.81	217.06	229.85	239.91

As to the extra components of the social security system, the most important one is the subsistence minimum. It focuses on individuals or households without enough means and who are not able to provide in these means on their own. Moreover, it has a residual character in that people should first try to acquire other benefits like unemployment benefits or pensions. Consequently, also the subsistence minimum is of minor importance in the research project since it focuses on individuals that are not involuntarily unemployed, retired, etc.

The fact whether a household member is working or not working and for how many hours, may have consequences on the eligibility to the social benefits that do not belong to the social security system. Scholarships, e.g., do depend on the household income. The same applies to eligibility to social dwellings and social loans. The fact whether one is eligible to a scholarship and the amount to which one is eligible can be modelled in the exercise. The amounts themselves however, remain untaxed and are thus added to the household's nonlabour income. Since the eligibility to social dwellings depends on a lot of other criteria, and people explicitly have to take many administrative steps to have access to these other benefits, they are not taken into account in the exercise.

3 The reforms under consideration

3.1 The Belgian tax reform[6]

3.1.1 Repayable tax credit

A first line of force of the tax reform is the introduction of a 'repayable tax credit' for the lowest labour incomes. A tax credit of 619.73 euro is to be introduced for labour incomes (after deduction of social security contributions and professional costs) between 3,718.40 and 12,394.68 euro. Working individuals that do not pay taxes or pay less taxes than this credit receive an extra income equal to the difference between the tax credit and the taxes paid. Between 2,478.94 and 3,718.40 euro there is a gradual increase in the tax credit from 0 to 619.73 euro. Between 12,394.68 and 16,113.08 euro there is a gradual decrease of the tax credit.

3.1.2 Changes of tax brackets and abolition of highest marginal tax rates

A second characteristic of the reform is a change of the middle tax brackets and the abolition of the 52.5 and 55% marginal tax rates. The new marginal tax rates scheme are shown in Table 6 below.[7]

Table 6: Marginal tax rates (bands in euro)

X	lower bound	rate
0-6,494.81	0	25%
6,494.81-9,246.43	1,623.70	30%
9,246.43-15,418.98	2,449.19	40%
15,418.98-28,259.86	4,918.21	45%
$\geqslant$28,259.86	10,696.61	50%

3.1.3 Equalization of tax exemption of married individuals and singles

Up to now, the tax exemption of married individuals and (possibly cohabiting) singles differ. On the basis of this exemption, tax credits are calculated. The tax exemption of married individuals is to be brought on the singles' level (i.e., 5,280.13 euro).

[6]Tax reform act of 10.08.2001. The implementation of the tax reform act will be spread over the period 2001-2004.

[7]Note that the given tax brackets differ from these of the 2000 tax system. This is again because of inflation adaptations (cf. supra). However, up to the time writing this report, the exact nominal values of the tax system of 2001 are not yet available.

3.1.4 Applicability of marital quotient

In the current legislation, only married people can apply the marital quotient. The tax reform proposal also allows the application of the marital quotient for individuals that have a cohabitation contract.

3.1.5 Other measures

Another feature of the fiscal reform is that tax credits associated with replacement incomes are to be individualized. Note however, that in the light of the current exercise, this measure should not have any effect on the selected sample of households. Finally, separate taxation of nonlabour incomes is to be introduced for married individuals. Up to now, under some conditions capital income and income from property, e.g., is added to the labour income of the spouse with the highest labour income.

3.2 Introduction of a negative income tax system

A second tax reform that will be considered in the application is the introduction of a negative income tax system. In the application there will be individual taxation by means of the following two parameter system:

$$T = (1 - t)\, w\ell - G,$$

where T is the tax liability, t ($\geqslant 0$) the constant marginal tax rate and G ($\geqslant 0$) the minimum guaranteed income. The parameters t and G will be chosen in such way that the tax reform is revenue neutral for the government. Note that this negative income tax system covers both social security contributions and direct taxes.

4 An approach to model collective labour supply

4.1 Pareto efficient household allocations

A fundamental characteristic of the collective approach is that it explicitly takes into account that multiperson households consist of several individuals with own, and possibly different, preferences. Rather than assuming an explicit bargaining rule on the basis of which household decisions are taken or assuming noncooperative household behaviour, Chiappori (1988, 1992) assumes that the intrahousehold allocation process results in Pareto efficient outcomes. That is, no individual's welfare can be increased without decreasing the welfare of another individual.

Let us focus on households consisting of two working age individuals.[8] Males'

[8] In what follows, it will be assumed that children have no bargaining power in the household and that they are internalized in the preferences of the adult members of a household.

and females' preferences are represented by means of the following direct utility functions ($i = m, f$):

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

where v^i is a well-behaved utility function with a Hicksian consumption aggregate c^i and leisure amounts l^m and l^f as arguments. The vector $\mathbf{d}$ captures demographic characteristics like the number of children and education level. Note that the above utility functions allow for an externality with respect to the other individual's leisure. Externalities with respect to consumption and household public goods (e.g., rent), are excluded in the analysis.[9] The household has limited resources at its disposal that are used to finance the household's consumption $c = c^m + c^f$:

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

Constituent parts of this household budget constraint are the individual labour incomes $w^m \ell^m$ and $w^f \ell^f$, where w^i and $\ell^i = T - l^i$ are individual i's gross wage rate and labour supply (with T the individual's time endowment). The budget constraint further consists of the household's nonlabour income y that may be composed of individually assignable nonlabour incomes y^m and y^f and some nonlabour income y^h that cannot be assigned to one of the household members. Finally, there is the function τ that captures the income tax that may depend on earned incomes, nonlabour income and some household characteristics.

A household allocation $\left(c^m, c^f, l^m, l^f\right)$ is Pareto efficient if it is the solution to the following maximization problem:

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

subject to

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

and

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

where $\overline{u}^f$ is some required utility level for individual f. By varying $\overline{u}^f$ the set of Pareto efficient allocations can be traced out. An interpretation of $\overline{u}^f$ is that the variable represents individual f's bargaining power. In general this bargaining power may depend on wages, nonlabour incomes and other variables.[10] Changes

[9]The reason for this choice is that in the given setting we cannot identify which expenditures are for public consumption and which expenditures have external effects (at least not without very strong additional assumptions). Examples of collective models with more general preferences can be found in Browning and Chiappori (1998) and Chiappori, Fortin and Lacroix (forthcoming).

[10]Such variables are sometimes called 'distribution factors'. These are defined as variables that affect the bargaining power, but that do not have any direct influence on individual preferences or the budget constraint. Examples in applications of such variables are the sex ratio (defined as the number of females over the number of males and females in a population) and divorce laws (Chiappori, Fortin and Lacroix, forthcoming) and a dummy indicating whether a couple is married or cohabiting (Vermeulen, 2001).

in wages, e.g., may shift bargaining power from one individual to the other, which on its turn has consequences on the household's allocation of consumption and leisure.

4.2 Empirical specification and identification of the collective labour supply model

4.2.1 Introduction

In the literature, several applications of collective labour supply models can be found. In Chiappori et alii (forthcoming) and Vermeulen (2001) collective labour supply models are estimated for couples where both individuals participate in the labour market. Both models assume linear budget constraints. Blundell et alii (2001) introduce nonparticipation and unobserved preference heterogeneity in the collective setting with linear budget constraints. Nonlinear budget constraints resulting in convex budget sets are considered by Donni (forthcoming). As already mentioned in the introduction, we want to introduce both nonparticipation and nonlinear income taxation that may result in nonconvex budget constraints. Rather than deriving a collective model that can be econometrically estimated in one shot, an alternative approach is opted for.

A first characteristic of this alternative model is that labour supply will be treated as a discrete choice problem. That is, individuals are assumed to have the choice over only a limited number of working hours. This approach already proved to be useful in a unitary setting (see, e.g., Van Soest, 1995, Bingley and Walker, 1997, and Blundell et alii, 1999). The advantage of the discrete choice approach is that econometric problems related to nonconvex and nonlinear budget constraints are relatively easily tackled.[11] In the empirical exercise, the following sets of weekly working hours for men and women are chosen: $\ell^m \in \{30, 37, 38, 40\}$ and $\ell^f \in \{0, 8, 20, 30, 40\}$. Women are thus allowed not to participate in the labour market; for men this is not the case.[12] Taking into account the individuals' wages, nonlabour incomes, household characteristics and the tax system, total household consumption can be calculated for each combination of the individuals' labour supply.

A second characteristic of the model described below is that it will be identified in a rather piecemeal way. More concrete, it will make use of both information obtained by econometric estimations and information coming from a calibration exercise.

[11] See, e.g., Blundell et alii (1988) for a continuous labour supply model with nonconvex budget constraints.

[12] These labour supply choices were chosen on the basis of the observed labour supplies for the used dataset (cf. infra). A first caveat is that there were 3 men in the sample of 1886 couples with a labour supply of zero. Too few however, to take account of this choice in an adequate way. These men were assumed to have a labour supply equal to the mean of the working men. A second caveat is that, especially for men, the observed hours typically reflect the number of hours that are worked in many sectors. We do not take account of labour demand restrictions in this study however.

4.2.2 Specification of the individual utility functions

To make things more clear, let us translate the Pareto optimality problem (1) in an empirically tractable form. First, we choose the specification of the individual utility functions v^m and v^f. These are assumed to be of the following form ($i = m, f$ and $i \neq j$):

$$u^i = \beta_1^i(\mathbf{d}) \ln\left(c^i - \overline{c}(\mathbf{d})\right) + \beta_2^i(\mathbf{d}) \ln\left(l^i - \overline{l}(\mathbf{d})\right) + \delta^i(\mathbf{d}) \ln\left(l^i - \overline{l}(\mathbf{d})\right) \ln\left(l^j - \overline{l}(\mathbf{d})\right). \quad (2)$$

The preference parameters $\overline{c}(\mathbf{d})$ and $\overline{l}(\mathbf{d})$ capture 'subsistence' or minimum consumption and leisure. Think of the latter as the time needed to sleep and essential caring tasks when there are children in the household. The minimum consumption and leisure amounts are assumed to depend on household characteristics $\mathbf{d}$. As is clear from equation (2) the utility functions consist of a Stone-Geary part and a part that can be considered as a leisure interaction term.[13] How can we now identify the parameters $\beta_1^i(\mathbf{d})$, $\beta_2^i(\mathbf{d})$ and $\delta^i(\mathbf{d})$ ($i = m, f$), given that we have a mix of effects coming from individual preferences and an intrahousehold bargaining process that is reflected in $\overline{u}^f$ (see (1)) ?

4.2.3 Identification of the Stone-Geary part of individual preferences

A crucial assumption that is made in the exercise, is that the Stone-Geary parameters $\beta_1^i(\mathbf{d})$ and $\beta_2^i(\mathbf{d})$ equal those of single males and females who are assumed to have preferences that can be represented by the Stone-Geary utility function. One may be critical of this assumption, since it implies that apart from a leisure interaction term, singles and individuals in couples have the same preferences. Leaving things as they are, the parameters $\beta_1^i(\mathbf{d})$ and $\beta_2^i(\mathbf{d})$ are easily estimated by means of two samples of single males and single females (cf. infra).

Although the minimum consumption and leisure $\overline{c}(\mathbf{d})$ and $\overline{l}(\mathbf{d})$ can be estimated in principle, it is chosen to fix these in the following way. Minimum leisure for singles without children is set equal to 70 hours per week. If there are children in the household, then the following additional minimum leisure levels are assumed: 17.5 hours for children less than 3 years old, 10.5 hours for children between 3 and 6, 7 hours for children between 6 and 12 and 3.5 hours for children over 12. Under the assumption that individuals in couples share 'child burden' equally, half of the hours that singles' minimally spend on their children is added to the base amount of 70 hours per week.

Minimum weekly consumption levels are derived for five types of households, depending on whether there are no, one, two, three, or four or more children in the household. Per type of household the minimum consumption is fixed quite arbitrarily to the minimum consumption of the lowest observed consumption level in the dataset for that type of household, divided by two for couples and

[13]Perhaps it is better to talk about Klein-Rubin-Samuelson preferences instead of Stone-Geary preferences (see, Klein and Rubin, 1948/1949 and Samuelson, 1948/1949). Anton Barten is thanked for pointing to this.

minus one.[14]

4.2.4 Identification of leisure interaction terms and bargaining power

The leisure interaction terms $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$ and individual f's bargaining power $\overline{u}^f$ remain to be identified. To identify these, a calibration exercise is done. The idea of it is the following. For each household and for each element of a discrete set of individual preferences (which are distinguished by the leisure interaction terms $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$), a discrete set of Pareto efficient allocations is calculated. From these sets of Pareto efficient allocations (one for each couple of individual preferences), the allocation is chosen that gives rise to the best fit of observed labour supply.

The identification of the above variables is done in two rounds. First the bargaining power is identified, along with provisory values for the leisure interaction terms. After that, individual leisure interaction terms $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$ are identified. For each household, the algorithm that is implemented to put this into practice is the following.

