DISCRETE CHOICE MODELS OF LABOUR SUPPLY, BEHAVIOURAL MICROSIMULATION AND THE SPANISH TAX REFORMS*

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Abstract

The aim of the present study is to show the potential of behavioural microsimulation models as powerful tools for the *ex ante* evaluation of public policies. We analyse the impact of recent Spanish income tax reforms upon efficiency and household and social welfare and study the effects of various (basic-income and vital-minimum) flat tax schemes. The analysis is performed using a microsimulation model in which labour supply is explicitly taken into account. Instead of following the traditional continuous approach (Hausman 1981, 1985*a*, and 1985*b*), we estimate the direct utility function employing the methodology proposed by Aaberge *et al.* (1995) and van Soest (1995). We maintain population heterogeneity by applying a social welfare analysis to the complete sample, rather than merely focusing on the active population. The source of our data is a sample of Spanish individuals in the 1995 wave of the EC Household Panel. We find that the redistribution policies considered have only had a minor impact on economic efficiency but, by contrast, have significantly affected social welfare.

Keywords: microsimulation; fiscal policy; labour supply; social welfare evaluation;

JEL Classification: D31, H21, H23, C25, H31, J22

1. Introduction

Over the past 20 years, there have been wide-scale changes in the Spanish redistribution system (see Cantó *et al.*, 2002, for a historical description). Since 1979, the year income tax was introduced, two main reforms have been implemented. In 1989, a large-scale reform provided married wage earners with the choice of making separate individual tax declarations. The Personal Income Tax (PIT) system was again reformed in 1999, and the subsequent equity and efficiency effects have been the subject of both political and academic debate. The aims of this reform were to simplify income tax administration and costs, to combat tax evasion, to reduce the tax burden and, simultaneously, to increase progressivity. The reform was also intended to bring the Spanish income tax system more into line with other EU countries.

Two main points of the reform must be stressed. The first is the replacement of tax allowances (amounts deducted from the gross tax due) with tax deductions (amounts deducted from the tax base) in compensation for individual circumstances. Some of the 1998 tax deductions were included in the subsistence-level minimum income (i.e. personal and family tax deductions); others were directed towards different types of expenditure (i.e. tax deductions for payroll expenditure) and some were eliminated altogether (i.e. accommodation rental). The second is the reduction in the number of tax brackets (from 9 to 6) and the level of tax rates. In particular, maximum and minimum marginal rates fell asymmetrically; the former were reduced from 56 to 48 % and the latter from 20 to 18 %.

The evaluation of the reform has been performed principally by employing arithmetical simulation techniques. Castañer *et al.* (2000) use the Taxpayers Panel of the Spanish Tax Agency (*Panel de Declarantes por IRPF*) to examine the implications of the reform in terms of redistribution and welfare, and show that the system introduced in 1999 reduces total redistribution, mainly through the reduction of tax receipts. Using the European Community Household Panel and the microsimulation model GLADHISPANIA, Oliver and Spadaro (2007) offer similar results. Levy and Mercader-Prats (2002) analyse the withholding mechanism and the efficiency effects of the reform, demonstrating that it failed to reduce compliance costs. Sanchís and Sanchís (2001) simulate the new PIT system, taking into account the effects on household consumption of a VAT increase introduced to compensate for the fall in income tax revenue.

The main shortcoming of arithmetical analysis is its non-inclusion of behavioural reactions. With respect to the labour market, for example, some of the changes introduced by the reform are specifically designed to encourage the participation of certain target groups. Even if these objectives are not achieved, household consumption/labour supply patterns should be affected, at least in the medium-long run. The principal aim of the present study is to clarify such issues by measuring the impact of the reforms upon labour supply behaviour and to evaluate their effects on individual and social welfare.

Some attempts have been made to evaluate Spanish PIT reforms, including labour supply behavioural reactions (Labeaga and Sanz, 2001, García and Suarez, 2002, Prieto and Alvarez, 2002 and Castañer *et al.*, 2004); however, all these studies base the labour supply model on the traditional continuous approach (see Hausman, 1981 and 1985*a*), which displays significant shortcomings (see Aaberge *et al.*, 1995 or van Soest, 1995); its principal drawback, however, is that it imposes overly strict behavioural restrictions, requiring the labour supply function to satisfy the Slutsky conditions. The estimation results thus suffer from a lack of robustness and their usefulness for policy evaluation is thereby reduced (see MaCurdy *et al.*, 1990, and MaCurdy, 1992).

These weaknesses have encouraged researchers to estimate total income elasticities (Feldstein, 1995, Auten and Carroll, 1999, Gruber and Saez, 2002) or direct utility functions by a discretisation of the labour supply alternatives (Aaberge *et al*., 1995, van Soest, 1995, Hoynes, 1996, Bingley and Walker, 1997, Keane and Moffit, 1998 and Blundell *et al.*, 2000). This second approach has been extensively employed in recent analyses of tax reforms. This method has the advantage of capturing behavioural changes (since these are likely to occur at the corner or kink points of the labour supply function) and thereby providing researchers with an estimation of the elasticity at the extensive margin. It also permits the computational and analytical difficulties associated with utility maximization under non-linear and non-convex budget constraints to be avoided, as the budget constraint is now directly modelled in the utility function; finally, it enables researchers to consider fixed costs, simultaneous participation and the intensity of work choices, as well as spouses' joint labour supply decisions (see, for instance, Aaberge *et al*., 2006).

An excellent application of behavioural microsimulation based on discrete choice models and a convincing illustration of the potential this approach offers, is provided by Blundell *et al.* (2000), who evaluate the probable effect of the introduction of the Working Families Tax Credit (WFTC) in the UK. Their results show the importance of introducing discrete behavioural responses to evaluate the WFTC program, since individuals' reactions occur at the extensive margin, due principally to an increase in the labour force participation of single mothers. Similar research has been performed to evaluate recent reforms in the USA (Hoynes, 1996 and Keane and Moffit, 1998), Italy, Norway and Sweden (Aaberge *et al.*, 2000, 2004), the Netherlands (Das and Van Soest, 2001), Germany (Bonin *et al.*, 2002), France (Bargain, 2005) and Australia (Creedy *et al.*, 2003, Creedy *et al.*, 2004, Kalb *et al.*, 2005). One of the primary objectives of the current paper is, therefore, to employ the “discrete choice" framework to provide an estimation of labour supply reactions in Spain.

A striking feature of most of the above-mentioned studies is that policy evaluation is performed using only the subsample for which it is possible to estimate labour supply responses. The inactive population (i.e. pensioners, students, handicapped, etc.) is excluded from the overall analysis of the reforms; this diverges somewhat from standard microsimulation practice, which aims to maintain total population heterogeneity in evaluation (see Bourguignon and Spadaro, 2006). Moreover, structural changes, such as the 1999 reform in Spain, affect the entire population and produce general welfare effects which should be incorporated into any evaluation exercise.

In our opinion, one potential solution to these problems is to perform a microsimulation exercise which combines arithmetic and behavioural instruments to adjust after-tax figures and produce results for the population as a whole. To our knowledge, the only research using such an approach is that of Creedy *et al.*, (2003), Creedy *et al.*, (2004) and Kalb *et al.*, (2005), all of whom employ the behavioural Melbourne Institute Tax and Transfer Simulator to examine the effects of changes in the Australian redistribution system upon labour supply and income distribution (for the whole population). They propose approximating measures of pre- and post-reform income distribution to analyse inequality and poverty.

An alternative to computing synthetic inequality or poverty indexes based on income distribution is to directly evaluate policy changes in individual utility or in their money metric representation, as in the present study. This approach is common in optimal taxation studies and has been employed in several policy-oriented papers e.g. King (1983), Aaberge et al. (1995, 2000, 2006).[1] Our intention is to make a further contribution to this research field by combining arithmetic and behavioural microsimulation to evaluate a policy reform based on changes in individual utility levels for the entire sample, rather than for merely the subsample of individuals for whom labour supply responses can be calculated.

[1] For a complete list see Bourguignon and Spadaro (2006).

Firstly, we estimate the structural labour supply for two subsamples (single persons and couples) of potential participants in the labour market. Secondly, we use the estimation results from the behavioural modules of the microsimulation model to compute the ex-post patterns of labour supply and utility of all individuals of the population. Thirdly, we perform an arithmetical simulation for the remaining population in the sample. This procedure provides an overall evaluation of both the efficiency and welfare impacts of the reforms considered. Given the policy implications of the evaluation results, we consider not only the 1999 reform but also two hypothetical scenarios contemplated by the basic income-flat tax (BIFT) and vital minimum-flat tax (VMFT) approach (see Atkinson, 1995), in order to examine their potential to reduce inequality and to increase social welfare in Spain (see Oliver and Spadaro, 2007). Our results show that, in the Spanish case, the redistribution policies analysed have only a limited influence on economic efficiency but significantly affect social welfare.

The paper is structured as follows: Section 2 describes the dataset, the microsimulation model and the main features of the systems simulated (1998, 1999 and the BIFT and VMFT); Section 3 presents the discrete labour supply model and its econometric specification and estimation; the various policy scenarios are evaluated in Section 4, while our conclusions are presented in Section 5.

2. Data, the microsimulation models and principal characteristics of redistribution systems

We use Spanish data from the European Community Household Panel (ECHP). At the time we constructed the microsimulation model, the latest available Spanish wave was that for 1995. Since we intend to compare the 1998 and 1999 scenarios, and the monetary variables in the 1995 wave date from 1994, we update them by employing the nominal growth rate i.e. inflation plus real growth. In order to update incomes from 1994 to 1998 we use the factor 1.281, and for 1994 to 1999 the factor 1.335. In Table 1 we compare disposable household income for the 1998 and 1999 ECHP waves (currently available but as yet not incorporated into the microsimulation model) to its counterpart in our updated dataset. Having updated disposable income, we convert this to gross income using the microsimulation model GLADHISPANIA, as disposable income allows us to calculate social contributions, total income tax and monthly taxation withheld at source, employing a fixed-point algorithm which iterates until it ascertains the withholdings, income tax and social insurance contribution patterns which best fit the disposable incomes observed in the data[2]. Table 1 gives the results of the model's calibration and compares them to the corresponding aggregate figures reported in official statistics. The initial number of households in the database is 6,522, of which 102 observations were discarded for lack of information regarding the household head (data which is needed to accurately calculate income tax), leaving 6,420 households, representative of the total number of Spanish households (12,068,375 in 1995, source Instituto National de Estadística, INE). The statistics describing the variables used in the econometric section are given in Table 2, while the scenarios we simulate using GLADHISPANIA are described below.

GLADHISPANIA simulates the PIT and social contributions affecting salaries (for both employers and employees) and self-employed workers. Social security contributions are determined by a variety of factors and various "social security affiliation categories" exist, each regulated differently. The microsimulation model computes the tax base (closely related to gross salary) and the rate applicable to each individual taking into account personal circumstances. Social security contribution bases and rates are almost identical in the 1998 and 1999 direct redistribution systems, as only minor changes were made (in order to update the bases and take inflation into account).

The 1998 and 1999 Spanish direct redistribution systems

The 1999 reform introduced an income tax structure in which individual circumstances conditions were taken into account principally via tax allowances (amounts deducted from the gross tax due) rather than tax deductions (amounts deducted from the tax base). Some of the 1998 tax deductions were included in the subsistence-level minimum income (i.e. personal and family tax deductions); others became tax deductions for various types of expenditure (i.e. salaries paid to employees), while a further group was eliminated altogether (i.e. accommodation rental). One of the principal innovations of the tax reform was the introduction of two "minimum income exemptions", the first being individual and the second family-based, which reduced taxable income as follows; the minimum personal allowance is 3,305.57 euros (6,611.13 euros for joint declarations). The minimum family allowance is: (a) 601.01 euros per dependent relative, aged over 65 and with income below a given level. (b) 1,202.02 euros per child for the first two children and 1,803.04 euros per child after the third child, for dependent

[2] A full description of the microsimulation model (GLADHISPANIA), of the dataset and of the disposable to gross algorithm is contained in Oliver and Spadaro (2004*a*).

children under 25 with income below a given level. These sums are increased by 150.25 euros per child aged between 3 and 16 (for expenses regarding educational material), and 300.50 euros per child under 3. Finally, an increase of 2,103.54 or 2,704.55 euros is applied for each disabled dependent person, with income below a given level, included in (a) or (b) independently of their age. These deductions are made to gross income and therefore no longer exist as tax credits for the same items.

The joint tax rates scheme is eliminated, the number of tax brackets are reduced from 9 to 6, and both the minimum rate (from 20 to 18 %, from the first euro) and the maximum rate (from 56 to 48 %) are reduced (see Table 3). The majority of tax credits are eliminated, although some become income deductions (e.g. family tax credits or earner's tax credits, as explained above). Tax credits for accommodation rental, childcare and medical expenses are also eliminated, while to replace deductions from gross income for mortgage interest payments for primary residence purchase, a new tax credit is introduced, applicable to investment in either purchase or restoration.

To illustrate the changes implied by the reform, Figure 1 shows the budget constraints for several archetypal cases. The horizontal axis shows gross annual family income and the vertical axis post-reform gains, given as the difference in disposable income between 1999 and 1998. The reform was intended to reduce income tax, and this is reflected by the fact that all the archetypal households simulated are located on the positive axis i.e. their post-reform disposable income increases. Nevertheless, gains are not equally distributed; as all the figures show, individuals with the lowest gross annual income (less than 5,500 euros, approximately), do not pay personal income taxes either before or after the reform; consequently, their disposable income is identical under both systems. All households whose income exceeds this figure benefit from the reform. All lines increase, and thus the rich benefit more as, basically, a direct result of flattening marginal tax rates and converting almost all tax credits into tax allowances. Disposable household income is increased for one- or two-earner couples with dependent children and incomes above 10,000 and 20,000 euros, respectively, although the 1998 system permitted singles with dependent child (single parents) to be taxed at a different and more generous rate. For two-earner families with incomes between 10,000 and 20,000 euros the lines cross several times, showing that dependent children do not produce a clear effect within this tax bracket. When comparing household types it seems evident that the 1999 system specially benefits couples with children if we compare them with singles with children. However, in the case of childless households there is not a clear effect about which type of household is benefiting more under this system.

The BIFT and VMFT scenarios

As mentioned above, the debate regarding the suitability of the reforms for the Spanish redistribution system is not over. Recently, alternative "flat tax" schemes have been proposed (Oliver and Spadaro, 2007); their underlying objective is the simplification of the tax structure and the simultaneous introduction of a type of “citizens' income”. In order to explore their implications for welfare and redistribution, we perform simulations of the BIFT and the VMFT reforms, both of which would replace the 1999 PIT but leave the social security contributions scheme unchanged.

The VMFT reform replaces the 1999 PIT with a vital minimum, consisting of a tax allowance per equivalent adult[3] and a proportional tax on taxable income. The BIFT reform consists of a universal lump-sum transfer, called “basic/citizens' income” (i.e. a sum the government allocates to each household, independent of income and status) plus a flat tax on taxable income. As for VMFT, we take the number of household members into account, thereby calculating a basic income per equivalent adult.

The advantages and disadvantages of a VMFT and BIFT scheme are well-known (see Atkinson, 1995). They are horizontally equitable, as all sources of income are treated equally, and imply greater transparency and simplicity both for taxpayers and the tax authorities; the latter must bear minor collection costs, but in turn benefit from reduced tax evasion and a wider tax base, since tax allowances and deductions are eliminated. In addition to the possibility of causing capital flows to other countries with more advantageous fiscal treatments of capital, and potential redistribution towards the rich, the main disadvantage of such schemes is the labour supply disincentives which may be produced by a high flat tax. The econometric model used in the next section takes such disincentives into account and quantifies their impact.

We perform four simulations for different flat rates. To facilitate the analysis of redistribution, basic income and vital minimum levels have been chosen, in order to respect government budget constraints (with respect to 1999, our reference year) in an arithmetic framework. Departing from a maximum marginal tax rate of 46%, which allows 4,632 euros of annual basic income per equivalent adult (and 13,997 euros as the vital minimum), we reduce the flat tax rate to 38% (3,526 and 12,002 euros of basic income and vital minimum

[3] The equivalence scale used is the square root of the number of household members. Qualitative results are, however, insensitive to alternative definitions of equivalent scales.

per equivalent adult, respectively), 30% (2,421 and 9,589 euros) and 25% (1,730 and 7,737 euros). Obviously, reducing the flat tax implies reducing the basic income or vital minimum figures.

3. The labour supply model, econometric methodology and results

3.1. The labour supply model

We assume that individuals derive utility from household income, y, and from leisure, $L = T - h$, with T total time available and h hours of work, with the following utility function:

$$U = U(y, h; Z) \tag{1}$$

where Z represents individual characteristics. Consumers maximize utility, subject to the usual budget constraint, which is defined in terms of gross real wages, w, total household non-labour income, μ, and the tax system $T(h, w, \mu, Z)$, where $h = T - L$. If there are no fixed costs, the budget constraint is:

$$y = wh + \mu - T(h, w, \mu, Z) \tag{2}$$

where $T(h, w, \mu, Z)$ are tax payments net of benefits, which in the Spanish tax system depend on hours, wages, non-labour income and demographic characteristics. The consumer's problem then takes the form:

$$Max_h \quad U(y,h,Z) \text{ subject to } y \leq \mu + wh - T(\mu,w,h,Z) \tag{3}$$

The solution to (3) is complex because $T(.)$ is non-linear, although it is always possible to optimize for a given marginal tax rate (and to obtain a parametric Marshallian labour supply function). The discrete choice approach, instead of estimating the Marshallian labour supply parameters, starts by specifying utility $U(.)$ and estimating its parameters. Below, we adopt the flexible quadratic utility function (as in Keane and Moffit, 1998, and Blundell *et al.*, 2000):

$$U^*(y, h, Z) = \alpha_{yy}\, y^2 + \alpha_{hh}\, h^2 + \alpha_{yh}\, yh + \beta_y(Z)\, y + \beta_h(Z)\, h + \varepsilon_{hi} \tag{4}$$

for the singles subsample, and

$$U^*(y,h_h,h_c,Z_h,Z_c,Z) = \alpha_{yy} y^2 + \alpha_{h_h h_h} h_h^2 + \alpha_{h_c h_c} h_c^2 + \alpha_{yh_h} yh_h + \alpha_{yh_c} yh_c + \alpha_{h_h h_c} h_h h_c + \\ + \beta_y y + \beta_{h_h} h_h + \beta_{h_c} h_c + \varepsilon_{h_h h_c} \tag{5}$$

for couples. The variables h_i and Z_i, $i = h, c,$ are, respectively, hours and demographic characteristics of the couple member *I,* while the household head is represented by h and the spouse by c. The parameters of income and hours may be linear functions of individual demographic characteristics, and thus:

$$\beta_y = \beta_{y0} + \beta'_y Z$$
$$\beta_{h_h} = \beta_{h_h 0} + \beta'_{h_h} Z_h \qquad (6)$$
$$\beta_{h_c} = \beta_{h_c 0} + \beta'_{h_c} Z_c$$

These functional forms are easily tractable and also allow a wide range of potential behavioural responses.[4]

Another important issue is the presence of fixed costs i.e. the costs an individual must pay in order to work, such as childcare costs or travelling expenses. We assume they are dependent on observed variables, and thus $FC = Z_{fc}\beta_{fc}$. In the model they are subtracted directly from disposable income for any choice that involves working. Individuals thus evaluate utility, $U = U(y - FC, h; Z)$, for all possible values of income (net of fixed costs). The effect of such costs for each individual (household) depends on the observables Z_{fc}, whose weights, β_{fc}, are estimated together with the remaining parameters of the utility function.