Identification of the bargaining power

- Calculate $u^f_{\max}(\delta)$ and $u^f_{\min}(\delta)$ for each $\delta \in \{\delta_{\min}, ..., \delta_{\max}\}$, where $\delta^m(\mathbf{d}) = \delta^f(\mathbf{d}) = \delta$ in first instance. The utility level $u^f_{\max}(\delta)$ is defined to be the value of individual f's utility function $v^f(.;\delta)$ for $\delta^f(\mathbf{d}) = \delta$, when f receives all household consumption minus the minimum consumption needed for individual m, and leisure amounts l^m and l^f are chosen in such way that f's utility is maximal. This value of course will depend on the individual wages, the household's nonlabour income, socio-economic characteristics and the tax system. The utility level $u^f_{\min}(\delta)$ is defined as the maximal utility f can obtain given that m obtains a utility of $u^m_{\max}(\delta)$. Therefore, before $u^f_{\min}(\mathbf{d})$ can be derived, m's maximal utility $u^m_{\max}(\delta)$ must be calculated in the same way as $u^f_{\max}(\delta)$. In general, $u^m_{\max}(\delta)$ can be generated from an infinity of consumption and leisure bundles $\left(c^m, l^m, l^f\right)$, corresponding to the indifference surface labeled by $u^m_{\max}(\delta)$. In our discrete choice case however, we only have a limited set of bundles that satisfy this condition. Now we choose that consumption and leisure bundle $\left(\widehat{c}^m, \widehat{l}^m, \widehat{l}^f\right)$ that results in the maximum possible utility for f, where $u^f_{\min}(\delta) = v^f\left(\widehat{c} - \widehat{c}^m, \widehat{l}^m, \widehat{l}^f, \mathbf{d};\delta\right)$, $\widehat{c}$ being the consumption level corresponding to leisure amounts $\widehat{l}^m$ and $\widehat{l}^f$. Both $u^f_{\max}(\delta)$ and $u^f_{\min}(\delta)$ can thus be considered as the boundaries (dictatorial positions if you want) of the calculated Pareto frontier for given preferences δ.

[14] The reason for this choice is that Stone-Geary preferences are well-behaved provided $\beta^i_1(\mathbf{d})$ and $\beta^i_2(\mathbf{d})$ $(i = m, f)$ are positive and provided c^i is greater than the minimum consumption (see, e.g., Barten and Böhm, 1982).

- Define K utility levels $u_k^f(\delta) = u_{\min}^f(\delta) + (k-1)\frac{\left(u_{\max}^f(\delta) - u_{\min}^f(\delta)\right)}{K-1}$, where $k = 1, ..., K$.[15]

- For each k, m maximizes his utility subject to the budget constraint, f's required utility level $u_k^f(\delta)$ and the labour supplies being in the choice set:

$$\max_{c^m, c^f, l^m, l^f} v^m\left(c - c^f, l^m, l^f, \mathbf{d}; \delta\right)$$

  subject to

$$v^f\left(c^f, l^m, l^f, \mathbf{d}; \delta\right) \geq u_k^f(\delta),$$
$$c \leq y + w^m \ell^m + w^f \ell^f - \tau\left(w^m \ell^m, w^f \ell^f, y, \mathbf{d}\right),$$
$$\ell^m \in \{30, 37, 38, 40\},$$

  and

$$\ell^f \in \{0, 8, 20, 30, 40\}.$$

  This maximization procedure results for each k in an optimal labour supply and consumption bundle $\left(\ell^m(\delta, k), \ell^f(\delta, k), c^m(\delta, k), c^f(\delta, k)\right)$.

- For each δ, choose the allocation k of the discrete set of Pareto efficient allocations that minimizes the criterion

$$5\left(\ell^m(\delta, k) - \ell_*^m\right)^2 + \left(\ell^f(\delta, k) - \ell_*^f\right)^2,$$

  where ℓ_*^i $(i = m, f)$ is individual i's observed labour supply. Note that the weights attached to the individuals' deviations from observed labour supply are not equal. This is because of the fact that the discretization of men does not allow much variation in hours worked. This step results in an optimal labour supply and consumption allocation $\left(\ell^{m\prime}(\delta), \ell^{f\prime}(\delta), c^{m\prime}(\delta), c^{f\prime}(\delta)\right)$ for each couple of individual utility functions $v^m(.; \delta)$ and $v^f(.; \delta)$.

- An index for the female's bargaining power $\mu(\delta)$ can be defined by $\frac{k}{K}(\delta)$. The more this number approaches one, the higher the female's bargaining power.[16]

- Over all individual preferences characterized by δ, choose the household's bargaining power index μ, such that the criterion

$$5\left(\ell^{m\prime}(\delta) - \ell_*^m\right)^2 + \left(\ell^{f\prime}(\delta) - \ell_*^f\right)^2$$

  is minimized. Apart from the bargaining power μ, this step results in two individual utility functions with a common δ-parameter.

[15] Note that the boundaries of the Pareto frontier are obtained for $k = 1$ and $k = K$.

[16] For a given δ, the approach is ordinal in so far that the utility levels $u_k^f(\delta)$ are adequately redefined.

Identification of the leisure interaction terms A next step in the algorithm consists of a logistic regression of the bargaining power index μ on a number of variables. One of the starting points of the collective approach, is that the individuals' bargaining power may be affected by changes in wages, nonlabour incomes and other variables (cf. supra). This dependence on exogenous variables is a crucial distinction from the unitary model.[17] Let $\mathbf{e}$ be a vector of explanatory variables not belonging to the vector of household characteristics $\mathbf{d}$.[18] Once we have obtained an estimated bargaining power index $\mu(\mathbf{e},\mathbf{d})$ for each household, the above algorithm is redefined to take account of both this $\mu(\mathbf{e},\mathbf{d})$ and different leisure interaction terms for the individuals.

- First calculate $u^f_{\max}(\delta^f)$ and $u^f_{\min}(\delta^f)$ for each $\delta^f \in \{\delta^f_{\min},...,\delta^f_{\max}\}$ and each $\delta^m \in \{\delta^m_{\min},...,\delta^m_{\max}\}$, in the same way as before.

- Define K utility levels $u^f_k(\delta^f) = u^f_{\min}(\delta^f) + (k-1)\frac{\left(u^f_{\max}(\delta^f)-u^f_{\min}(\delta^f)\right)}{K-1}$, where $k = 1,...,K$. Choose from this set, the required utility level $u^f_p(\delta^f)$ such that p corresponds to the nearest integer of $\mu(\mathbf{e},\mathbf{d})K$.

- Solve the following Pareto optimality problem:

$$\max_{c^m,c^f,l^m,l^f} v^m\left(c-c^f,l^m,l^f,\mathbf{d};\delta^m\right)$$

  subject to

$$v^f\left(c^f,l^m,l^f,\mathbf{d};\delta^f\right) \geq u^f_p\left(\delta^f\right),$$
$$c \leq y + w^m\ell^m + w^f\ell^f - \tau\left(w^m\ell^m, w^f\ell^f, y, \mathbf{d}\right),$$
$$\ell^m \in \{30,37,38,40\},$$

  and

$$\ell^f \in \{0,8,20,30,40\}.$$

  For each couple of utility functions, this results in an optimal labour supply and consumption bundle $\left(\ell^m\left(\delta^m,\delta^f\right),\ell^f\left(\delta^m,\delta^f\right),c^m\left(\delta^m,\delta^f\right),c^f\left(\delta^m,\delta^f\right)\right)$.

- Choose the individual utility functions, defined by δ^m and δ^f, that minimize the criterion

$$5\left(\ell^m\left(\delta^m,\delta^f\right)-\ell^m_*\right)^2 + \left(\ell^f\left(\delta^m,\delta^f\right)-\ell^f_*\right)^2.$$

- Finally, the calibrated δ^m and δ^f parameters are regressed on a set of household characteristics. Estimated parameters, say $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$, close the model.

[17] In the given setting, wages are of special importance. Since we are in a context with nonlinear income taxation, the question can be asked which wage concept should be taken up in the regression ? Gross wage rates are clearly inadequate, since depending on the number of hours both individuals work, other levels of household consumption are obtained. In the empirical exercise, the female's and male's marginal contributions to the household's earnings when switching from the lowest labour supply choice to the highest are chosen.

[18] The vector $\mathbf{e}$ consists, e.g., of the above wage concept variables and the difference in individually assignable nonlabour incomes (which may affect the bargaining position within the household).

4.3 Baseline datasets

Let us first summarize how the different parameters of the collective labour supply model are identified. Firstly, the Stone-Geary parameters $\beta_1^i(\mathbf{d})$ and $\beta_2^i(\mathbf{d})$ $(i = m, f)$ are estimated on two samples of male and female singles. Secondly, the female's bargaining power index $\mu(\mathbf{e}, \mathbf{d})$ is obtained via the first round calibration and the subsequent estimation and prediction of the calibrated bargaining power indices. Finally, $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$ are obtained via the second round calibration and the subsequent estimation and prediction of these leisure interaction terms.

In the empirical exercise, we will focus attention on two pre-reform baseline datasets. The *first* dataset is simulated by means of the collective labour supply model with parameters that are identified as explained above. Necessary ingredients for this dataset are (1) (naturally) the identified collective model, (2) household characteristics, wages and nonlabour incomes observed in the used Belgian microdataset and (3) the Belgian tax-benefit system. This dataset thus consists of the Belgian microdataset with observed labour supply replaced by 'collectively' determined labour supply. Two offspring of this dataset are the collectively determined labour supplies after application of the two tax reforms referred to earlier. This dataset is most important from the point of view of the second objective of this study; namely quantifying distortions from using the unitary model when the collective model is more appropriate. Since this dataset is obtained by means of a fully deterministic model, all deviations in policy simulations (and normative evaluations of the latter) are entirely due to the inappropriate use of a unitary model, at least if the latter is flexible enough to capture a great deal of behavioural reactions.

The *second* dataset will consist of a simulated dataset by means of the collective model with calibrated, instead of estimated, bargaining power indices μ and leisure interaction terms δ^m and δ^f. In order to allow for shifts in the bargaining power due to policy changes, the constant in the regression of μ on the explanatory variables $\mathbf{e}$ and $\mathbf{d}$, is changed in such way that the calibrated μ equals the estimated bargaining power index $\mu(\mathbf{e}, \mathbf{d})$. Since every household in the sample may have different parameters (even if they have the same characteristics), the model thus allows for three sources of 'unobserved heterogeneity': the constant in the regression of μ, and the two leisure interaction terms δ^m and δ^f. If the calibration results in a good fit of the observed dataset, then this second dataset should be very similar to the former.

5 Specification of the unitary models and econometric issues

5.1 Singles

As has already been indicated above, preferences of male and female singles are assumed to be of the Stone-Geary type. To keep notation simple, let us skip the indices for male and female preferences for the moment. Further, let us assume that an individual has J labour supply choices, each associated with a particular consumption level. The utility that is derived by individual i at the j'th labour supply choice is given by:

$$u_{ij} = \beta_1(\mathbf{d}_i)\ln(c_{ij} - \overline{c}(\mathbf{d}_i)) + \beta_2(\mathbf{d}_i)\ln\left(l_{ij} - \overline{l}(\mathbf{d}_i)\right) + \varepsilon_{ij}, \tag{3}$$

where ε_{ij} is an individual unobserved preference component that may depend on the labour supply choice. The minimum consumption and leisure $\overline{c}(\mathbf{d}_i)$ and $\overline{l}(\mathbf{d}_i)$ are fixed as described in the former section. The marginal propensities to consume $\beta_1(\mathbf{d}_i)$ and $\beta_2(\mathbf{d}_i)$, on the other hand, are estimated and assumed to be heterogeneous across individuals. Three different models will be considered, which depend on the heterogeneity assumptions made.

The first model assumes that there is only unobserved heterogeneity across individuals via the disturbance ε_{ij}. More specifically, this model assumes that the marginal propensities to consume depend on observed household characteristics as follows:

$$\beta_1(\mathbf{d}_i) = \beta_{10} + \beta'_{11}\mathbf{d}_i \tag{4}$$

and

$$\beta_2(\mathbf{d}_i) = \beta_{20} + \beta'_{21}\mathbf{d}_i. \tag{5}$$

By making the appropriate distributional assumptions on ε_{ij}, this model can be estimated by means of McFadden's conditional logit model (see, e.g., Greene, 1997). Under the assumption of rationality, it can be shown that if the disturbances are independent and identically distributed with type I extreme value distribution,

$$F(\varepsilon_{ij}) = \exp(-\exp(-\varepsilon_{ij})),$$

then the probability that individual i makes choice k equals:

$$\Pr(z_i = k) = \Pr(u_{ik} > u_{ij},\ \forall j \neq k) = \frac{\exp(\mathbf{x}'_{ik}\beta)}{\sum_{j=1}^{J}\exp\left(\mathbf{x}'_{ij}\beta\right)}, \tag{6}$$

where z_i is a random variable indicating the choice made, and $\mathbf{x}'_{ij}\beta$ is shorthand notation for equation (3) with equations (4) and (5) substituted for $\beta_1(\mathbf{d}_i)$ and $\beta_2(\mathbf{d}_i)$. The likelihood function for this conditional logit model equals:

$$\log L = \sum_{i=1}^{n}\sum_{j=1}^{J} d_{ij}\log\Pr(z_i = j),$$

where d_{ij} is a binary indicator that equals 1 if i made labour supply choice j, and 0 otherwise. This likelihood function is easily estimated by means of standard techniques. Two important drawbacks of the conditional logit model are the assumption of identical tastes across individuals with the same demographic characteristics and its independence of irrelevant alternatives property. This boils down to any odds ratio being independent of a third alternative:

$$\frac{\Pr(z_i = j)}{\Pr(z_i = k)} = \frac{\exp\left(\mathbf{x}'_{ij}\beta\right)}{\exp(\mathbf{x}'_{ik}\beta)},$$

which is a rather restrictive assumption. The other two models are alternatives to the conditional logit model that introduce unobserved preference heterogeneity across individuals and do not imply the independence of irrelevant alternatives property.