3.2. Econometric methodology

We directly estimate the parameters of the utility function (4) or (5) for different subsamples of the Spanish population, and select a sample consisting only of potential wage-earners.[5] However, since it is likely that marital status significantly affects labour supply (mainly for the wife but also for the husband), we construct additional subsamples. We estimate the utility function separately for singles (4) and couples (5), which affects both the coefficients and the necessity of including fixed costs. As we estimate a discrete choice model, we must first decide the finite set $h_i \in \{h^1, h^2, ..., h^{Ki}\}, i = h, c$, according to which individuals choose their hours. The observability rule in a typical multinomial model is:

$$\begin{aligned} h_i &= h^1 \text{ if } h \leq h^B{}_1 \\ &= h^2 \text{ if } h^B{}_1 < h \leq h^B{}_2 \\ &\ldots\ldots\ldots\ldots\ldots\ldots \\ &= h^{K-1} \text{ if } h^B{}_{K-1} < h \leq h^B{}_{K-1} \\ &= h^K \text{ if } h > h^B{}_{K-1} \end{aligned}$$

[4] See Stern (1986) for a discussion of the properties of these and other functions.
[5] Self-employed, retired people, individuals under 25 years or over 65 are omitted from this sample.

The appropriate number of intervals is evaluated by examining the histograms of hours for both singles and the two members of the couple (see Figure 2). Having decided the choice set, we have K_i alternative values for hours for agent i ($K_h \cdot K_c$ for the household), which determine total income for the individual (household):

$$y[h_i] = w_i h_i + \mu - T(h_i, w_i, \mu; Z_i) \qquad \text{for} \qquad h \in \{h^1, h^2, ..., h^{K_i}\} \tag{7}$$

$$y[h_{h(\cdot)}, h_{c(\cdot)}] = w_h h_{h(\cdot)} + w_c h_{c(\cdot)} + \mu - T(h_{h(\cdot)}, h_{c(\cdot)}, w_h, w_c, \mu; Z_h, Z_c, Z) \tag{8}$$

for all possible combinations of $h_{h(.)} \in \{h^1{}_{h(.)}, h^2{}_{h(.)}, ..., h^{Kh}{}_{h(.)}\}$, and $h_{c(.)} \in \{h^1{}_{c(.)}, h^2{}_{c(.)}, ..., h^{Kc}{}_{c(.)}\}$. The variables w_h and w_c are, respectively, gross wages of the household head and the spouse. To take into account unobserved market wage rates for non-working individuals, we adopt the common approach of estimating the wage equation separately and using estimated wages as if they were true values of unobserved wages.[6] The individual (household) maximizes (4) or (5) over the set of hours $h_i \in \{h^1, h^2, ..., h^{Ki}\}$. To estimate the model we must add stochastic terms to the utility function. In what follows, we only add shocks specific to the state or hours regime for each of the possible choices, which we assume are generated by extreme value distributions. Following these assumptions, we derive the choice probability for agent i as:

$$\Pr[h_i = h^j, Z] = \Pr[U_{i^j} > U_{i^k} \forall k \neq j, k \in \{1,2,...,K\}] = \\ = \frac{\exp[U(y_{i^j}, T - h^j; Z)]}{\sum_{k=1}^{K} \exp[U(y_{i^k}, T - h^k; Z)]} \tag{9}$$

where $U(.) = U^*(.) - \varepsilon_{hi}$.

Similarly, for a couple, we can write the joint probability of choosing a combination of hours $(h_{h(.)}, h_{c(.)})$ as:

$$\Pr[h_{h(\cdot)} = h^j_{h(\cdot)}, h_{c(\cdot)} = h^k_{c(\cdot)}, Z_h, Z_c, Z] = \Pr[U_{\{h^j_h, h^k_c\}} > U_{\{h^j_h, h^k_c\}} \forall s \neq j, t \neq k] = \\ = \frac{\exp[U\ (y[h^j_h, h^k_c], T - h^j_h, T - h^k_c; Z_h, Z_c, Z)]}{\sum_s \sum_t \exp[U\ (y[h^s_h, h^t_c], T - h^s_h, T - h^t_c; Z_h, Z_c, Z)]} \tag{10}$$

where now $U(.) = U^*(.) - \varepsilon_{hhhc}$. Under the hypothesis of independent errors, we can write the log-likelihood function of each model, respectively, as:

[6] The results of these estimations are available upon request. In the case of the spouse of the household head, non-observed wage rates are predicted using Heckman's (1979) approach to take into account potential sample selectivity bias. Note that in this case non-participation is high (see Figure 1c). In the case of singles and the household head we finally opted to run a simple OLS method to predict wage rates, since we found no evidence of selection bias (the Mills ratio is non-significantly different from zero). We are aware that there are alternative methods of imputing wages for non-workers. We opt for this alternative because there is no agreement about an optimal procedure.

$$\ln \Phi_s = \sum_{i=1}^{N} \sum_{k=1}^{K} d_k \left[\ln \Pr(h_i = h^{ki}; Z_i \right] \quad (11)$$

$$\ln \Phi_c = \sum_{i=1}^{N} \sum_{k=1}^{K} d_{jk} \left[\ln \Pr(h_{h(\cdot)} = h^j_{h(\cdot)}, h_{c(\cdot)} = h^k_{c(\cdot)}; Z_h, Z_c, Z \right] \quad (12)$$

where the sub-indices *s* and *c* stand for singles and couples, respectively. The variables d_k and d_{jk} are (1, 0) dummies: $d_k = 1$ if $[h_i = h^{ki}]$ and $d_{jk} = 1$ if $[h_{h(.)} = h^j{}_h$ *and* $h_{c(.)} = h^k{}_c]$. As usual, all parameters in the utility functions are estimated by maximum likelihood.

3.3. Results

The estimation of the model initially requires the set of labour supply alternatives for each individual to be identified; this is achieved by examining the data for working hours (see Aaberge *et al.*, 2006, for example). Figure 2*a* presents the distribution of hours of work for singles; Figures 2*b* and 2*c*, respectively offer analogous figures for the household head (as part of a couple) and spouse. Considerable differences can be observed in the non-participation rate, which is approximately 20% for singles and 6% for household heads (as part of a couple), a figure which rises to 59% for the spouse.

The model is similar across the three distributions; a considerable percentage of observations return a figure of between 35 and 42 hours worked, which corresponds to full-time work in Spain. We establish different choice sets for singles and for the two members of couples, on the basis of these distributions. For singles we construct brackets for 0-4, 5-34, 35-44 and >44 hours, which correspond to actual hours values (in the utility function) of 0, 30, 40 and 50, respectively. For couples, the choice set of the household head is 0, 40 and 50, since there is no part-time employment. These choices correspond to the intervals 0-4, 5-44 and >44. For the second member of the couple, the "0" option corresponds to bracket 0-4, the option "25" corresponds to the interval 5-34 and the option "40" corresponds to the bracket "over 35 working hours".

We obtain estimates of the parameters of the utility function for singles (eq. 4) by optimizing (11) and for couples (eq. 5) by optimizing (12). The subsample of singles corresponds to households with only one adult, with or without children, (16.6% with one or more children and 83.4% without children), whereas the subsample of couples corresponds to couples with or without children (75.7% with one or more children and 24.3% without children). We exclude self-employed or retired, to then estimate the models using subsamples of potentially active individuals. We also exclude observations for which hourly wages are very low and we do not have information about labour status for each month.[7] The typology of households used both for simulation and estimation is reported in Table 4.

We consider age, gender, education and number of children[8] as the observables entering vectors Z_m, Z_f and Z in equation (6), capturing differences in preferences. Tables 5 and 6 present the results of the estimations, for the subsamples of singles and couples respectively, giving the values of the coefficients which correspond to hours of leisure. In general terms, the results are consistent with economic theory; the marginal utility of income increases at a decreasing rate and is almost always positive. Some demographic variables affecting both income and hours of leisure are significant in the singles specification. In particular, common fixed costs significantly affect utility; these can be attributed to unobservables such as the cost of commuting. Such fixed costs cannot be more precisely identified (see, for example, Blundell *et al.*, 2000) as some of their possible determinants, such as variables for region or size of the municipality of residence, are not provided by the dataset.

The coefficients in the regression corresponding to couples show that the marginal utility of income is positive for 94% of the sample, while the utility function is concave at standard significance levels. The older the spouse and the younger the household head, the higher is the marginal utility of income. The marginal utility of hours of leisure of the household head is positive, yet negative for the spouse, although this increases in line with the age of the spouse; this suggests that, as women's labour market participation has increased recently, they need to remain in employment longer in order to obtain retirement benefits. Alternatively, the negative coefficient of leisure, which increases with age, may be explained by childbearing, causing women to temporarily leave the labour force or to work only part-time, to then return when their children grow up. This occurs in Spain in the case of the first child, but more particularly with second and subsequent children (see Labeaga et al., 2001). The effect of hours on marginal utility is dominant, and is not significantly affected by childrearing. Both low-educated men and women prefer to work longer hours than high-educated individuals. Fixed costs do not seem to affect utility for couples. Most of these results are similar to those provided by the existing literature (see Blundell *et al.*, 2000), although some of them also reflect the specific nature of the Spanish labour market, which, concretely, is inflexible with regard to the supply of hours (due partly to the rigidity of labour demand). Moreover, although the rate of labour market activity of women in Spain has notably increased in the last

[7] Since we use weekly hours and annual wages these observations probably correspond to individuals who are not working for the whole year.
[8] We also tried additional variables, but only retained those which had significant coefficients.

decades, this is still low relative to similar countries; the majority of the spouses in the couples subsample are women.

Finally, Tables 5 and 6 also show wage elasticities (for both hours of work and participation). Although it is possible to compute a distribution of these figures, we only report the values computed at sample means. We observe that the elasticity of singles' labour supply is approximately zero and that elasticities are higher in the case of couples: the average hours elasticity of the household head is approximately 0.1, and 0.29 for the spouse. These results are basically a result of participation elasticity, which is 0.11 for the head and 0.26 for the spouse. These results are in line with the empirical literature on the econometrics of labour supply (see Blundell and McCurdy, 1999), although, when comparing our results for married females with other similar studies, in which values range from 0.2 (see Bargain, 2005, for France) to 0.7 (see Das and van Soest, 2001, in the German case), very low levels should be observed. Our results probably reflect the rigidity of the Spanish labour market mentioned earlier.

4. Evaluation of the Spanish reforms: efficiency and welfare effects

The effects of the reforms are simulated at both the individual and the population level. First, we quantify efficiency costs by examining changes in household labour supply. Given the discrete nature of the labour supply alternatives, the results are reported in terms of transition matrices (Section 4.1). Secondly, we identify winners and losers, by comparing individual utility prior to and following the reform (Section 4.2). The third and fourth evaluation exercises concern the social welfare effects of each reform. Section 4.3 compares the scenarios we have simulated, ordering them by a social welfare function which sums individuals' weighted indirect utility. The weights capture the inequality aversion of social planners (this is the classical optimal taxation approach *à la* Ramsey-Mirrlees). Several specifications are tested, in order to perform a sensitivity analysis with respect to the level of aversion to inequality of social planners. To complement the social welfare effects, Section 4.4 explores an alternative social evaluation method, based on a social welfare function which assigns weights to individual utilities, measured in terms of equivalent incomes (King 1983). The advantage of this approach, with respect to the previous method, is that it does not depend on the cardinalisation of the individual utility function.

4.1 Efficiency effects

One of our main goals is to quantify the efficiency costs (measured in terms of hours of work) of the reforms. The reference scenario is the one in force in 1999.[9] To generate a plausible baseline, given that predictions of the model do not perfectly fit the observed hours, we proceed as follows. Firstly, we record the discrete hours level for each individual which is closest to their observed hours level. Secondly, we take random draws from an extreme value distribution for the stochastic part of the utility at each choice. These draws are accepted if they result in an optimal hours level which matches the discretised value observed in the reference scenario; if this is not the case, the draw is rejected and another one is sought, until a perfect match between observed and predicted hours is obtained. We present results with 100 draws for the single sample and 80 draws in the case of the couples, although the main qualitative and quantitative results are maintained for different number of draws.

Tables 7 and 8 present the transition matrices for several reforms. Rows (i) contain the observed distribution of working hours in 1999, whereas columns (j) show the predicted distribution for each simulated scenario. Each cell a_{ij} of the matrix (for $i \neq j$) displays the percent of individuals (households) changing from the observed alternative i to the predicted alternative j. The diagonal elements refer to the percent of singles (couples) whose labour supply is unchanged following the reform.

Table 7 offers the results for the singles subsample.[10] The values to the right of the diagonal reflect percent of individuals who increase their labour supply after the reform and vice versa. The first point to note is that almost all individuals remain on the diagonal, i.e. the reforms have only a minor impact upon labour supply. Comparing the 1999 and 1998 scenarios, we can observe that only 0.17% percent of the individuals who do not work in 1999, enter the labour market at different number of hours in 1998, while 0.06% of individuals working some number of hours increase their supply of labour. On the other hand, 0.13% of the individuals exit from the labour market while 0.64% of them reduce their labour supply after the reform. Similarly, neither does the BIFT-25 scenario significantly affect labour supply, due to the reduced flat tax and basic income. The second point of interest is that, as expected, the higher the marginal tax rate, the greater are the effects on the labour supply. Under the BIFT-38 scenario, participation falls by 3.71%, while reduction in labour

[9] Since we use 1994 data grossed up to 1998, one must claim that differences in the two years tax and social security systems can affect the results. Fortunately, the 1994 and 1998 tax and social security systems are basically the same.
[10] We have simulated BIFT and VMFT reforms using different tax rates, basic income and vital minimum figures. However, the paper only presents the results obtained using a flat tax rate of 38% and a comparison of the 1998 and 1999 tax schedules. The complete set of results can be found in Labeaga *et al*. (2005).

supply affects an additional 0.56% of the individuals. Under the BIFT-46 scenario, more than 6.5 % of individuals reduce their labour supply (more than 5% of them decide to stop working). The VMFT scheme produces only minor labour market disincentives in line with the 1998 reform.

Table 8 presents the transition matrices for couples. As there are nine possible alternatives, for various combinations of the hours of work of the household head (*hh*) and his/her spouse (*hs*), this table is somewhat complicated. In this case, not all of the elements to the right (or left) of the diagonal represent an increase (or fall) in the total hours of work. We can observe substitution between spouses' working hours. As in the previous case, two points should be stressed: firstly, the majority of households are on the diagonal, which implies that they do not alter their labour supply; secondly, the higher the marginal tax rate, the greater are the labour supply effects.

When comparing the 1998 and 1999 systems very few changes can be observed. We obtain very similar results under the VMFT scenario. Whatever the flat tax is, a very low percent of household members enter or exit the labour market. One potential explanation for this low response may be that fixed costs are not significant.[11] The picture is different under BIFT. In particular, under the BIFT-38 scenario, 2.21% of household members decide to reduce the labour supply or to leave the labour market, while only 0.49% increases participation and/or effort. In terms of hours of work these figures represent a reduction of about 3%, while the BIFT-46 reform reduces hours of work by more than 4%. Once more, the extreme case in terms of reduction of labour supply is BIFT-46.

The principal conclusion to be drawn from this analysis is that, on average, the efficiency effects are minor for all of the scenarios examined and for each household type; the only exceptions are for the BIFT scenarios with high flat tax rates (38 and 46%). The response of singles is low, as expected and at the light of the estimated elasticities; but it is still significant since for the BIFT38 and BIFT46 scenarios the 5-6% average change in hours of work cannot be considered as “negligible”, in terms of the political feasibility of the reform. Under these two scenarios the effects on labour supply of the couples is also significant.

4.2 Winners and losers

[11] Coefficients that are not significant are eliminated from the utility function employed in the simulation.

A first approximation of the welfare effects is obtained by examining the households whose utility increases following the reform (winners) and those for whom it falls (losers). In each reform there are winners and losers, but their distribution by income deciles is not uniform. Analysing distribution by income decile, we establish which part of the population benefits or loses; unfortunately, however, this does not allow us to unequivocally rank the reforms in terms of social welfare.

The utility function is computed using the parameters estimated in Section 3[12]. For households which are not potential workers we assume that hours of work are fixed to zero and calculate the utility as follows. Firstly, fiscal units are identified, following the criteria established by the Tax Agency (parents and children under 18 or disabled children). If the fiscal unit is a couple, the estimated coefficients for couples are employed. Alternatively, if the fiscal unit is a single parent, the coefficients for singles are used. Other household members (grandparents, uncles, children over 18, etc.) are treated as singles. The new household typology is shown in Table 4, while Figure 3 presents the results for the entire sample; the winners and losers in each reform are shown by income deciles.

Comparing the 1998 and 1999 systems, the latter displays more winners than losers; however, the winners are concentrated at the top of the income distribution. These results are in line with those of Oliver and Spadaro (2004*b*), indicating that the 1999 reform favours rich households. The VMFT scenarios produce similar results; the poorer deciles (1 to 4) are not affected by the reforms, since such households are largely exempt from income tax. Other deciles show more losers than winners, since the marginal tax rate increases. Concretely, from the fourth to the seventh or eighth decile the number of winners increases progressively, and then decreases (except for the VMFT-25 reform, in which winners account for between 35 and 45%, starting from the sixth decile). Losers first appear in the fifth decile and their number increases progressively (except under VMFT-25, where they are fewer in the final decile, due to the low marginal tax rate). Except in the case of the VMFT-25 reform, the winners always exceed losers. The BIFT reforms affect everyone; given the existence of a minimum income, the initial deciles are comprised exclusively of winners, while losers are concentrated in the higher deciles. Starting from the fourth and fifth deciles, the number of losers increases progressively. The higher the basic income awarded to each household, the higher is the number of winners at the low-medium part of the distribution. Comparing the

[12] Although the parameter estimates of the utility function may vary, according to a range of demographic characteristics, we recognise that assuming the same utility function for potential workers and for the inactive population is a strong assumption.

BIFT and the VMFT scenarios, we can see that, despite similar effects at higher incomes, the BIFT treatment of poor households increases the number of winners, which may be considered as an argument in its favour.

4.3 Social welfare evaluation: an optimal taxation approach

Having available pre- and post-reform individual utility profiles, and willing to postulate the existence of a social welfare function, it becomes possible to introduce distributional concerns into the analysis. Concretely, we may assume a social planner objective function which assigns weights to individual utilities (for example à la Bergson-Samuelson) and employ it to evaluate the social desirability of the reforms. This approach is typical in the optimal taxation framework (see Mirrlees, 1971, and more recently, in a discrete microsimulation framework, Spadaro, 2005). This procedure has the advantage of summarising, in one number, the welfare associated with each reform. However, it does require the specification of a social welfare function, which depends on the particular cardinalisation of the utility function. Most importantly, it implies defining value judgements regarding the weights assigned to each agent, which has provoked much criticism of the optimal taxation approach. Specifically, no basis exists to identify the "correct" social welfare function (for a brilliant discussion of these issues, see Stern, 1976). Thus, we wish to stress the importance of performing a sensitivity analysis of the social welfare evaluation results, with respect to different specifications of the value judgements and, equally, the need to recognise that all the optimality results must be interpreted in light of what was previously mentioned.