The second model that we consider is the random parameters logit or the mixed logit model (see, e.g., Train, 1998 and McFadden and Train, 2000). In particular, we assume that the marginal propensities to consume are now:

$$\beta_1(\mathbf{d}_i) = \beta_{10} + \beta_{11}'\mathbf{d}_i + \upsilon_{1i}$$

and

$$\beta_2(\mathbf{d}_i) = \beta_{20} + \beta_{21}'\mathbf{d}_i + \upsilon_{2i}.$$

Unobserved preference heterogeneity enters the model via the disturbances υ_{1i} and υ_{2i}. We assume that these disturbances are normally distributed with mean zero: $\upsilon_{1i}\tilde{\ }N(0,\sigma_1^2)$ and $\upsilon_{2i}\tilde{\ }N(0,\sigma_2^2)$. With the above shorthand notation, the utility derived from making labour supply choice j equals:

$$u_{ij} = \mathbf{x}_{ij}'\beta = \mathbf{x}_{ij}'\mathbf{b} + \mathbf{x}_{ij}'\upsilon_i + \varepsilon_{ij},$$

where $\mathbf{b}$ is a vector of average preference parameters and $\upsilon_i = (\upsilon_{1i}, \upsilon_{2i})'$. Unobserved preference heterogeneity now equals $\mathbf{x}_{ij}'\upsilon_i + \varepsilon_{ij}$ and is correlated with individual characteristics and labour supply choices. Moreover, thanks to this setting, the random parameters logit model does not exhibit the independence of irrelevant alternatives property. This is easily seen if one considers the probability that individual i makes choice k, which depends on the entire distribution of the coefficients vector β:

$$\Pr(z_i = k) = \int \frac{\exp(\mathbf{x}_{ik}'\beta)}{\sum_{j=1}^{J}\exp(\mathbf{x}_{ij}'\beta)} f(\beta)\, d\beta. \qquad (7)$$

The likelihood function now equals:

$$\log L = \sum_{i=1}^{n}\sum_{j=1}^{J} d_{ij} \log \int \frac{\exp(\mathbf{x}_{ik}'\beta)}{\sum_{j=1}^{J}\exp(\mathbf{x}_{ij}'\beta)} f(\beta)\, d\beta.$$

Standard maximum likelihood estimation of this function is not possible, since the above integral cannot be calculated analytically. However, by means of simulated maximum likelihood, estimates of $\mathbf{b}$, σ_1^2 and σ_2^2 can be obtained (see, e.g., Train, 1998). This method approximates $\int \frac{\exp(\mathbf{x}_{ik}'\beta)}{\sum_{j=1}^{J}\exp(\mathbf{x}_{ij}'\beta)} f(\beta)\, d\beta$ by the average of the sum over randomly drawn values of β (from a mean zero normal distribution in our case). This results in a simulated maximum likelihood function of the form:

$$\log SL = \sum_{i=1}^{n}\sum_{j=1}^{J} d_{ij} \log \frac{1}{R}\sum_{r=1}^{R} \frac{\exp(\mathbf{x}_{ik}'\beta_r)}{\sum_{j=1}^{J}\exp(\mathbf{x}_{ij}'\beta_r)},$$

where R is the number of draws of β, and β_r is the r'th draw from $f(\beta)$. It can be shown that the estimated parameters $\mathbf{b}$, σ_1^2 and σ_2^2, obtained by maximizing $\log SL$, are consistent and asymptotically normal under some regularity conditions and conditions on the number of repetitions R.

A third alternative to estimate individual preference parameters is based on Hoynes'(1996) labour supply model with discrete unobserved heterogeneity. Here we assume that there is only unobserved preference heterogeneity with regard to the marginal propensity to consume $\beta_1(\mathbf{d}_i)$. In particular, the preference parameters are assumed to be of the following form:

$$\beta_1(\mathbf{d}_i) = \theta_i + \beta_{11}'\mathbf{d}_i$$

and

$$\beta_2(\mathbf{d}_i) = \beta_{20} + \beta_{21}'\mathbf{d}_i.$$

In the empirical exercise, it is assumed that θ_i can take two values, θ^1 and θ^2, with probabilities π^1 and $\pi^2 = 1 - \pi^1$. Both the values for θ_i and the associated probabilities are estimated by maximum likelihood techniques. In the model, a higher value for the discrete heterogeneity θ_i implies a larger marginal propensity to consume, and thus a higher work effort. The individual likelihood contribution now consists of two parts, each associated with one value of the heterogeneity factor:

$$\Pr(z_i = k) = \pi^1 \frac{\exp\left(\mathbf{x}_{ik}'\beta\left(\theta^1\right)\right)}{\sum_{j=1}^{J}\exp\left(\mathbf{x}_{ij}'\beta\left(\theta^1\right)\right)} + \pi^2 \frac{\exp\left(\mathbf{x}_{ik}'\beta\left(\theta^2\right)\right)}{\sum_{j=1}^{J}\exp\left(\mathbf{x}_{ij}'\beta\left(\theta^2\right)\right)}, \tag{8}$$

where $\beta(\theta^a)$ is shorthand notation for the vector preference factors, θ^a appearing in the marginal propensity to consume $\beta_1(\mathbf{d}_i)$; $(a = 1, 2)$. The likelihood function to be maximized equals:

$$\log LD = \sum_{i=1}^{n}\sum_{j=1}^{J}\sum_{a=1}^{2}\pi^a \frac{\exp\left(\mathbf{x}_{ik}'\beta\left(\theta^a\right)\right)}{\sum_{j=1}^{J}\exp\left(\mathbf{x}_{ij}'\beta\left(\theta^a\right)\right)},$$

and results in an estimated coefficients vector $\left(\theta^1, \theta^2, \beta_{11}', \beta_{20}, \beta_{21}'\right)'$ and probabilities π^1 and $\pi^2 = 1 - \pi^1$.[19]

Each of these three estimation procedures will be applied to estimate single males' and females' preference parameters. Depending on some test results and the comparison of fit, one of these will be kept to use in the calibration and simulation exercises.

5.2 Couples

In order to be able to quantify the distortions from using a unitary model when the collective approach is appropriate, an empirical specification of the former

[19] In the empirical exercise, π^1 and π^2 are replaced by the expressions $\frac{\exp(m)}{1+\exp(m)}$ and $1 - \frac{\exp(m)}{1+\exp(m)}$, where the scalar m is estimated. This procedure guarantees that π^1 and π^2 are between zero and one, and add up to 1.

is needed. This empirical unitary model will be estimated on the 'collectively' generated data. Of course, this model should have a certain degree of flexibility, in the sense that it must be able to describe a wide range of household labour supply behaviour. The behavioural model we opt for is an extended version of the couples' Stone-Geary utility function. The extension consists of the leisure interaction term $\delta(\mathbf{d})\ln\left(l^m - \bar{l}(\mathbf{d})\right)\ln\left(l^f - \bar{l}(\mathbf{d})\right)$. It makes the model similar to the collective model we derived above and allows for richer behavioural effects than the Stone-Geary utility function.

In what follows we assume that each couple has J labour supply choices. Each choice is characterized by the specific labour supply of both adult individuals in the household and the corresponding consumption level. The latter of course depends on the wages, nonlabour income and the tax system. The utility derived from labour supply choice j by household i is assumed to be equal to:

$$\begin{aligned} u_{ij} &= \beta_1(\mathbf{d}_i)\ln\left(c_{ij} - \bar{c}(\mathbf{d}_i)\right) + \beta_2(\mathbf{d}_i)\ln\left(l_{ij}^m - \bar{l}(\mathbf{d}_i)\right) + \beta_3(\mathbf{d}_i)\ln\left(l_{ij}^f - \bar{l}(\mathbf{d}_i)\right) \\ &\quad + \delta(\mathbf{d}_i)\ln\left(l_{ij}^m - \bar{l}(\mathbf{d}_i)\right)\ln\left(l_{ij}^f - \bar{l}(\mathbf{d}_i)\right) + \varepsilon_{ij}. \end{aligned}$$

Preference heterogeneity across households is taken up via the preference factors $\beta_k(\mathbf{d}_i)$ and the disturbance ε_{ij}. The latter is assumed to be drawn from a type I extreme value distribution. Depending on the type of heterogeneity in the preference parameters, two empirical models will be considered.

In the first model it is assumed that:

$$\beta_1(\mathbf{d}_i) = \beta_{10} + \beta_{11}'\mathbf{d}_i,$$

$$\beta_2(\mathbf{d}_i) = \beta_{20} + \beta_{21}'\mathbf{d}_i$$

and

$$\beta_3(\mathbf{d}_i) = \beta_{30} + \beta_{31}'\mathbf{d}_i.$$

Consequently, no unobservable preference heterogeneity is taken up, apart from the disturbance ε_{ij}. This model amounts to the conditional logit model and is estimated along the lines described above.

The second model assumes discrete unobserved heterogeneity in $\beta_1(\mathbf{d}_i)$ and the same $\beta_2(\mathbf{d}_i)$ and $\beta_3(\mathbf{d}_i)$ as above:

$$\beta_1(\mathbf{d}_i) = \theta_i + \beta_{11}'\mathbf{d}_i,$$

where θ_i is assumed to take two values θ^1 and θ^2 with probabilities π^1 and $\pi^2 = 1 - \pi^1$. This empirical model *à la* Hoynes (1996) can be estimated by means of maximum likelihood techniques (cf. discussion of the singles' models).

5.3 Missing wages

Many single women and women in couples do not participate in the labour market, as will be seen in the next section. Consequently gross wages are not observed for these individuals. However, to apply the above discrete choice models, gross wages are needed for every individual.

To obtain estimates of gross wages for nonparticipating single women, the by now standard Heckman's two step estimation procedure was applied (see, e.g., Greene, 1997). It turned out however that the null hypothesis of no sample selection could not be rejected. Therefore, gross wages were estimated by means of OLS on the basis of the following equation:

$$\ln w_i^f = \gamma' \mathbf{d}_i + \varepsilon_i,$$

where w_i^f is the gross wage of individual i, $\mathbf{d}_i$ a vector of demographic characteristics, like educational dummies, number of children and region, γ a coefficients vector, and ε_i is a spherical disturbance.

For women in couples, the null hypothesis of no sample selection was rejected. Therefore, gross wages for nonparticipating women in couples are obtained by means of Heckman's two step estimation procedure.

6 Data

The dataset used in the exercise is drawn from the Socio-Economic Panel (SEP) of the Center for Social Policy. This panel is primarily used for research of poverty issues, the effectiveness of social security and the welfare distribution. For the current analysis we use the 1992 and 1997 waves of the panel. Three subsamples are selected for the exercise. The first two subsamples consist of female and male singles. The sample selection is for singles with or without dependent children, aged between 25 and 55 inclusive and who are employed or voluntarily unemployed (i.e., students, self-employed and retired individuals are excluded). This leaves samples of 267 female and 199 male singles. The third sample consists of de facto couples on which the same sample selection of singles is applied to. This results in a sample of 1886 couples.

The SEP contains only net incomes coming from different sources.[20] To obtain necessary but lacking gross labour incomes, a simplified direct taxation scheme (cf. supra) was inverted. There are also some problems with nonlabour incomes in the dataset. Firstly, the SEP does not contain any information on savings. Secondly, there are indications that the nonlabour income that cannot be assigned to individuals is rather badly measured. Therefore, consumption based nonlabour incomes are imputed by means of the National Statistics Institute household budget survey of 1997-98.

Summary statistics of the three selected samples are given in Tables 7, 8 and 9.

[20] In order to make nominal data comparable, account is taken of an inflation rate of 10.71% between 1992 and 1997 (see Ministry of Economic Affairs, Belgostat figures).

7 Estimation results

In this section, we will first focus on some estimation results with regard to missing wages of nonparticipants. Then the estimation results of singles' preference parameters are discussed. Finally, calibration and estimation results are considered of both the collective and the unitary models for couples.

7.1 Estimation of missing wages

7.1.1 Single women

When applying Heckman's two step estimation procedure, it turned out that sample selection bias could be ignored. Therefore, gross wages for nonparticipating single women are estimated by means of OLS (see Table 10) for the estimation results). In Table 11, some descriptive statistics of observed and predicted gross wages are given.

7.1.2 Women in couples

Gross wages for nonparticipating women in couples are derived via Heckman's two step estimation procedure. Table 12 gives participation and wage equation parameter estimates. The null hypothesis of no sample selection is rejected, since the coefficient associated with Heckman's lambda is different from zero at the 5% significance level. Summary results on females' wages are shown in Table 13.