The social welfare function employed in the present study is:

$$W = \frac{1}{\lambda} \sum U(y, L, X)^{\lambda} \qquad (13)$$

where U represents agents' utility and λ is a parameter belonging to the interval $(-\infty, 1]$, controlling the concavity of the social welfare function and thus capturing the value judgements of the social planner with regard to inequality aversion.[13] For $\lambda = 1$, the planner assigns the same marginal weight to every household (the utilitarian specification), while for $\lambda \to -\infty$ the government is only interested in the welfare of the poorest household (the

[13] To reduce the computational burden, the utility for couples and singles has been normalized to their respective means.

Rawlsian specification). This specification (or similar forms) has been employed in the majority of research into optimal taxation, as it permits, easily and transparently (by adjusting the parameter *λ)*, the dependence of the optimality results regarding the hypothesis regarding the distributional concerns of the social planner to be analysed.

The results are shown in Figure 4. On the x-axis, *λ* takes values ranging from –2 (a social welfare function with greater inequality aversion) to 1 (utilitarian). The y-axis displays the percentage increase or decrease in social welfare with respect to the reference scenario (1999). The reform which yields the maximum value of social welfare (from among the alternatives evaluated and the functional forms employed), independently of the social planner's inequality aversion, is BIFT-46. The effects (in terms of welfare) of a higher basic income dominate the efficiency loss (in terms of labour supply) produced by a higher tax rate, no doubt due to the small implicit extensive elasticities estimated in Section 3. Other BIFT reforms with lower marginal tax rates are nevertheless more desirable than the VMFT or 1999 systems.[14]

4.4 Social welfare evaluation: computing equivalent incomes

We complete and complement the policy evaluation by computing equivalent incomes.[15] This allows us to construct a social welfare function in terms of money metric utility which does not depend on the cardinalisation of the utility functions employed. Once more, it is important to perform a sensitivity analysis of the social welfare evaluation results with respect to different specifications of the value judgements.

A prior step to computing equivalent incomes is to calculate the equivalent variation for each household. This is defined by the amount of money which must be awarded to (or subtracted from) household *i* before the reform, in order for the household to be unaffected by the reform. Following the notation in Section 3, the equivalent variation of household *i*, VE_i, is obtained by solving for VE_i in the following equation:

$$Max_j\left[U(y_{ij}^1, h_j, Z_i; \nu_j) + \varepsilon_{ij}\right] = Max_k\left[U(y_{ik}^0 + VE_i, h_k, Z_i; \nu_k) + \varepsilon_{ik}\right] \qquad (14)$$

where y_{is}^0 and y_{is}^1 represent disposable income prior to and following the reform for household *i* and choice *s*, respectively. Equivalent variation VE_i is a variable which depends on the distribution of the error term, disposable income prior to and following the reform and,

[14] Similar results are obtained from a separate analysis of couples and singles.
[15] See King (1983) and Creedy and Duncan (2002).

finally, household characteristics. The optimal post-reform choice, *j*, is not necessarily the same as choice *k*, the optimal choice with the equivalent variation.[16] As is often the case in simulation studies, we assume that policy reforms do not affect the error terms. A positive/ negative equivalent variation indicates households whose utility increases/decreases following the reform. Obviously, other money metric utility measures exist, such as the compensating variation or consumer surplus; the advantage of the equivalent variation measure is that the reference prices are pre-reform.[17]

The distribution by income deciles of the equivalent variation for each reform (using the 1999 system as a baseline) is presented in Table 9. Households lose, on average, 262€ under the 1998 system, a figure which increases for the top income deciles. By contrast, the BIFT schemes produce significant improvements in terms of average welfare, as the considerable positive equivalent variations for the lowest deciles compensate for the losses suffered by the top deciles. The BIFT schemes produce average equivalent variation figures of 1,379€ (for a tax rate of 46%), 995€ (38), 611€ (30) and 367€ (25). Under VMFT schemes, there is a slight increase in average welfare, due to the positive sums computed for the deciles from 5 to 8-9.

Equivalent incomes, *Ye*, may be computed using the equivalent variation for each household. The equivalent income is defined in terms of indirect utility, *V(·)*, as:

$$V(t_a, Ye) = V(t, m) \tag{15}$$

where t_a is the reference price and *m* is non labour income. Using the cost function:

$$Ye = E(t_a, V(t_b, m_b)) \tag{16}$$

where *E(·)* is the cost function, m_b and t_b are the post-reform non labour income and prices and $V(t_b, m_b)$ is the post-reform utility level. Using as reference the 1999 system, equivalent income is:

$$Ye = y^0 + VE \tag{17}$$

This equivalent income is a measure of the welfare of each agent; this does not depend on the cardinalisation of the utility function employed. It then becomes possible to construct a social welfare function in the following way:

$$BS = \frac{1}{N\lambda} \sum (Ye)^{\lambda} \tag{18}$$

[16] Note that for non-potential workers (inactive, self-employed), the equivalent variation may be computed as the difference in disposable income prior to and following the reform.

[17] For a discussion, see King (1983).

where, as in the previous sub-section, λ is a parameter belonging to the bracket $(-\infty,1]$ which captures the social planner inequality aversion (as above) and N represents the number of households.

Figures 5*a* and 5*b* show the results for values of λ from -2 to 1 and represent the changes in social welfare *(BS)* with respect to the reference scenario. Figure 5*a* compares the 1999, 1998 and VMFT scenarios, while Figure 5*b* compares the reference system (1999) and the BIFT scenarios.[18] The first and most important result is that BIFT-46, BIFT-38, BIFT-30 and BIFT-25 yield (in that order) the highest values of social welfare, independently of λ. Comparing Figures 4*a* and 4*b*, the increase in social welfare associated with BIFT is much larger than that for VMFT schemes. The BIFT scenarios appear to represent the best trade-off between equity and efficiency; they are much more effective in increasing social welfare than a vital minimum-flat tax mechanism, independently of the social planner's aversion to inequality.

Another interesting result is that, employing this social welfare evaluation methodology, VMFT schemes and the 1998 and the 1999 systems produce very similar effects (see Figure 4*a*). This is particularly true for social planners who are inequality-averse. The explanation is intuitive: the more Rawlsian the planner, the less weight is given to changes at the middle or the top of the distribution. Since the VMFT, 1999 and 1998 schemes have similar impacts upon poorer households, their evaluation in terms of social welfare is practically identical.

This social evaluation technique suggests that basic income flat tax schemes are the most socially desirable redistribution mechanisms, reinforcing the results given in Section 4.3; the minor effects upon labour supply and the considerable increase in the welfare of poor households demonstrate that the BIFT mechanism is a powerful instrument for income redistribution. Moreover, we have placed several caveats upon social welfare evaluation methods but the robustness of our results indicate that BIFT schemes are preferred (or are indifferent to) for every type of policy evaluation we have performed.

5. Conclusions

This paper evaluates the efficiency and welfare effects (at both individual and social levels) of recent reforms of the Spanish Income Tax system, compared to various BIFT and VMFT alternatives. The analysis employs a microsimulation model in which labour supply

[18] We present the simulation results in two separate figures for purposes of clarity, given the considerable difference in scale between the BIFT changes and those produced in other scenarios.

reactions are explicitly considered. Instead of adopting the Hausman approach, we estimate the direct utility function using the methodology proposed by Aaberge et al. (1995) and Van Soest (1995). This is the first attempt to estimate a discrete labour supply model for a sample of Spanish households.

We show that the scenarios simulated have little impact on the efficiency of the economy (as measured by labour supply effects), while the welfare effects of VMFT reforms are limited. By contrast, BIFT schemes produce significant improvements in the welfare of the poorest households (and thus social welfare). These results are robust to different social welfare evaluation techniques.

In our opinion, the contributions of this paper have implications for both methodology and policy. From a methodological point of view, the study represents the first attempt to evaluate the welfare effects (at both the individual and social level) of the recent Spanish tax reforms, including labour supply reactions estimated using a discrete choice approach and combining behavioural and arithmetical microsimulation. We underline the limitations and shortcomings of this type of analysis but, at the same time, we show that behavioural microsimulation models are powerful tools for the *ex-ante* evaluation of public policies.

With respect to policy, the main contribution of this paper consists of highlighting the potential of a BIFT scheme as an institutional redistribution mechanism which can both reduce inequality and increase social welfare in Spain. Its feasibility depends on the associated efficiency costs (in terms of reductions in labour supply) it may produce, although the results of our econometric estimations indicate that such costs are minor.

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Table 1. Calibration of GLADHISPANIA (in billions of euros)

	1998			1999		
	Official Statistics	Gladhispania	Difference	Official Statistics	Gladhispania	Difference
	(1)	(2)	(3) = (2-1)/1	(4)	(5)	(6) = (5-4)/4
Mean disposable household income[(a)]	18,334	18,130.6	-1.11%	18,375	19,311	5.09%
Personal Income Tax collection[(b)]	39.2	39.1	-0.25%	39.54	37.83	-4.33%
Average income tax rate[(c) (d)] = (net tax/taxable income)	15.13%	15.59%	3.03%	23.15%	23.87%	3.12%
Employees' Social Security contributions[(e)]	13.7	13.37	-2.40%	14.57	14.26	-2.13%

(a) Comparison of updated 1995 ECHP with 1998 and 1999 ECHP (in euros); (b) Source: Informe Anual de Recaudación Tributaria, 2001; (c) Source: Memoria de la Administración Tributaria 2001; (d) In 1999 the definition of taxable income was changed (the new personal and family minimum allowances are deducted from taxable income) which explains the increase in the average income tax rate, (e) Source: Anuario de Estadísticas Labourales y de Asuntos Sociales 2002;