7.2 Estimation of singles' preference parameters

The models that are considered in this study are discrete choice models. I.e., it is assumed that individuals only have a limited number of labour supply choices. Each of these choices is characterized by a particular leisure amount and consumption level. The latter depends on the wages, nonlabour incomes and the tax system. Observed weekly working hours, both for singles and individuals in couples, are discretized as shown in Table 14. The table also gives observed frequencies. Women can choose between five alternatives, whereas men have a choice set of four alternatives. Especially the choice set for men can be open to discussion. Observed working hours are very concentrated around 38 hours, both for single men and for men in couples. Note that this is the number of hours that is standard in many economic sectors. Therefore, the question can be asked in how far labour demand constraints are playing a role in men's labour supply. The problem seems to be less acute for women, since many of them do not participate in the labour market or are working part-time.

In Tables 15-20, estimation results are given of the three alternative discrete choice models that were discussed in the previous section. All three models estimate Stone-Geary utility functions for single men and women, with different assumptions on preference heterogeneity across individuals.

It is clear that for single women, the likelihood values considerably increase as soon as unobserved preference heterogeneity is assumed. The different specifications can be tested by means of the likelihood ratio test. Twice the difference between the log likelihood value of the less restrictive model and log likelihood of the more restrictive model is asymptotically distributed as chi-square, under the null hypothesis of the more restrictive model. Degrees of freedom equal two for both the random parameters logit and the discrete choice model, when compared to the conditional logit. The conditional logit model (Table 15) is rejected when compared to the random parameter logit model (Table 16) at the 5% significance level. The test statistic equals 34.436 and is to be compared to the critical value $\chi^2_{0.05}(2) = 5.99$. Also the discrete heterogeneity model (Table 17) rejects the conditional logit model (test statistic of 56.864). The parameter associated with the probability that the first consumption parameter is obtained equals 0.119. Consequently, the probability that the individual has the first consumption parameter in her preferences equals 53.0% (cf. discussion on estimation methods).

For single men, the fit does not really improve if unobserved heterogeneity is assumed. Both the random parameters logit model (Table 19) and the discrete heterogeneity model (Table 20) cannot reject the null hypothesis of no unobserved preference heterogeneity as captured by the conditional logit model (Table 18). Test statistics are respectively 0.67 and 0.498, which are smaller than $\chi^2_{0.05}(2) = 5.99$. The probability parameter equals 0.503, which amounts to a probability of 62.3% of having the first consumption parameter.

Other useful information to discriminate between the different models, is the number of correctly predicted labour supply choices. This is done by means of equations (6), (7) and (8), where the labour supply choice is chosen with the highest probability. For the discrete heterogeneity model, each individual is allocated the θ-parameter that minimizes the squared deviation between predicted and observed labour supply. Table 21 gives the percentages of correct predictions for both male and female singles, for the different discrete choice models. It is easily seen that for all singles, the number of hits considerably increases in the discrete heterogeneity case.

Taking both the likelihood ratio tests and the number of hits into account, preference parameter estimates obtained by the discrete heterogeneity model will be used further on in the calibration and simulation exercises.

7.3 Calibration and estimation of couples' labour supply models

In this subsection, we first discuss the results on the identification of the collective labour supply model. On the basis of this identified collective model, two baseline datasets will be generated (cf. supra). The first one is simulated by means of estimated parameters of the collective model. The second baseline dataset is generated by means of calibrated parameters of the model. In order to be able to quantify the distortions of the unitary model, an extended version of the Stone-Geary utility function is estimated on the 'collectively' generated datasets. These estimation results are discussed at the end of this subsection.

7.3.1 The collective model

To discuss the results of the identification exercise of the collective model, we refer to the algorithm described in section 4. As was indicated there, the collective labour supply model is identified in two rounds.

First round calibration exercise The first round of the exercise consists of the derivation of a discrete set of Pareto efficient household allocations for several individual utility functions, characterized by their value for the leisure interaction term. The Stone-Geary part of the individual utility functions $\beta_1^i(\mathbf{d})$ and $\beta_2^i(\mathbf{d})$ $(i = m, f)$ equal the corresponding parameters in male and female singles' utility functions, where the latter are estimated by means of the discrete heterogeneity model. In this round, the leisure interaction term is the same in the male's and female's utility function $\left(\delta^m(\mathbf{d}) = \delta^f(\mathbf{d}) = \delta\right)$. In concrete, we derive per leisure interaction term $\delta \in \{-0.1, -0.08, ..., 0.08, 1\}$, $K = 100$ Pareto efficient allocations.[21] Each household is then given the Pareto efficient allocation k and leisure interaction term δ that minimize the deviation from observed labour supply. An index for the female's bargaining power is given by $\frac{k}{K}$ (cf. supra). Some summary statistics of the first round calibrated δ's and μ's are given in Tables 22 and 24.

Regression of the bargaining power index μ The above first round calibration exercise results in a vector of female bargaining power indices $\mu = \frac{k}{K}$, one index per couple in the sample. This bargaining power index is then regressed on a set of explanatory variables. The idea is that changes in, e.g., wages or individual nonlabour incomes may affect the bargaining position of household members. In this way, tax reforms may have an extra effect (on top of the usual effects in unitary labour supply models) on labour supply and welfare of households or household members. Since the range of the bargaining power index is restricted between 0 and 1, it is modelled by means of a logistic model:

$$\mu_i(\mathbf{e}_i, \mathbf{d}_i) = \frac{\exp(\beta_1'\mathbf{e}_i + \beta_2'\mathbf{d}_i + \varepsilon_i)}{1 + \exp(\beta_1'\mathbf{e}_i + \beta_2'\mathbf{d}_i + \varepsilon_i)},$$

where $\mu_i(\mathbf{e}_i, \mathbf{d}_i)$ is the wife's bargaining power index in household i, $\mathbf{e}_i$ a vector of economic variables (including wage concepts and nonlabour incomes), $\mathbf{d}_i$ a vector of demographic variables and β_1 and β_2 two coefficients vectors. The random variable ε_i is assumed to be normally distributed with mean zero. The above form is linearized by means of the logit transformation:

$$\text{logit}(\mu_i(\mathbf{e}_i, \mathbf{d}_i)) = \ln \frac{\mu_i(\mathbf{e}_i, \mathbf{d}_i)}{1 - \mu_i(\mathbf{e}_i, \mathbf{d}_i)} = \beta_1'\mathbf{e}_i + \beta_2'\mathbf{d}_i + \varepsilon_i.$$

[21] The restriction of δ being greater than or equal to -0.1 guarantees a positive marginal utility of own leisure for each individual.

In Table 23, OLS estimation results are given of the wife's bargaining power. Except for the constant, explanatory variables were retained that are significantly estimated at the 5% significance level. Important explanatory variables from the point of view of the collective approach are the household nonlabour income, the difference in individual nonlabour incomes and both wage variables. An increase in the household's nonlabour income and an increase in the difference between the female's nonlabour income and the male's, has a significantly estimated positive effect on the female's bargaining position. Also an increase in the female's earnings capacity (as captured by the first wage variable) improves her bargaining position in a significant way. On the other hand, an increase in the male's earning capacity (as captured by the second wage variable), significantly decreases the female's bargaining power index.

The significance of these economic variables in the bargaining power index, implies that a change in these variables have implications on the household allocation problem that go beyond these of the unitary approach. Changes of, e.g., earning capacities not only have an effect on the household's budget set, but also on the final allocation on the Pareto frontier. Some descriptive statistics on calibrated and estimated bargaining power indices are given in Table 24.

Second round calibration exercise and regressions individual leisure interaction terms In the second round of the identification exercise, each household is allocated its predicted female's bargaining power index $\mu(\mathbf{e},\mathbf{d})$. For discrete sets of males' and females' leisure interaction terms δ^m and δ^f, each pair defining a pair of utility functions, the corresponding Pareto efficient household allocations are calculated by means of $\mu(\mathbf{e},\mathbf{d})$. These Pareto efficient allocations are calculated for the male and female utility functions characterized by $\delta^m, \delta^f \in \{-0.1, -0.08, ..., 0.08, 1\}$. For each household, the pair (δ^m, δ^f) is chosen that minimizes the deviation between observed and calibrated labour supply. Then calibrated leisure interaction terms are regressed on some demographic variables. In Tables 25-28, OLS estimates and summary statistics on calibrated and estimated leisure interaction terms are given. As is clear from the tables, calibrated female leisure interaction terms are on average smaller than male ones'. But note that a comparison of these preference parameters can be misleading, since males' and females' representations of preferences differ considerably.

Tables of hits and misses for baseline datasets Tables 29-32 consists of the number of hits and misses for each labour supply choice for men and women. The first two tables give the results for the first baseline dataset. This dataset consists of simulated data by means of estimated bargaining power indices $\mu(\mathbf{e},\mathbf{d})$ and leisure interaction terms $\delta^m(\mathbf{d})$ and $\delta^f(\mathbf{d})$. Tables 31 and 32 give the hits and misses of the 'calibrated' collective household model (cf. supra). As is clear from the tables, the 'simulated' collective model is able to predict 38.8% of females' labour supply choices correctly. However, only 21.2% of the men are correctly predicted. Note the large overestimations of the number of men in the 30 and 40 hours categories. Of course, with regard to the evaluation exercise of the distortions of the unitary model, this bad fit does not matter. The 'calibrated' collective model, on the other hand, has a much better fit. Correctly predicted labour supply choices are 94.5% for women and 93.7% for men.

7.3.2 The unitary model

In Tables 33-36, estimates of the coefficients of the couples' utility function are given for the two baseline datasets. Tables 33 and 35 give conditional logit model estimates. Estimates obtained by means of the discrete heterogeneity model are given in Tables 34 and 35. Coefficients associated with demographic variables are retained that are significant at the 5% significance level for the conditional logit model. Likelihood ratio tests strongly reject the conditional logit model when tested against the discrete heterogeneity model. Test statistics for the simulated and calibrated baseline datasets respectively equal 238.27 and 28.05. These are to be compared to the critical value of $\chi^2_{0.05}(2) = 5.99$. The parameters associated with the probability of having the first consumption parameter in the preferences equal 1.659 for the simulated baseline dataset and 1.945 for the calibrated one. This amounts to probabilities of respectively 84.0% and 87.5%.

Both sets of discrete heterogeneity estimates give rise to a considerable number of bad behaved direct utility functions. There are 1170 households that have negative marginal utilities of consumption or of leisure in the simulated baseline dataset.[22] As to the calibrated dataset, there are 1437 violations of the restriction of nonnegative marginal utilities. Note that these violations also imply a rejection of quasi-concavity of the utility function for a large number of households.

Of course, rejections of unitary behavioural restrictions could be expected beforehand. As has been shown earlier, the wife's bargaining power index significantly depends on wage variables and nonlabour incomes. This feature makes the collective model distinct from the unitary model. It implies that observed (multi-person) household behaviour cannot be considered as resulting from the maximization of unique rational preferences, subject to a budget constraint. Note further that the simulated data come from a perfectly deterministic collective model. Nowhere in the model there is white noise. By means of observed wages, nonlabour incomes and other household characteristics, the labour supply of the household members can be exactly predicted, along the lines of the collective model. Putting collectively generated data in the strait-jacket of the unitary model then, indeed may result in a strong rejection of the unitary theoretical implications. Of course, with observed real world data things might be obscured somewhat due to white noise, unobserved heterogeneity that cannot be adequately captured, etc.

[22] These marginal utilities are evaluated at the consumption-leisure bundle where utility is maximal. Note however that marginal utilities should be nonnegative for all consumption-leisure bundles.

It can be argued that the above result clearly shows that applying the unitary model when it is inappropriate may have large consequences on policy evaluations. Together with the many rejections of the unitary model in the literature, and the failure to reject collective restrictions, this result seems to give strong support to the thesis that it is time to shift the burden of proof to the unitary model (see, e.g., Alderman et alii, 1995).

One problem with these unitary estimates is that they lack any economic meaning for many households. It turns out that violations of the restriction of positive marginal utilities heavily depends on the parameter associated with the leisure interaction term. Therefore, in the tax reform evaluation exercise, this parameter is changed in an ad-hoc way so that at least the marginal utilities are not negative for most of the households.[23] Note however that even this, possibly controversial, intervention does not guarantee that households' utility functions are quasi-concave.

8 Policy simulations

In this section, we dig deeper into the study's objective of quantifying the distortions in policy evaluations, due to the use of a unitary model when it is inappropriate. Two tax reforms are focused on (see section 3 for details). The first reform is the future Belgian tax reform that will be gradually introduced over the years 2001 to 2004. The second proposal is a revenue neutral negative income tax, replacing the current tax system. Each tax reform will be discussed for both the simulated and the calibrated baseline datasets (cf. supra).[24]

8.1 The Belgian tax reform proposal

8.1.1 Singles

Some summary statistics and labour supply effects for female and male singles are shown in Tables 37-40. It is clear from Tables 37 and 38 that the females' labour supply is not very much affected by the tax reform. Mean labour supply remains more or less constant and most of the single women stay in the status quo position (see diagonal of Table 38 that contains 96.3% of the females). Two women enter the labour market. Note that the increase in participation is one of the objectives of the tax reform. Although mean gross earnings are only slightly affected by the tax reform, mean consumption increases by almost 2%. This is for a great deal because of the broadening of the middle income tax brackets and the abolition of the highest income tax rates. Both measures imply less income taxes to be paid on a given amount of gross income.