Table 2. Descriptive statistics of the variables used in the econometric section

SINGLES Variable	Mean	Standard deviation	**COUPLES** Variable	Mean	Standard deviation
Yearly disposable income	14,692	9,559	Yearly disposable income	24,030	15,756
Weekly hours of leisure	135.22	17			
			Children (in %):		
Age	41.8	11.3	no children	24.3	
Education (in %):			one child	30.4	
university graduate	37.1		two children	38.3	
secondary school	21.2		three or more children	7.0	
less than secondary school	41.7				
			Head of the household:		
Children (in %):			Weekly hours of leisure	127.7	11.6
no children	83.4		Age	38.9	8.3
one child	10.4		Education (in %):		
two children	5.02		university graduate	30.8	
three or more children	1.16		secondary school	19.9	
			less than secondary school	49.3	
			Males (in %)	92.8	
			Spouse:		
			Weekly hours of leisure	153.1	18.5
			Age	36.6	8.1
			Education (in %):		
			university graduate	25.6	
			secondary school	20.7	
			less than secondary school	53.7	
			Males (in %)	7.2	
Number of observations	259		Number of observations	1,015	

Table 3. Tax rates schedule (in euros)

1998				**1999**	
Individual taxation		**Joint taxation option**		**Individual or joint**	
Bracket	Tax rate	Bracket	Tax rate	Bracket	Tax rate
0-2,806.73	0	0-5,415.12	0	0-3,606.07	0.18
2,806.73-6,977.75	0.20	5,415.12-13,492.72	0.20	3,606.07-12,621.25	0.24
6,977.75-13,793.23	0.23	13,492.72-19,028.04	0.246	12,621.25-24,641.50	0.283
13,793.23-21,005.37	0.28	19,028.04-26,390.44	0.29	24,641.50-39,666.08	0.372
21,005.37-30,621.57	0.32	26,390.44-35,255.37	0.33	39,666.08-66,111.33	0.45
30,621.57-40,838.77	0.39	35,255.37-47,485.97	0.39	> 66,111.33	0.48
40,838.77-51,837.29	0.45	47,485.97-59,716.56	0.45		
51,837.29-63,106.27	0.52	59,716.56-72,938.83	0.53		
> 63,106.27	0.56	> 72,938.83	0.56		

Table 4. New typology of households

	Total households	**Potential workers**
Singles	1,000	259
Couples	3,195	1,024
Other households		
Fiscal unit treated as couples	1,852	
Fiscal unit treated as singles	373	
Other individuals treated as singles	3,392	
Total	9,812	1,283

Table 5. Estimation for singles

Variable	Coefficient	Z	
Income^2	-0.413	-0.81	
Hours of leisure^2	-236.955	-7.31	***
Income x hours of leisure	29.061	5.00	***
Income	-25.546	-3.77	***
x Age	0.506	1.96	**
x Education	0.045	0.05	
x Children	0.199	1.19	
Hours of leisure	458.942	7.04	***
x Age	-0.490	-0.32	
x Educ1	-4.197	-1.07	
x Educ2	0.398	0.14	
Fixed costs	2.401	4.75	***
Average wage elasticity (hours)	0.0		
Average wage elasticity (participation)	0.0		
Number of observations	259		
Log likelihood	-273.84		

Note. The variables have been rescaled as follows: Income = disposable income in euros/30,000; Hours of leisure = (24x7 – weekly hours of work)/150; Age = (age in years – 38)/10; Education = average number of years of study/10; Educ1 = university graduate; Educ2 = secondary school; Children = number of children (under 16) in the household. * parameter significant at 10%, ** parameter significant at 5%, *** parameter significant at 1%

Average wage elasticities are computed by increasing the gross wage rate by 1%.

Table 6. Estimation for couples

Variable	Coefficient	z	
Income^2	-0.228	-1.92	*
Hours of leisure of the household head^2	-89.641	-12.45	***
Hours of leisure of the spouse^2	87.964	10.97	***
Income x Hours of leisure of the household head	-0.155	-0.14	
Income x Hours of leisure of the spouse	-0.309	-0.35	
Hours of leisure of the household head x Hours of leisure of the spouse	-31.879	-3.47	***
Income	2.097	1.12	
x Age of the household head	-0.419	-0.79	
x Age of the household head^2	-0.025	-0.09	
x Age of the spouse	1.443	2.44	**
x Age of the spouse ^{2}	-0.391	-1.30	
Hours of leisure of the household head	204.505	10.23	***
x 1 (male)	-13.553	-8.74	***
x Education of the household head	-8.330	-3.89	***
x Age of the household head	3.644	4.63	***
Hours of leisure of the spouse	-122.422	-6.77	***
x 1 (male)	-11.268	-5.28	***
x Education of the spouse	-13.036	-10.15	***
x Age of the spouse	1.923	2.86	***
x Age of the spouse^2	0.573	1.08	
x 1(one dependent child)	2.929	2.42	**
x 1(two or more dependent children)	5.570	3.89	***
Fixed costs	-1.6302	-1.82	
x 1(one dependent child)	0.6132	0.62	
x 1(two or more dependent children)	1.2990	1.50	*
Average wage elasticity of the head (hours)	0.01		
Average wage elasticity of the spouse (hours)	0.29		
Average wage elasticity of the head (participation)	0.11		
Average wage elasticity of the spouse (participation)	0.26		
Number of observations	1024		
Log likelihood	-1456.2512		

Note. The variables have been rescaled as follows: Income = disposable income in euros/30,000; Hours of leisure = (24x7 – weekly hours of work)/150; Age = (age in years – 38)/10; Education = average number of years of study/10. * parameter significant at 10%, ** parameter significant at 5%, *** parameter significant at 1%

Average wage elasticities are computed by increasing the gross wage rate by 1%.

Table 7. Transition matrices for singles (using 1999 as the reference system)

	Hours worked	**1998 scenario** 0	30	40	50	Total (%)
1999 scenario	0	**19.14**	0.05	0.10	0.02	19.31
	30	0.01	**13.06**	0.04	0.01	13.13
	40	0.02	0.15	**49.24**	0.01	49.42
	50	0.10	0.25	0.24	**17.57**	18.15
	Total (%)	19.27	13.50	49.62	17.61	100.00

	Hours worked	**BIFT38** 0	30	40	50	Total (%)
1999 scenario	0	**19.28**	0.01	0.01	0.00	19.31
	30	0.92	**11.53**	0.49	0.19	13.13
	40	2.02	0.14	**46.72**	0.54	49.42
	50	0.77	0.17	0.25	**16.96**	18.15
	Total (%)	22.99	11.85	47.47	17.69	100.00

	Hours worked	**VMFT38 scenario** 0	30	40	50	Total (%)
1999 scenario	0	**18.93**	0.11	0.17	0.10	19.31
	30	0.17	**12.61**	0.25	0.09	13.13
	40	0.06	0.20	**48.95**	0.20	49.42
	50	0.08	0.05	0.19	**17.83**	18.15
	Total (%)	19.24	12.98	49.56	18.22	100.00

Note. All figures are percentages.

Table 8. Transition matrices for couples (using 1999 as the reference system)

	Combination of working hours (household head_spouse)	1998 scenario 0_0	0_25	0_40	40_0	40_25	40_40	50_0	50_25	50_40	Total
1999 scenario	0_0	**0.28**	0.00	0.00	0.09	0.01	0.00	0.02	0.00	0.00	0.42
	0_25	0.00	**0.21**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
	0_40	0.00	0.00	**5.76**	0.02	0.00	0.01	0.01	0.00	0.01	5.82
	40_0	0.00	0.00	0.00	**39.99**	0.00	0.01	0.01	0.00	0.00	40.02
	40_25	0.00	0.00	0.00	0.03	**5.89**	0.00	0.00	0.00	0.00	5.93
	40_40	0.00	0.00	0.02	0.08	0.01	**18.17**	0.01	0.00	0.00	18.30
	50_0	0.01	0.00	0.00	0.07	0.00	0.00	**20.50**	0.00	0.00	20.58
	50_25	0.00	0.00	0.00	0.01	0.00	0.01	0.00	**2.36**	0.00	2.39
	50_40	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	**6.29**	6.34
Total		0.29	0.22	5.79	40.32	5.93	18.22	20.56	2.36	6.30	**100.00**

	Combination of working hours (household head_spouse)	BIFT38 scenario 0_0	0_25	0_40	40_0	40_25	40_40	50_0	50_25	50_40	Total
1999 scenario	0_0	**0.42**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
	0_25	0.00	**0.20**	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.21
	0_40	0.02	0.01	**5.73**	0.05	0.00	0.00	0.01	0.00	0.00	5.82
	40_0	0.08	0.01	0.02	**39.87**	0.00	0.00	0.04	0.00	0.00	40.02
	40_25	0.00	0.00	0.01	0.19	**5.64**	0.00	0.08	0.00	0.01	5.93
	40_40	0.04	0.02	0.20	0.67	0.05	**17.01**	0.30	0.01	0.00	18.30
	50_0	0.04	0.00	0.01	0.32	0.00	0.00	**20.21**	0.00	0.00	20.58
	50_25	0.00	0.00	0.00	0.06	0.00	0.00	0.04	**2.28**	0.00	2.39
	50_40	0.00	0.00	0.02	0.24	0.01	0.02	0.10	0.01	**5.95**	6.34
Total		0.61	0.25	5.98	41.41	5.70	17.03	20.77	2.30	5.95	100.00

	Combination of working hours (household head_spouse)	VMFT38 scenario 0_0	0_25	0_40	40_0	40_25	40_40	50_0	50_25	50_40	Total
1999 scenario	0_0	**0.41**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
	0_25	0.00	**0.19**	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.21
	0_40	0.00	0.00	**5.77**	0.03	0.00	0.01	0.01	0.00	0.00	5.82
	40_0	0.00	0.00	0.01	**39.71**	0.04	0.04	0.20	0.01	0.01	40.02
	40_25	0.00	0.00	0.00	0.11	**5.71**	0.00	0.08	0.00	0.00	5.93
	40_40	0.00	0.01	0.14	0.40	0.05	**17.42**	0.25	0.01	0.00	18.30
	50_0	0.00	0.00	0.01	0.07	0.00	0.04	**20.45**	0.01	0.01	20.58
	50_25	0.00	0.00	0.00	0.03	0.00	0.00	0.04	**2.31**	0.00	2.39
	50_40	0.00	0.00	0.01	0.10	0.01	0.02	0.06	0.01	**6.13**	6.34
Total		0.42	0.20	5.95	40.48	5.82	17.53	21.10	2.36	6.15	100.00

Note. All figures are percentages.