[23] The parameter associated with the leisure interaction term is given a value of 45 if a violation is observed for a household in the simulated baseline dataset. Households in the calibrated baseline dataset are allocated a parameter value of 2, if there is a negative marginal utility.

[24] Note that the future Belgian tax reform is referred to as 'tax reform' in the tables that follow. 'Negative income tax' is used for the revenue neutral negative income tax reform.

Contrary to female singles, males seem to substitute leisure for consumption (see Tables 39 and 40). Mean labour supply decreases by about 2.5 hours per week. The increase of the consumption level, following the decrease in the average tax level, is outweighed by the decrease in consumption due to the decrease in gross earnings.

In Table 41, the numbers of winners and losers of the tax reform are shown. It is clear from the table that no one loses from the tax reform and that most of the singles have a strict welfare increase. Since nobody loses, it can be argued that the tax reform increases the aggregate welfare level of singles, without having recourse to strong cardinality and comparability assumptions (see mean utilities in Tables 37 and 39). The reform however, does not unambiguously decrease inequality among singles. Table 42 shows pre and post tax reform Gini coefficients for male and female singles. The variable that is under analysis for the Gini coefficient is equivalent household consumption.[25] It is seen from the table that inequality increased among male singles. On the contrary, inequality among female singles seems to decrease after the tax reform. Table 42 also gives mean tax rates in the pre and post reform situation. Perhaps not surprising given the above results, the average tax rate of both males and females decreases.

8.1.2 Couples

Tables 43-49 give some aggregate measures and labour supply effects for couples of the Belgian tax reform. Results are obtained by means of the collective and the unitary model on the simulated dataset. Most of the women and men in couples do not change their labour supply after the tax reform. The diagonals of Tables 44 and 45 contain 91% of the wives and 93% of the husbands. A relatively high number of women (i.e., 47 or 7.6% of the wives who did not work in the pre reform situation) enter the labour market after the tax reform. Aggregate labour supply of both men and women slightly decrease according to the simulation results obtained by the collective model. Although this has a negative effect on gross earnings, the effect is not transferred to the mean household consumption. Of course, this is only possible because of the decrease of the average income taxes (see Table 43). These results are not contradicted by the unitary model (see Tables 46-48): mean labour supply of both men and women decrease, but this is not accompanied by a decrease of mean household consumption. Also the percentage of women entering the labour market, does not differ very much: 97 women or 9.7% of the nonparticipating women in the pre reform situation. Note however that the levels of labour supply of both men and women considerably differ between the unitary and collective model. The number of nonparticipating women, e.g., is heavily overestimated by the unitary model. The same applies for men who are in the thirty hours bracket (compare Tables 44 and 45 to Tables 47 and 48).

By far the most important difference between the collective and the unitary model, is the ability of the former to say something on what happens within the

[25] The OECD equivalence is used. The first adult in the household has a weight equal to 1, other adults have 0.7 and children below 13 years old have a weight of 0.5.

household. It is clear from Table 43 that both the consumption level of men and women increase after the tax reform. This does not change the consumption share of women however. Note that the consumption is very skewed towards women.[26] Further, the tax reform seems to have a positive impact on the bargaining power of women, which on average increases from 0.62 to 0.63.

Some normative results of the tax reform are given in Tables 49 and 50. Especially Table 49 is important from the study's point of view. The table shows the number of winners and losers of the tax reform for both the collective and the unitary model. Although by far most of the households (1830 couples or 97% of the population) win according to the unitary model, this is not necessarily the case for the individual household members. On the basis of the collective model, there is a decrease of the welfare level of one of the spouses in 620 of the 1830 households that win in the unitary setting. On the other hand, the tax reform implies a Pareto improvement for 1236 households, or 65.5% of the couples. Table 50 gives pre and post tax reform Gini coefficients, concentration ratios and the mean tax rate. The Gini coefficients are again constructed by means of equivalent household consumption. The concentration ratio that is used here focuses on income taxes paid. The welfare indicator is again equivalent household consumption.[27] Although the levels of the Gini coefficients and the concentration ratios differ between the unitary and the collective model, the directions of change of these variables are the same. Both models indicate that inequality, with equivalent consumption as the underlying variable, slightly decreases after the tax reform. On the other hand, the concentration ratio increases according to both models. This implies that the tax system is more progressive after the tax reform. But note that the redistributive effect of the tax system is somewhat eroded because of the decrease of the mean income tax rate (see, e.g., Bishop et alii, 1998).

Tables 51-58 give the tax reform evaluation results on the basis of the calibrated dataset. These results are roughly the same as those obtained on the simulated dataset. Both men and women tend to decrease their labour supply. Note that the average impact of the tax reform on the females' labour supply (-1.8 hours per week or 7.6%) is more pronounced than in the simulated baseline case. The number of wives and husbands that change their labour supply is also greater than for the simulated dataset. Only 74.8% of the women and 54.7% of the men remain on the diagonal in Tables 52 and 53. On the one hand, there is an important participation effect for a relatively high number of women (51 women or 15% of the women who did not work in the pre reform situation). On the other hand, many women tend to work part time instead of full time after the reform (208 women or 29% of the women in the forty hours bracket work less in the new situation). Most men who change their labour supply, opt to work less after the reform. According to the unitary model, labour supply ef-

[26] One explanation might be that public consumption (e.g., rent and children's expenditures) are internalized by women. Clearly more work is needed to take up public consumption in a more adequate way.

[27] See Bishop et alii (1998) for more information on the construction of the Gini and concentration ratio.

fects are less pronounced. Most of the women and men in couples work the same number of hours before and after the tax reform (respectively 91% and 95% of the individuals are on the diagonal in Tables 55 and 56). Note again that pre reform labour supply differs considerably from that obtained by the calibrated collective model. Both the overestimated numbers of nonparticipating women, and men who are in the thirty hours bracket leap to the eye.

As was the case for the tax reform simulation on the simulated dataset, women's bargaining power increases due to the tax reform (index changes from 0.62 to 0.63; see Table 51). Note however that this increased bargaining power is not translated in an increase of the women's consumption share. Of course, this is because utility is not only derived from consumption but also from leisure.

Some welfare evaluation results are given in Tables 57 and 58. The number of winning households is smaller than in the simulated baseline case according to the unitary model. As was the case before, some of these households do not belong to the set of households to which the tax reform was a Pareto improvement. This latter set contains 1439 households or 76% of the population, which is somewhat higher than for the simulated dataset (see Table 57). Once again, these results stress the importance of the collective model when analysing tax reforms. Although Gini coefficients and concentration ratios differ when obtained by the simulated or the calibrated dataset, directions of change are the same. Inequality tends to decrease for both the unitary and the collective model, whereas the progressivity of the tax system increases. As could be expected beforehand, also the mean tax rate is decreased after the tax reform.

8.2 Negative income tax

The next reform we focus on is the replacement of the current tax system by a revenue neutral negative income tax. This tax system is characterized by two parameters: the marginal tax rate and the minimum guaranteed income. These parameters are fixed in such way that the government revenues, coming from taxes paid by singles and by couples, remain constant. Depending on the model used (unitary versus collective) or the dataset on which the simulations are done (simulated or calibrated dataset), these parameters may differ. In Table 59, the values of the parameters are given for the different situations. All in all, these parameters do not differ that much.

8.2.1 Singles

The effects on singles of the introduction of a negative income tax are shown in Tables 60-65. Both females' and males' mean labour supply remain rather constant. However, the directions of the change in mean labour supply are different. Women tend to work less on average, whereas men work more after the reform (see Table 60). Nine women (3% of the population) leave the labour market, probably because of the minimum guaranteed income (see Table 61). However, most of the female and male singles do not change their labour supply after the reform (respectively 91% and 75.9% of the individuals are on the diagonal in Tables 61 and 63. Mean consumption increases for both sexes, in spite of the fact that average taxes slightly increase. The effects on the merely indicative mean welfare level are negligible (see Tables 60 and 62).

In Table 64, the numbers of gainers and losers of the reform are shown. The number of individuals who are strictly worse off is greater than the number of individuals that are strictly better off after the introduction of the negative income tax. There are 168 female singles (or 62.9% of the women) whose welfare level decreased after the reform. Only 65 women (24%) are strictly better off after the reform. Note that at least those women who do not participate in the labour market are made better off. The percentage of men that is strictly worse off is comparable to the female's: 65.3%. There are few winners among single men: namely 36 individuals or 18.1% of the males. Table 65 shows that inequality, measured on equivalent household consumption, increases for both men and women. Gini coefficients increase with respectively 1.1 and 1.6 percent point. The table also shows that the tax burden, measured in terms of the mean tax rate, decreases for both men and women.

8.2.2 Couples

Couples' results on the negative income tax reform for the simulated dataset are given in Tables 66-73. Also here, average labour supply of wives and husbands is quite stable for the collective model (see Table 66). This rather constant mean labour supply can be explained by the fact that most of the household members do not change their labour supply after the reform: 89% of the women and 90% of the men are on the diagonal of Tables 67 and 68. Most of the women who change their labour supply leave the labour market. E.g. 83 women (or 4.4% of the population) who are working 8 hours in the pre reform situation, stop working after the tax reform according to the collective model. This can be explained by the relatively high minimum guaranteed income for these women (see Table 67). Contrary to the singles' case, income taxes paid by couples decrease (which is quite logical, since the negative income tax reform is revenue neutral). The tax reform results obtained by means of the unitary model differ somewhat. On average women's labour supply decreases. Note that the effect is more pronounced than in the collective case (-11% versus 2.2%). The males' mean labour supply however increases, which is divergent from the result obtained by the collective model. Similar between both models is the large number of women who leave the labour market after the introduction of the negative income tax (see Table 70).

The introduction of the negative income tax is on average disadvantageous to women: their bargaining power index decreases from 0.62 to 0.60. This is also translated in a decrease of the average utility level of women (again having recourse to rather strong cardinality and comparability assumptions). On the other hand, mean utility of men in couples seems to increase after the reform. This, among others, results in an increase of the consumption share of men (see Table 66).

The impact of the tax reform on individual households is obscured somewhat by the above summary statistics. Useful information on that is provided in Table 57. It is clearly seen from the table that the impact of the reform largely differs between households. According to the collective model, the reform implies a Pareto improvement for 559 couples, or 29.6% of the population. However, in 630 households (33% of the population), the welfare level of the husband increases at the cost of the wife. In 12.7% of the households, we see the reverse picture where wives are better off after the tax reform, whereas men are worse off. These ambiguous effects of the reform are only very partially captured by the unitary model that indicates that 797 households (or 42.3%) are better off, and 1076 households (or 57% of the population) reach a lower welfare level after the reform. Table 73 gives pre and post reform Gini coefficients, concentration ratios and mean income tax rates for the unitary and the collective models. According to both models, inequality (with equivalent household consumption as the underlying variable) seems to increase among couples. The concentration ratio is fairly stable, although the direction of change is different. Both models agree with each other as to the decrease of the mean income tax rate.

In Tables 74-81, results are given of the negative income tax reform when analysed on the calibrated dataset. As to the mean labour supply, the collective model gives results similar to those obtained by the simulated dataset. Women's labour supply slightly decreases whereas men's labour supply remains constant (see Table 74). Roughly speaking, labour supply changes are also very similar for both datasets (see Tables 75 and 76). Note that this is also the case for the results obtained by the unitary model: mean labour supply of women decreases, whereas men tend to work somewhat more (see Table 77). As to mean consumption and utility levels of the household members, the collective model obtains different results over both datasets. The effect on the wives' bargaining power however is the same (i.e., bargaining power decreases after the reform).

As to the welfare analysis, grosso modo the same results as above are obtained (see Tables 80 and 81). When evaluated by means of the unitary model, the tax reform implies that almost twice as many households are worse off than the number of households that are better off (1228 versus 609 households). These effects on the household level are disentangled by means of the collective model. Table 80, e.g., shows that 305 households (or 16.2% of the population) are strictly worse off, in the sense that both household members have a lower welfare level after the tax reform. It also shows that for 302 households from the 609 households that are better off according to the unitary model, there are welfare decreases for one of the spouses.

9 Conclusion

The objective of this study is twofold. Firstly, it presents a new methodology to model household labour supply. It is based on Chiappori's (1988, 1992) collective approach to household behaviour. Crucial in this approach, is that it takes into account that multi-person households consist of several individuals with different preferences. Among these individuals, an intrahousehold bargaining process that results in Pareto efficient outcomes, is assumed to take place. The presented approach is rather general, in the sense that it takes account of both nonparticipation issues and income taxation that may result in nonconvex budget sets. A feature of the approach is that it directly models the household's Pareto efficient allocation, that is chosen from a possibly nonconvex utility possibility set. Preferences of individual household members are quite general, in that they allow for external labour supply effects. The resulting empirical model is identified by means of both econometric estimations and calibration methods.