Table 9. Equivalent variations (in euros)

	1998	46%		38%		30%		25%	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Decile		**BIFT (4,632)**	**VMFT (13,997)**	**BIFT (3,526)**	**VMFT (12,002)**	**BIFT (2,421)**	**VMFT (9,589)**	**BIFT (1,730)**	**VMFT (7,737)**
1	0	4729	0	3600	0	2472	0	1767	0
2	1	4454	0	3363	0	2272	0	1590	0
3	6	3108	0	2234	0	1360	2	811	0
4	-32	2486	5	1706	5	926	4	438	3
5	-155	2229	115	1464	112	695	103	221	8
6	-269	1543	354	915	332	286	154	-108	-51
7	-317	959	687	490	500	28	244	-263	-76
8	-378	37	1012	-143	703	-328	235	-446	-149
9	-488	-1380	846	-1073	387	-767	-77	-607	-283
10	-988	-4372	-1448	-2600	-909	-830	-80	272	612
Mean	**-262**	**1379**	**157**	**995**	**113**	**611**	**59**	**367**	**6**

Figure 1: Post-reform income increase (in euros per year)

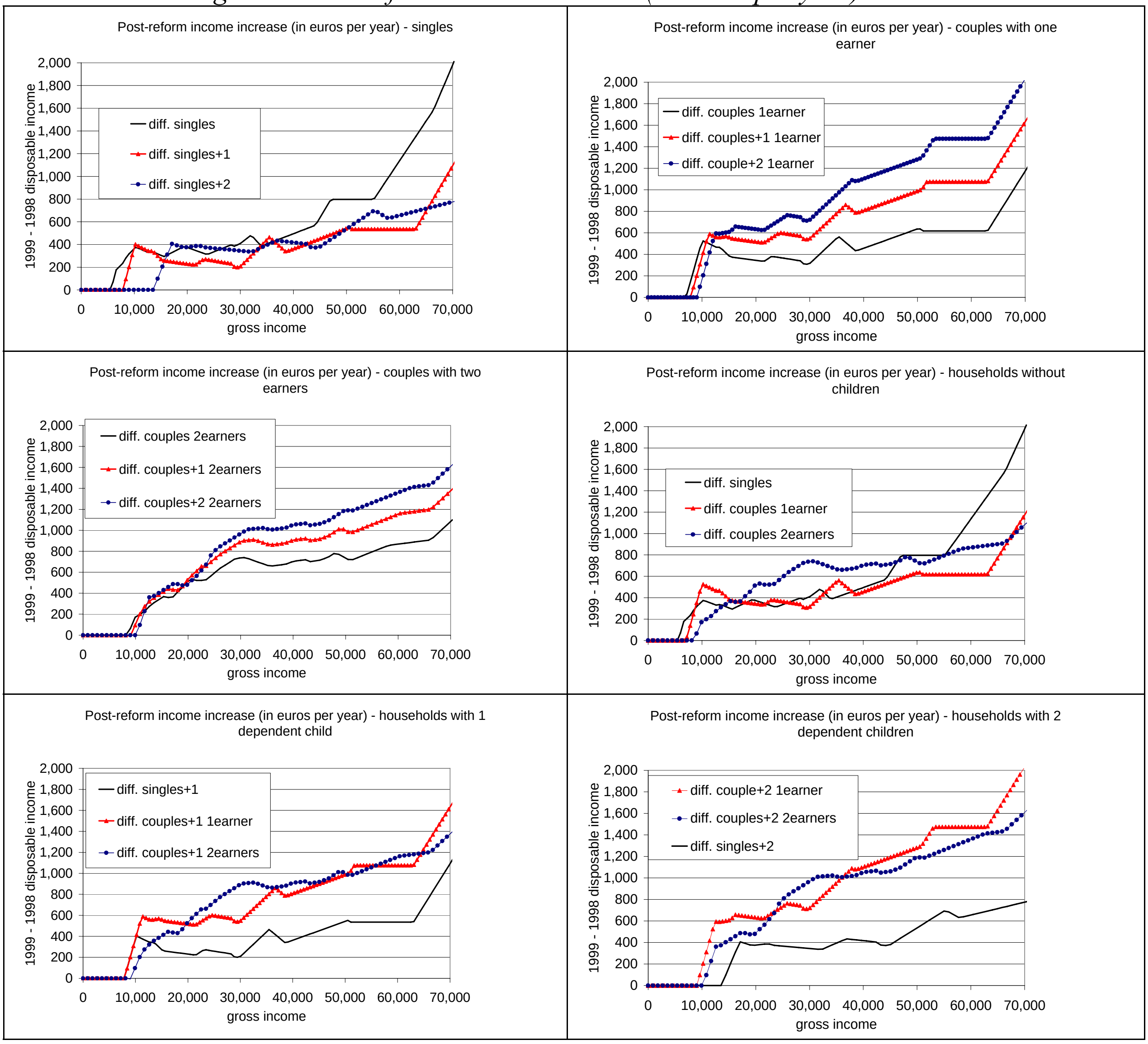
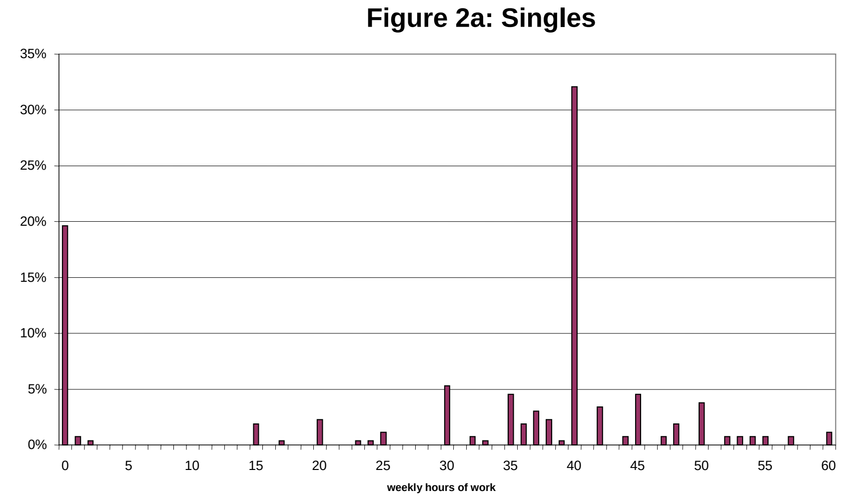
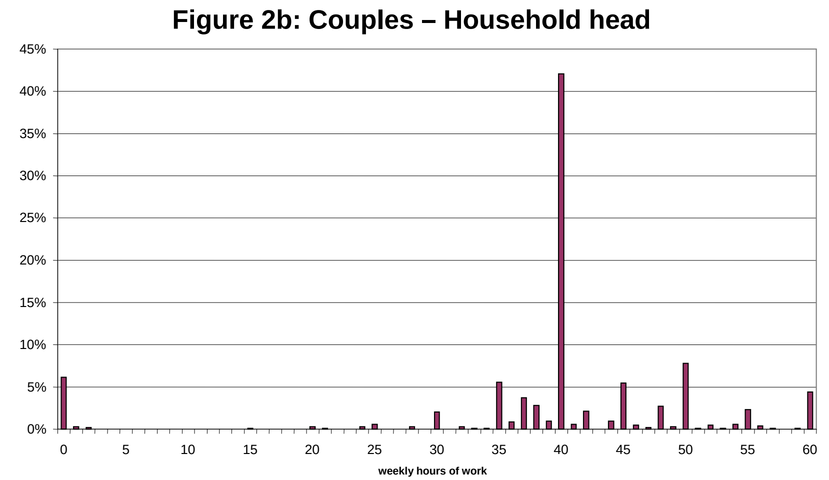


Figure 2: Weekly hours of work of singles and couples (household head and spouse)





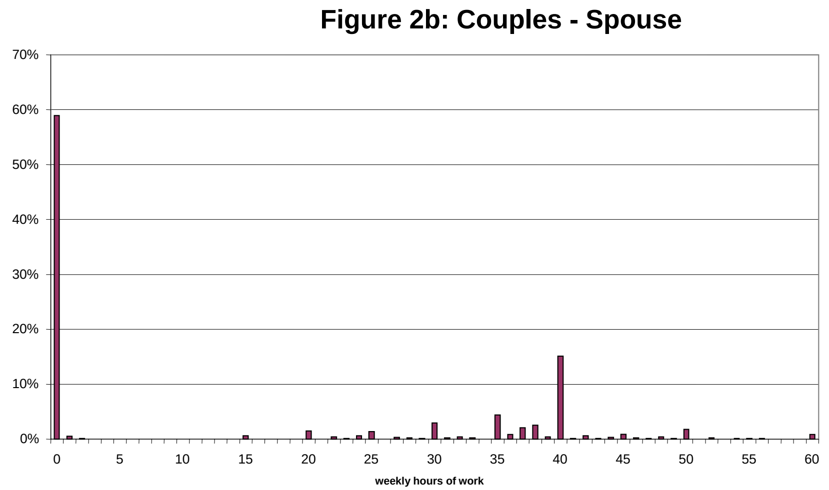


Figure 3: Winners and losers measured by utility level reached (whole sample)