A second objective of the study is that it wants to quantify the distortions from using a standard unitary model when the collective model is more appropriate. To do this, real world data are created by means of the above collective labour supply model. This dataset is based on Belgian microdata. A quite flexible unitary model is then estimated on this artificial dataset. Both the collective and the unitary model are in a next step used to evaluate two tax reforms. The first reform is the Belgian 2001 income tax reform that is to be gradually introduced over the years 2001 to 2004. A second reform that is focused on is the replacement of the current tax system by a revenue neutral negative income tax. Note that the unitary approach can safely be used to evaluate the tax reforms on two samples of male and female singles.

The main results of the study are the following. Firstly, theoretical restrictions of the unitary model are rejected, when the model is estimated on the artificial collective dataset. This is not very surprising, since the collective model clearly incorporates some elements that cannot give rise to a consistent preference ordering on the household level. Secondly, the fit of the unitary model is not very good. The number of women in couples that do not participate in the labour market, e.g., is heavily overestimated. Thirdly, the collective model and the unitary model obtain, more or less, similar results as to the effects of the tax reforms on mean labour supply. According to both models, mean labour supply of men and women in couples only slightly decreases because of the future Belgian tax reform. Also the percentages of women who enter the labour market after the reform do not differ very much. Perhaps the most important result of this study is that it clearly indicates that the collective and the unitary models may have conflicting opinions on the welfare economic consequences of tax reforms. According to the unitary model, e.g., the welfare level of 97% of the couples in the dataset strictly increases after the future Belgian tax reform. However, for a large part of this set of couples, the reform is not a Pareto improvement. That is, for many of these households, one of the individuals wins at the expense of the other household member. On the other hand, the Belgian tax reform implies a Pareto improvement for more than 65% of the couples. Moreover, no household ends at a post reform allocation that is Pareto inferior with regard to the pre reform allocation. Note that the tax reform is also beneficial to female and male singles.

A possible deficiency of the study at hand, is that it does not explicitly model household public consumption (e.g., rent or expenditures on children that do not yet have any bargaining power). A second deficiency is that the collective model is identified in a rather piecemeal way, using both econometric estimations and calibration methods. A future research avenue may be the derivation of econometrically identifiable structural collective labour supply models that take both nonparticipation and nonconvex budget sets into account. Probably, some additional assumptions on individual preferences (e.g., egoistic preferences or Beckerian caring preferences) will be needed (see, e.g., Chiappori, 1988, Chiappori et alii, 2001 and Donni, forthcoming).

Appendix

Table 7: Descriptive statistics single women (267 obs.)

Variable	Mean	Std.dev.	Min.	Max.
Dummy for labour market participation; 1 = working	0.95	0.21	0.00	1.00
Dummy for schooling, 1 = higher eduction	0.41	0.49	0.00	1.00
Dummy for social status; 0 = blue collar worker, 1 = white collar worker	0.73	0.45	0.00	1.00
Dummy 1 for region; 1 = Walloon Region (Flemish Region benchmark)	0.27	0.44	0.00	1.00
Dummy 2 for region; 1 = Brussels Capital Region (")	0.26	0.44	0.00	1.00
Age	39.02	8.82	25.00	54.92
Dummy for children, 1 = children	0.46	0.50	0.00	1.00
Number of (dependent) children	0.72	0.93	0.00	5.00
Number of children $\leq$ 3 years old	0.03	0.20	0.00	2.00
Number of children $>$ 3 and $\leq$ 6 years old	0.06	0.27	0.00	2.00
Number of children $>$ 6 and $\leq$ 12 years old	0.20	0.51	0.00	3.00
Number of children $>$ 12	0.43	0.73	0.00	4.00
Number of years employed	16.61	9.28	0.00	66.00
Hourly gross wage rate in euro	12.57	7.31	0.00	63.04
Contractual working hours per week	32.64	10.70	0.00	60.00
Weekly consumption based nonlabour income in euro	56.94	56.09	-188.64	223.86

Table 8: Descriptive statistics single men (199 obs.)

Variable	Mean	Std.dev.	Min.	Max.
Dummy for labour market participation; 1 = working	1.00	0.062	0.00	1.00
Dummy for schooling, 1 = higher eduction	0.34	0.47	0.00	1.00
Dummy for social status; 0 = blue collar worker, 1 = white collar worker	0.55	0.50	0.00	1.00
Dummy 1 for region; 1 = Walloon Region (Flemish Region benchmark)	0.33	0.47	0.00	1.00
Dummy 2 for region; 1 = Brussels Capital Region (")	0.14	0.35	0.00	1.00
Age	36.83	7.77	25.00	54.83
Dummy for children, 1 = children	0.05	0.22	0.00	1.00
Number of (dependent) children	0.08	0.39	0.00	3.00
Number of children $\leq$ 3 years old	0.00	0.05	0.00	1.00
Number of children $>$ 3 and $\leq$ 6 years old	0.00	0.05	0.00	1.00
Number of children $>$ 6 and $\leq$ 12 years old	0.04	0.20	0.00	2.00
Number of children $>$ 12	0.04	0.25	0.00	3.00
Number of years employed	14.90	8.97	0.00	38.00
Hourly gross wage rate in euro	15.18	8.25	0.00	68.02
Contractual working hours per week	36.55	6.95	0.00	98.00
Weekly consumption based nonlabour income in euro	17.63	71.29	-613.43	207.79

Table 9: Descriptive statistics couples (1886 obs.)

Variable	Mean	Std.dev.	Min.	Max.
Dummy for labour market participation husband ; 1 = working	1.00	0.04	0.00	1.00
Dummy for labour market participation wife ; 1 = working	0.76	0.43	0.00	1.00
Dummy for marital status ; 1 = married	0.93	0.26	0.00	1.00
Dummy for schooling husband, 1 = higher eduction	0.35	0.48	0.00	1.00
Dummy for schooling wife, 1 = higher eduction	0.35	0.48	0.00	1.00
Dummy for social status husband; 0 = blue collar worker, 1 = white collar worker	0.56	0.50	0.00	1.00
Dummy for social status wife; 0 = blue collar worker, 1 = white collar worker	0.55	0.50	0.00	1.00
Dummy 1 for region; 1 = Walloon Region (Flemish Region benchmark)	0.27	0.45	0.00	1.00
Dummy 2 for region; 1 = Brussels Capital Region (")	0.07	0.25	0.00	1.00
Age husband	38.82	7.28	25.00	54.92
Age wife	37.20	7.27	25.00	55.00
Dummy for children, 1 = children	0.77	0.42	0.00	1.00
Number of (dependent) children	1.45	1.07	0.00	7.00
Number of children $\leq$ 3 years old	0.23	0.48	0.00	3.00
Number of children $>$ 3 and $\leq$ 6 years old	0.20	0.45	0.00	3.00
Number of children $>$ 6 and $\leq$ 12 years old	0.44	0.72	0.00	4.00
Number of children $>$ 12	0.58	0.86	0.00	5.00
Number of years employed husband	18.35	8.06	0.00	47.00
Number of years employed wife	13.52	8.08	0.00	39.00
Hourly gross wage rate husband in euro	15.45	8.57	0.00	133.08
Hourly gross wage rate wife in euro	9.34	7.59	0.00	101.77
Contractual working hours per week husband	37.80	7.57	0.00	99.00
Contractual working hours per week wife	23.29	15.49	0.00	90.00
Weekly consumption based nonlabour income in euro	108.46	120.16	-736.16	736.97
Weekly individually assignable nonlabour income husband in euro	4.45	28.14	0.00	480.53
Weekly individually assignable nonlabour income wife in euro	6.58	32.44	0.00	646.43

Table 10: OLS estimates of single women's wage equation

Variable	Coefficient	Std. error
Constant	1.821	0.108
Dummy higher education	0.410	0.062
Social status	0.288	0.068
Dummy 1 for region	0.176	0.068
Dummy 2 for region	0.029	0.068
Dummy for children	-0.139	0.114
Number of children	0.035	0.064
Number of years employed	0.020	0.008
Squared of number of years employed	-0.000	0.000
Number of observations: 250		
Adjusted R-squared: 0.283		

Table 11: Observed and predicted wages single women

	Mean	Std.dev.	Min.	Max.
Participants (250 observations)				
Observed gross hourly wage rates in euro	13.18	6.92	0.41	63.04
Predicted gross hourly wage rates in euro	12.15	3.48	5.55	20.56
Nonparticipants (17 observations)				
Predicted gross hourly wage rates in euro	7.85	1.69	5.57	11.73

Table 12: Heckman estimates wage equation women in couples

	Selection equation		Wage equation	
Variable	Coef.	S.e.	Coef.	S.e.
Constant	2.915	0.227	1.979	0.065
Dummy higher education	0.938	0.086	0.229	0.047
Dummy 1 for region	-0.192	0.078	0.003	0.031
Dummy 2 for region	0.303	0.157	0.089	0.050
Dummy for children	0.669	0.128	-0.142	0.057
Number of children	-0.442	0.048	0.117	0.030
Social status			0.243	0.028
Number of years employed			0.006	0.007
Squared of number of years employed			0.000	0.000
λ			-0.363	0.127
ρ			-0.734	
Number of observations	1886		1441	
Log likelihood function	-844.035			
Adjusted R-squared			0.239	

Table 13: Observed and predicted wages women in couples

	Mean	Std.dev.	Min.	Max.
Participants (1441 observations)				
Observed gross hourly wage rates in euro	12.25	6.33	0.29	101.77
Predicted gross hourly wage rates in euro	11.21	2.85	5.70	20.61
Nonparticipants (445 observations)				
Predicted gross hourly wage rates in euro	13.76	3.53	8.87	28.87

Table 14: Discretization of weekly working hours

	Women				Men			
	Range	Hours	Freq. sing.	Freq. coup.	Range	Hours	Freq. sing.	Freq. coup.
Choice 1	0	0	0.064	0.236	0-35	30	0.090	0.111
Choice 2	1-15	8	0.003	0.046	36-37	37	0.206	0.137
Choice 3	16-25	20	0.184	0.226	38-39	38	0.513	0.498
Choice 4	26-35	30	0.105	0.119	$\geqslant 40$	40	0.191	0.254
Choice 5	$\geqslant 36$	40	0.644	0.373				

Table 15: Conditional logit model labour supply single women

Variable	Coefficient	Std. error	P-value
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$	6.759	2.257	0.00
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$ * dummy higher education	-2.717	1.309	0.04
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$ * age	-0.105	0.418	0.01
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$	0.278	1.528	0.86
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * dummy higher education	-5.101	1.703	0.00
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * social status	-4.118	0.803	0.00
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * dummy child	2.909	0.831	0.00
Log likelihood: -299.118			

Table 16: Random parameters logit model labour supply single women

Variable	Coefficient	Std. error	P-value
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$	51.405	23.051	0.03
$\sigma_{consumption}$	1.369	3.022	0.65
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$ * higher education	-13.739	6.864	0.05
$\log\left(c-\overline{c}\left(\mathbf{d}\right)\right)$ * age	-0.631	0.326	0.05
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$	20.396	10.862	0.06
$\sigma_{leisure}$	25.792	9.847	0.01
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * higher education	-23.715	10.945	0.03
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * social status	-13.590	6.375	0.03
$\log\left(l-\overline{l}\left(\mathbf{d}\right)\right)$ * dummy child	8.509	4.731	0.07
Log likelihood: -281.892			

Table 17: Discrete heterogeneity model labour supply single women

Variable	Coefficient	Std. error	P-value
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)_1$	11.846	4.689	0.01
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)_2$	115.934	62.966	0.07
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$ * higher education	-2.586	1.785	0.15
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$ * age	-0.178	0.077	0.02
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$	5.704	3.418	0.10
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * higher education	-3.244	3.193	0.31
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * social status	-4.797	1.650	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * dummy child	3.044	1.588	0.06
Prob. consumption parameter 1	0.119	0.330	0.719
Log likelihood: -270.686			

Table 18: Conditional logit model labour supply single men

Variable	Coefficient	Std. error	P-value
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$	30.485	5.062	0.00
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$ * dummy child	-13.611	2.522	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$	123.856	22.837	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 regio	-25.153	7.537	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * age	-1.244	0.318	0.00
Log likelihood: -226.049			

Table 19: Random parameters logit model labour supply single men

Variable	Coefficient	Std. error	P-value
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$	32.837	6.618	0.00
$\sigma_{consumption}$	1.734	1.732	0.32
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$ * dummy child	-14.594	3.114	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$	133.292	28.600	0.00
$\sigma_{leisure}$	1.416	7.424	0.85
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	-26.760	8.223	0.00
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * age	-1.342	0.369	0.00
Log likelihood: -225.714			

Table 20: Discrete heterogeneity model labour supply single men

Variable	Coefficient	Std. error	P-value
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)_1$	31.838	9.823	3.24
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)_2$	36.217	13.537	2.68
$\log\left(c-\bar{c}\left(\mathbf{d}\right)\right)$ * dummy child	-14.996	5.527	-2.71
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$	136.390	51.971	2.62
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	-27.152	12.966	-2.09
$\log\left(l-\bar{l}\left(\mathbf{d}\right)\right)$ * age	-1.383	0.702	-1.97
Prob. consumption parameter 1	0.503	2.478	0.20
Log likelihood: -225.800			

Table 21: Percentages of correctly predicted labour supply choices

	Female singles	Male singles
Conditional logit model	53.2%	27.6%
Random parameters logit model	49.8%	27.6%
Discrete heterogeneity model	74.5%	39.7%

Table 22: Descriptive statistics on calibrated common leisure interaction terms

	Mean	Std. dev.	Min.	Max.
δ	0.108	0.278	-0.1	0.9

Table 23: Estimation results of the wife's bargaining power index

Variable	Coefficient	Std. error	P-value
Constant	0.441	0.296	0.137
Dummy higher education husband	-0.918	0.176	0.000
Dummy higher education wife	-0.906	0.177	0.000
Social status husband	0.431	0.156	0.006
Social status wife	-1.260	0.163	0.000
Weekly consumption based nonlabour income	0.004	0.001	0.000
Nonlabour income wife - nonlabour income husband	0.003	0.002	0.029
Wage 1	0.007	0.001	0.000
Wage 2	-0.149	0.002	0.000
Dummy 2 for region	-0.791	0.325	0.015
Number of observations: 1886			
Adjusted R-squared: 0.238			

Note: Wage 1 is the marginal contribution to the household's disposable income by the wife's earnings when switching from 0 to 40 hours. Wage 2 captures the husband's switching from 30 to 40 hours.

Table 24: Descriptive statistics on calibrated bargaining power indices

	Mean	Std. dev.	Min.	Max.
calibrated μ	0.622	0.319	0.0	0.99
estimated μ	0.620	0.262	0.0	0.99

Table 25: Estimation results of leisure interaction term wife

Variable	Coefficient	Std. error	P-value
Constant	-0.022	0.002	0.000
Dummy higher education wife	-0.010	0.002	0.000
Social status husband	0.005	0.002	0.004
Dummy for children	-0.029	0.003	0.000
Number of children	0.008	0.001	0.000
Dummy 1 for region	0.005	0.002	0.009
Number of observations: 1886			
Adjusted R-squared: 0.056			

Table 26: Descriptive statistics on calibrated and estimated leisure interaction term wife

	Mean	Std. dev.	Min.	Max.
Calibrated δ^f	-0.032	0.039	-0.1	0
Estimated δ^f	-0.032	0.010	-0.053	0.008

Table 27: Estimation results of leisure interaction term husband

Variable	Coefficient	Std. error	P-value
Constant	0.588	0.022	0.000
Dummy higher education husband	-0.042	0.021	0.046
Dummy higher education wife	-0.154	0.021	0.000
Social status husband	-0.065	0.019	0.001
Social status wife	0.247	0.019	0.000
Dummy for children	-0.204	0.029	0.000
Number of children	0.021	0.011	0.054
Dummy 1 for region	0.048	0.019	0.010
Number of observations: 1886			
Adjusted R-squared: 0.124			

Table 28: Descriptive statistics on calibrated and estimated leisure interaction term husband

	Mean	Std. dev.	Min.	Max.
Calibrated δ^m	0.500	0.380	-0.1	0.9
Estimated δ^m	0.500	0.136	0.144	0.884

Table 29: Actual versus simulated labour supply women in couples

	0	8	20	30	40	Total
0	337	81	15	6	6	445
8	34	14	9	4	25	86
20	91	39	58	66	173	427
30	33	23	30	52	87	225
40	120	49	83	181	270	703
Total	615	206	195	309	561	1886

Note: Rows are actual labour supply, columns simulated.

Table 30: Actual versus simulated labour supply men in couples

	30	37	38	40	Total
30	39	10	9	149	207
37	52	13	16	178	259
38	218	83	52	586	939
40	111	41	34	295	481
Total	420	147	111	1208	1886

Note: Rows are actual labour supply, columns simulated.

Table 31: Actual versus calibrated labour supply women in couples

	0	8	20	30	40	Total
0	393	44	8	0	0	445
8	0	73	12	1	0	86
20	0	0	391	30	6	427
30	0	0	0	222	3	225
40	0	0	0	0	703	703
Total	393	117	411	253	712	1886

Note: Rows are actual labour supply, columns calibrated.

Table 32: Actual versus calibrated labour supply men in couples

	30	37	38	40	Total
30	207	0	0	0	207
37	6	248	2	3	259
38	26	44	859	10	939
40	3	13	11	454	481
Total	242	305	872	467	1886

Note: Rows are actual labour supply, columns calibrated.

Table 33: Conditional logit model labour supply couples simulated data

Variable	Coefficient	Std. error	P-value
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	-31.667	12.644	0.012
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	11.380	1.399	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-26.960	1.548	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	-20.812	1.898	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	4.374	1.276	0.001
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * age wife	-0.310	0.081	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	-2.675	0.547	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$	-77.335	13.937	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	11.017	2.404	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-16.563	2.193	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	-13.251	2.705	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	-52.483	3.129	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$	94.656	4.432	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	10.747	1.880	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-21.430	1.743	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	3.313	1.497	0.027
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status husband	-2.747	0.733	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status wife	14.595	2.189	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * age husband	-1.508	0.090	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * number of children	-5.033	0.544	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right) * \log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	24.151	3.178	0.000
Log likelihood: -2543.877			

Table 34: Discrete heterogeneity model labour supply couples simulated data

Variable	Coefficient	Std. error	P-value
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	-32.820	2.547	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	13.679	1.328	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-32.556	1.697	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	-27.481	2.132	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	4.068	1.628	0.012
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * age wife	-0.140	0.000	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	-3.189	0.618	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$	-85.748	13.937*	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	13.513	2.404*	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-18.509	1.685	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	-13.242	2.705*	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	-49.010	3.075	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)_1$	110.270	4.100	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)_2$	144.298	5.806	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	13.068	1.709	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	-27.924	2.063	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	1.834	1.975	0.353
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status husband	-2.668	0.939	0.004
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status wife	22.514	2.775	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * age husband	-1.833	0.089	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * number of children	-2.070	0.749	0.006
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right) * \log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	27.634	0.000	0.000
Prob. consumption parameter 1	1.659	0.124	0.000
Log likelihood: -2424.740			

Note: Starred standard errors are indicative and equal the conditional logit model estimates.

Table 35: Conditional logit model labour supply couples calibrated data

Variable	Coefficient	Std. error	P-value
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	-14.852	5.841	0.011
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	3.290	1.225	0.007
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	4.667	1.298	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	-2.127	0.708	0.003
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * age wife	0.241	0.022	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	1.570	0.166	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$	-15.736	6.760	0.020
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	7.469	0.961	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	6.167	2.110	0.003
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	6.360	2.302	0.006
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	5.647	1.085	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 for region	-2.347	0.983	0.017
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 for region	-5.875	2.398	0.014
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	0.863	0.385	0.025
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$	-6.517	1.324	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	4.977	1.402	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	5.297	1.502	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status wife	8.202	0.416	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right) * \log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	0.023	1.478	0.988
Log likelihood: -4910.639			

Table 36: Discrete heterogeneity model labour supply couples calibrated data

Variable	Coefficient	Std. error	P-value
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	-10.065	6.700	0.133
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	3.544	1.575	0.024
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	5.087	1.633	0.002
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 region	-2.509	0.798	0.002
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * age wife	0.268	0.026	0.000
$\log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	1.596	0.190	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$	-10.018	7.706	0.194
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education husband	7.580	0.974	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	6.823	2.369	0.004
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	6.911	2.549	0.007
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * social status wife	6.026	1.130	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 1 for region	-2.404	0.992	0.015
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * dummy 2 for region	-6.007	2.414	0.013
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right)$ * number of children	0.785	0.394	0.046
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)_1$	-8.455	1.799	0.000
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)_2$	5.233	4.995	0.295
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 1 education wife	5.969	1.827	0.001
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * dummy 2 education wife	6.314	1.928	0.001
$\log\left(c - \bar{c}\left(\mathbf{d}\right)\right)$ * social status wife	9.160	0.574	0.000
$\log\left(l^m - \bar{l}\left(\mathbf{d}\right)\right) * \log\left(l^f - \bar{l}\left(\mathbf{d}\right)\right)$	-1.404	1.671	0.401
Prob. consumption parameter 1	1.945	0.418	0.000
Log likelihood: -4896.613			

Table 37: Summary statistics baseline versus tax reform simulations single women

	Baseline simulation	Tax reform
Mean labour supply	35.83	35.66
Mean gross earnings	496.04	494.37
Mean income tax	191.89	183.41
Mean nonlabour income	59.61	59.61
Mean consumption	363.76	370.57
Mean utility	5.82	5.83

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 38: Baseline versus tax reform simulations labour supply single women

	0	8	20	30	40	Total
0	20	2	0	0	0	22
8	0	7	0	0	0	7
20	0	0	11	0	0	11
30	0	0	3	15	1	19
40	0	0	0	4	204	208
Total	20	9	14	19	205	267

Note: Rows are baseline data, columns simulated.

Table 39: Summary statistics baseline versus tax reform simulations single men

	Baseline simulation	Tax reform
Mean labour supply	36.48	33.95
Mean gross earnings	574.48	548.53
Mean income tax	233.33	211.11
Mean nonlabour income	18.46	18.46
Mean consumption	359.61	355.88
Mean utility	4.43	4.44

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 40: Baseline versus tax reform simulations labour supply single men

	30	37	38	40	Total
30	24	0	0	0	24
37	72	52	0	0	124
38	2	14	13	2	31
40	0	2	0	18	20
Total	98	68	13	20	199

Note: Rows are baseline data, columns simulated.

Table 41: Welfare changes tax reform singles

	u(-)	u(0)	u(+)	Total
Single women	0	59	208	267
Single men	0	28	171	199

Note: The variable u refers to the individual's utility level. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the utility level.

Table 42: Gini and mean tax rate for singles for tax reform simulation

	Single women	Single men
Pre reform Gini	0.270	0.145
Post reform Gini	0.269	0.161
Pre reform mean tax rate	0.387	0.406
Post reform mean tax rate	0.358	0.385

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale.

Table 43: Summary statistics simulated baseline versus collective tax reform simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	19.90	19.52
Mean labour supply men	37.43	37.32
Mean gross earnings	891.58	885.54
Mean income tax	337.02	309.80
Mean household nonlabour income	113.55	113.55
Mean individual consumption women	558.24	577.01
Mean individual consumption men	109.87	112.29
Mean utility women	4.83	4.85
Mean utility men	12.34	12.37
Mean bargaining power index women	0.62	0.63
Mean consumption share women	0.83	0.83

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 44: Simulated baseline versus collective tax reform simulations labour supply women in couples

	0	8	20	30	40	Total
0	568	47	0	0	0	615
8	7	192	7	0	0	206
20	1	28	166	0	0	195
30	0	0	44	262	3	309
40	0	0	0	30	531	561
Total	576	267	217	292	534	1886

Note: Rows are baseline data, columns simulated.

Table 45: Simulated baseline versus collective tax reform simulations labour supply men in couples

	30	37	38	40	Total
30	418	1	0	1	420
37	26	106	8	7	147
38	2	29	52	28	111
40	0	9	21	1178	1208
Total	446	145	81	1214	1886

Note: Rows are baseline data, columns simulated.

Table 46: Summary statistics simulated baseline versus unitary tax reform simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	8.53	8.40
Mean labour supply men	35.57	35.22
Mean gross earnings	703.97	695.44
Mean income tax	242.65	214.36
Mean household nonlabour income	113.55	113.55
Mean household consumption	574.87	594.64
Mean household utility	167.73	170.34

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 47: Simulated baseline versus unitary tax reform simulations labour supply women in couples

	0	8	20	30	40	Total
0	908	97	0	0	0	1005
8	14	341	30	0	0	385
20	1	57	237	1	0	296
30	0	0	36	100	0	136
40	0	0	0	24	40	64
Total	923	495	303	125	40	1886

Note: Rows are baseline data, columns simulated.

Table 48: Simulated baseline versus unitary tax reform simulations labour supply men in couples

	30	37	38	40	Total
30	745	15	1	0	761
37	78	123	10	9	220
38	5	30	27	8	70
40	7	24	29	775	835
Total	835	192	67	792	1886

Note: Rows are baseline data, columns simulated.

Table 49: Welfare changes tax reform unitary versus collective model simulated data

		u(-)	u(0)	u(+)	Total
m(-)	f(-)	0	0	0	0
m(0)	f(-)	0	0	0	0
m(+)	f(-)	6	0	21	27
m(-)	f(0)	1	0	2	3
m(0)	f(0)	0	1	19	20
m(+)	f(0)	27	1	123	151
m(-)	f(+)	2	1	597	600
m(0)	f(+)	1	0	187	188
m(+)	f(+)	15	1	881	897
	Total	52	4	1830	1886

Note: The variables u,m and f refer to the household's utility level in the unitary model, the male's utility level in the collective model and the female's utility level in the collective model. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.

Table 50: Gini, concentration ratio and mean tax rate for unitary and collective models on simulated data for tax refom

	Unitary model	Collective model
Pre reform Gini	0.152	0.163
Post reform Gini	0.150	0.162
Pre reform concentration ratio	0.277	0.300
Post reform concentration ratio	0.293	0.319
Pre reform mean tax rate	0.304	0.334
Post reform mean tax rate	0.264	0.301

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale. The Gini coefficient is the ratio of the difference between the Lorenz curve and the line of absolute equality in a Lorenz diagram. The concentration ratio is constructed like the Gini coefficient, but compares proportions of income tax paid for proportions of households ranked according to equivalent consumption.