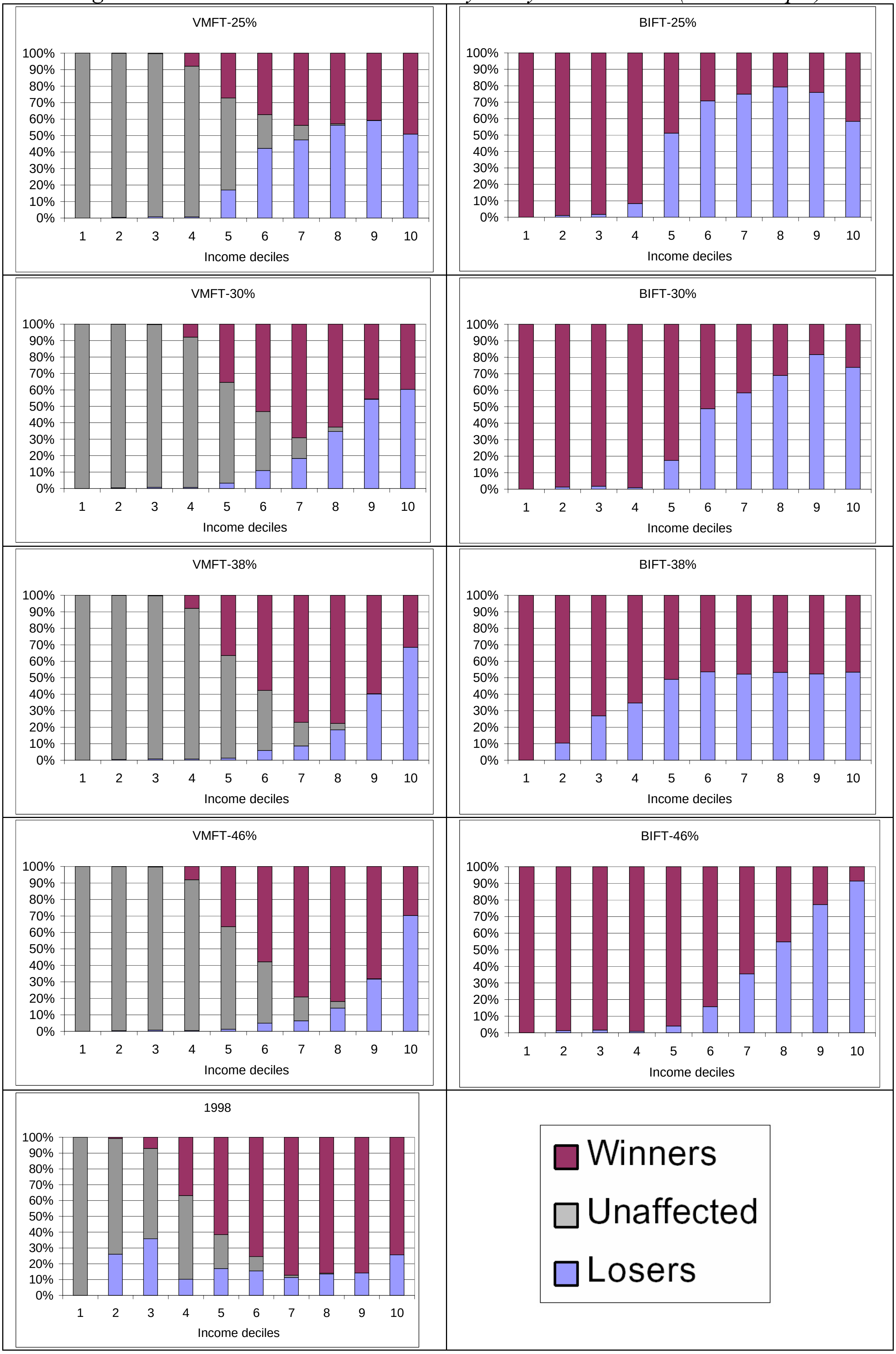


Figure 4: Social welfare variations with respect to the reference scenario (1999). Whole sample

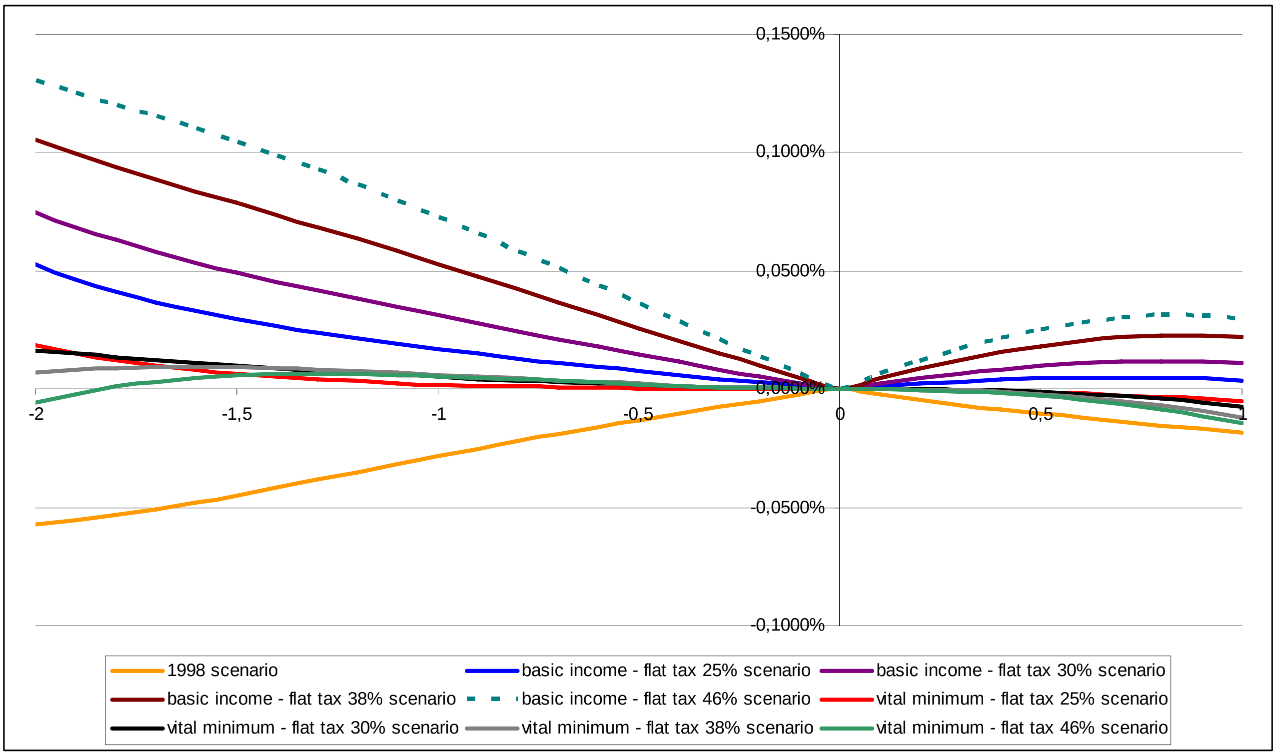


Figure 5a: Social welfare variation using equivalent incomes (with respect to the reference scenario, 1999). Whole sample

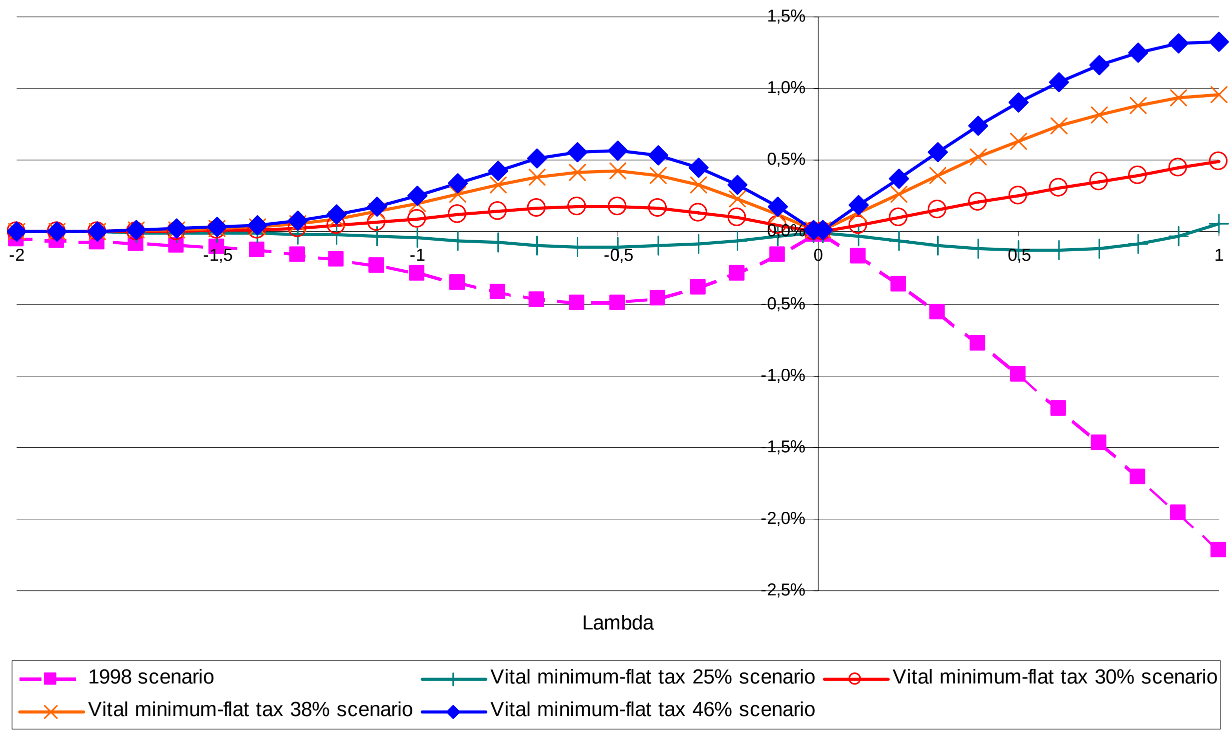


Figure 5b: Social welfare variation using equivalent incomes (with respect to the reference scenario, 1999). Whole sample