Table 51: Summary statistics calibrated baseline versus collective tax reform simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	24.19	22.35
Mean labour supply men	37.29	36.44
Mean gross earnings	901.26	864.78
Mean income tax	336.91	291.69
Mean household nonlabour income	113.55	113.55
Mean individual consumption women	499.09	508.98
Mean individual consumption men	178.81	177.66
Mean utility women	5.37	5.40
Mean utility men	11.84	11.90
Mean bargaining power index women	0.62	0.63
Mean consumption share women	0.74	0.75

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 52: Calibrated baseline versus collective tax reform simulations labour supply women in couples

	0	8	20	30	40	Total
0	341	51	0	0	0	392
8	11	95	17	0	0	123
20	1	77	320	7	1	406
30	0	8	92	152	2	254
40	0	0	3	205	503	711
Total	353	231	432	364	506	1886

Note: Rows are baseline data, columns simulated.

Table 53: Calibrated baseline versus collective tax reform simulations labour supply men in couples

	30	37	38	40	Total
30	202	32	10	2	246
37	121	153	17	31	322
38	72	358	333	91	854
40	17	39	65	343	464
Total	412	582	425	467	1886

Note: Rows are baseline data, columns simulated.

Table 54: Summary statistics calibrated baseline versus unitary tax reform simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	12.45	12.41
Mean labour supply men	33.37	33.24
Mean gross earnings	751.27	747.70
Mean income tax	271.39	246.80
Mean household nonlabour income	113.55	113.55
Mean household consumption	593.44	614.45
Mean household utility	96.76	97.05

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 55: Calibrated baseline versus unitary tax reform simulations labour supply women in couples

	0	8	20	30	40	Total
0	877	47	0	0	0	924
8	4	231	37	0	0	272
20	1	37	168	0	0	206
30	0	0	26	77	0	103
40	0	0	0	17	364	381
Total	882	315	231	94	364	1886

Note: Rows are baseline data, columns simulated.

Table 56: Calibrated baseline versus unitary tax reform simulations labour supply men in couples

	30	37	38	40	Total
30	1197	6	0	1	1204
37	19	45	4	5	73
38	4	6	9	7	26
40	11	15	13	544	583
Total	1231	72	26	557	1886

Note: Rows are baseline data, columns simulated.

Table 57: Welfare changes tax reform unitary versus collective model calibrated data

		u(-)	u(0)	u(+)	Total
m(-)	f(-)	0	0	0	0
m(0)	f(-)	0	0	1	1
m(+)	f(-)	8	0	56	64
m(-)	f(0)	0	0	2	2
m(0)	f(0)	6	0	14	20
m(+)	f(0)	36	0	102	138
m(-)	f(+)	67	3	290	360
m(0)	f(+)	38	1	158	197
m(+)	f(+)	318	1	785	1104
	Total	473	5	1408	1886

Note: The variables u,m and f refer to the household's utility level in the unitary model, the male's utility level in the collective model and the female's utility level in the collective model. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.

Table 58: Gini, concentration ratio and mean tax rate for unitary and collective models on calibrated data for tax reform

	Unitary model	Collective model
Pre reform Gini	0.190	0.131
Post reform Gini	0.186	0.129
Pre reform concentration ratio	0.413	0.229
Post reform concentration ratio	0.437	0.249
Pre reform mean tax rate	0.301	0.342
Post reform mean tax rate	0.262	0.300

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale. The Gini coefficient is the ratio of the difference between the Lorenz curve and the line of absolute equality in a Lorenz diagram. The concentration ratio is constructed like the Gini coefficient, but compares proportions of income tax paid for proportions of households ranked according to equivalent consumption.

Table 59: Negative income tax system parameters

	Marginal tax rate	Yearly minimum guaranteed income
Collective model		
Simulated dataset	0.5	2860 euro
Calibrated dataset	0.5	2900 euro
Unitary model		
Simulated dataset	0.5	2830 euro
Calibrated dataset	0.5	2750 euro

Table 60: Summary statistics baseline versus neg. income tax simulations single women

	Baseline simulation	Tax reform
Mean labour supply	35.83	35.61
Mean gross earnings	496.04	498.80
Mean income tax	191.89	193.63
Mean nonlabour income	59.61	59.61
Mean consumption	363.76	364.78
Mean utility	5.82	5.81

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 61: Baseline versus neg. income tax simulations labour supply single women

	0	8	20	30	40	Total
0	22	0	0	0	0	22
8	6	1	0	0	0	7
20	3	1	5	2	0	11
30	0	0	2	9	8	19
40	0	1	0	1	206	208
Total	31	3	7	12	214	267

Note: Rows are baseline data, columns simulated.

Table 62: Summary statistics baseline versus neg. income tax simulations single men

	Baseline simulation	Tax reform
Mean labour supply	36.48	36.73
Mean gross earnings	574.48	581.46
Mean income tax	233.33	234.96
Mean nonlabour income	18.46	18.46
Mean consumption	359.61	364.96
Mean utility	4.43	4.43

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 63: Baseline versus neg. income tax simulations labour supply single men

	30	37	38	40	Total
30	20	4	0	0	24
37	4	105	10	5	124
38	0	0	7	24	31
40	1	0	0	19	20
Total	25	109	17	48	199

Note: Rows are baseline data, columns simulated.

Table 64: Welfare changes negative income tax singles

	u(-)	u(0)	u(+)	Total
Single women	168	34	65	267
Single men	130	33	36	199

Note: The variable u refers to the individual's utility level. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the utility level.

Table 65: Gini and mean tax rate for singles for negative income tax simulation

	Single women	Single men
Pre reform Gini	0.270	0.145
Post reform Gini	0.281	0.161
Pre reform mean tax rate	0.387	0.406
Post reform mean tax rate	0.346	0.405

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale.

Table 66: Summary statistics simulated baseline versus collective neg. income tax simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	19.90	19.46
Mean labour supply men	37.43	37.43
Mean gross earnings	891.58	891.62
Mean income tax	337.02	335.81
Mean household nonlabour income	113.55	113.55
Mean individual consumption women	558.24	558.77
Mean individual consumption men	109.87	110.60
Mean utility women	4.83	4.82
Mean utility men	12.34	12.36
Mean bargaining power index women	0.62	0.60
Mean consumption share women	0.83	0.82

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 67: Simulated baseline versus collective neg. income tax simulations labour supply women in couples

	0	8	20	30	40	Total
0	613	2	0	0	0	615
8	83	105	18	0	0	206
20	5	19	150	21	0	195
30	1	0	7	279	22	309
40	0	0	0	24	537	561
Total	702	126	175	324	559	1886

Note: Rows are baseline data, columns simulated.

Table 68: Simulated baseline versus collective neg. income tax simulations labour supply men in couples

	30	37	38	40	Total
30	390	30	0	0	420
37	19	87	18	23	147
38	1	20	55	35	111
40	0	9	35	1164	1208
Total	410	146	108	1222	1886

Note: Rows are baseline data, columns simulated.

Table 69: Summary statistics simulated baseline versus unitary neg. income tax simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	8.53	7.59
Mean labour supply men	35.57	35.73
Mean gross earnings	703.97	701.12
Mean income tax	242.65	241.71
Mean household nonlabour income	113.55	113.55
Mean household consumption	574.87	572.96
Mean household utility	167.73	167.49

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 70: Simulated baseline versus unitary neg. income tax simulations labour supply women in couples

	0	8	20	30	40	Total
0	1003	2	0	0	0	1005
8	158	201	26	0	0	385
20	10	55	209	22	0	296
30	0	0	15	107	14	136
40	0	0	0	3	61	64
Total	1171	258	250	132	75	1886

Note: Rows are baseline data, columns simulated.

Table 71: Simulated baseline versus negative neg. income tax simulations labour supply men in couples

	30	37	38	40	Total
30	687	69	4	1	761
37	35	95	37	53	220
38	3	10	4	53	70
40	4	5	11	815	835
Total	729	179	56	922	1886

Note: Rows are baseline data, columns simulated.

Table 72: Welfare changes neg. inc. tax unitary versus collective model simulated data

		u(-)	u(0)	u(+)	Total
m(-)	f(-)	194	0	11	205
m(0)	f(-)	29	0	2	31
m(+)	f(-)	457	4	169	630
m(-)	f(0)	110	1	38	149
m(0)	f(0)	41	3	28	72
m(+)	f(0)	106	3	165	274
m(-)	f(+)	101	1	138	240
m(0)	f(+)	12	0	53	65
m(+)	f(+)	26	1	193	220
	Total	1076	13	797	1886

Note: The variables u,m and f refer to the household's utility level in the unitary model, the male's utility level in the collective model and the female's utility level in the collective model. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.

Table 73: Gini, concentration ratio and mean tax rate for unitary and collective models on simulated data for negative income tax

	Unitary model	Collective model
Pre reform Gini	0.152	0.163
Post reform Gini	0.162	0.173
Pre reform concentration ratio	0.277	0.300
Post reform concentration ratio	0.283	0.297
Pre reform mean tax rate	0.304	0.334
Post reform mean tax rate	0.286	0.317

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale. The Gini coefficient is the ratio of the difference between the Lorenz curve and the line of absolute equality in a Lorenz diagram. The concentration ratio is constructed like the Gini coefficient, but compares proportions of income tax paid for proportions of households ranked according to equivalent consumption.

Table 74: Summary statistics calibrated baseline versus collective neg. income tax simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	24.19	23.01
Mean labour supply men	37.29	37.29
Mean gross earnings	901.26	895.37
Mean income tax	336.91	336.15
Mean household nonlabour income	113.55	113.55
Mean individual consumption women	499.09	494.58
Mean individual consumption men	178.81	178.19
Mean utility women	5.37	5.38
Mean utility men	11.84	11.83
Mean bargaining power index women	0.62	0.60
Mean consumption share women	0.74	0.74

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 75: Calibrated baseline versus collective neg. income tax simulations labour supply women in couples

	0	8	20	30	40	Total
0	382	10	0	0	0	392
8	55	61	7	0	0	123
20	14	55	280	55	2	406
30	0	3	18	206	27	254
40	0	0	2	120	589	711
Total	451	129	307	381	618	1886

Note: Rows are baseline data, columns simulated.

Table 76: Calibrated baseline versus collective neg. income tax simulations labour supply men in couples

	30	37	38	40	Total
30	203	37	3	3	246
37	46	166	42	68	322
38	13	300	298	243	854
40	3	21	82	358	464
Total	265	524	425	672	1886

Note: Rows are baseline data, columns simulated.

Table 77: Summary statistics calibrated baseline versus unitary neg. income tax simulations for couples

	Baseline simulation	Tax reform
Mean labour supply women	12.45	11.70
Mean labour supply men	33.37	33.62
Mean gross earnings	751.27	750.58
Mean income tax	271.39	269.52
Mean household nonlabour income	113.55	113.55
Mean household consumption	593.44	594.61
Mean household utility	96.76	96.64

Note: Monetary values are in euro per week, labour supply is in hours per week.

Table 78: Calibrated baseline versus unitary neg. income tax simulations labour supply women in couples

	0	8	20	30	40	Total
0	923	1	0	0	0	924
8	118	147	7	0	0	272
20	9	45	141	11	0	206
30	0	0	3	76	24	103
40	0	0	0	2	379	381
Total	1050	193	151	89	403	1886

Note: Rows are baseline data, columns simulated.

Table 79: Calibrated baseline versus unitary neg. income tax simulations labour supply men in couples

	30	37	38	40	Total
30	1145	53	5	1	1204
37	7	18	16	32	73
38	1	0	2	23	26
40	0	2	4	577	583
Total	1153	73	27	633	1886

Note: Rows are baseline data, columns simulated.

Table 80: Welfare changes neg. inc. tax unitary versus collective model calibrated data

		u(-)	u(0)	u(+)	Total
m(-)	f(-)	235	4	66	305
m(0)	f(-)	108	4	27	139
m(+)	f(-)	438	19	209	666
m(-)	f(0)	88	1	26	115
m(0)	f(0)	40	2	17	59
m(+)	f(0)	171	10	84	265
m(-)	f(+)	77	6	93	176
m(0)	f(+)	19	1	16	36
m(+)	f(+)	52	2	71	125
	Total	1228	49	609	1886

Note: The variables u,m and f refer to the household's utility level in the unitary model, the male's utility level in the collective model and the female's utility level in the collective model. The labels (-),(0) and (+) refer to a decrease, a status quo or an increase in the corresponding utility level.

Table 81: Gini, concentration ratio and mean tax rate for unitary and collective models on calibrated data for negative income tax

	Unitary model	Collective model
Pre reform Gini	0.190	0.131
Post reform Gini	0.198	0.143
Pre reform concentration ratio	0.413	0.229
Post reform concentration ratio	0.412	0.226
Pre reform mean tax rate	0.301	0.342
Post reform mean tax rate	0.271	0.325

Note: The welfare indicator to construct the Gini coefficient is equivalent consumption. Use is made of the OECD equivalence scale. The Gini coefficient is the ratio of the difference between the Lorenz curve and the line of absolute equality in a Lorenz diagram. The concentration ratio is constructed like the Gini coefficient, but compares proportions of income tax paid for proportions of households ranked according to equivalent consumption.

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