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Labour Supply and Welfare Analysis of Income Tax Reforms using Microdata: An Application to British Married Women

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Abstract

This paper exposes key elements in the use of labour supply models to evaluate the welfare implications of personal income tax reforms.By way of illustration, after presenting the theoretical background of the topic, this paper investigates the welfare impact upon wives of the recent introduction of separate taxation of married couples in Great Britain. Following Hausman's approach, we use duality theory in order to obtain explicit and exact functions for the equivalent variation and deadweight loss change induced by this reform. The analysis is based on microeconomic data drawn from the Family Expenditure Survey for 1989. We assess simultaneously both the efficiency and the redistributional consequences of the new definition of the taxable unit.

keywords: Independent taxation, labour supply, equivalent variation, welfare analysis, microdata, married women.

JEL Classification: D6, D12, H31, J2.

Resumen

Este artículo presenta aspectos fundamentales del uso de modelos de oferta de trabajo en el análisis de las implicaciones de bienestar derivadas de reformas del impuesto personal sobre la renta. Como aplicación empírica, después de presentar los aspectos teóricos que subyacen al tema, el artículo estudia el impacto en bienestar que la reciente introducción en Gran Bretaña de la declaración separada ha tenido sobre las esposas británicas. Siguiendo a Hausman, se utiliza la teoría de la dualidad para obtener las funciones explícitas exactas de la variación equivalente y perdida de bienestar inducidas por esta reforma. El análisis empírico utiliza microdatos procedentes de la Family Expenditure Survey (Encuesta de Presupuestos Familiares) de 1989, y analiza tanto los aspectos de eficiencia como los aspectos redistributivos que surgen de la nueva definición de la unidad contribuyente.

palabras clave: Declaración separada, oferta de trabajo, variación equivalente, analisis de bienestar, microdatos, mujeres casadas.

clasificación JEL: D6, D12, H31, J2.

INTRODUCTION

In looking at the implications of income tax reforms, standard labour supply models have been intensively used in recent literature. Complications such as the econometric problems involved in nonlinear budget constraints or the existence of corner solutions have attracted much of the attention in previous empirical work. Apart from analysing labour supply responses to tax changes, the avaliability of microdata, together with the seminal contributions of Hausman (1981) and King (1983), has also made possible to evaluate the welfare gains induced by income tax reforms. It is clear that this renewed interest in evaluating the effects of tax reforms was enhanced by the fact that the 1980s witnessed a restructuring of tax systems in many western countries.

The main purpose of these reforms was to reduce the economic inefficiency induced by distorsonary taxation of income. With regard to personal income tax, one of these changes was the introduction of separate taxation rather than joint taxation of married couples. Britain introduced this modification in 1990. This shift in the definition of the taxable unit had important implications in the normative underpinnings of the aims pursued by personal income tax. Firstly, it ensured the individual as the proper target of fairness in the personal tax system. Secondly, in line with other reforms, it ratified the primacy of the principle of tax neutrality over other tax criteria.

Despite the importance of the unit of taxation, however, the recent move away from joint to individual taxation has received scant attention in applied work. This

paper aims to remedy this omission by evaluating the welfare effects on British married women of this change in the definition of the tax unit. To do this, we work out the exact functions for the equivalent variation and deadweight loss induced by the reform. Futhermore, in the case of the equivalent variation, the estimated standard errors are also reported. The computation of these standard errors permits the construction of confidence intervals for this welfare measure, which are useful inputs for helping policy-makers make a decision. The empirical estimation uses individual household data drawn from the Family Expenditure Survey (FES) and it is based on a final sample of 3043 observations.

The results suggest that the reform reduces the excess burden by a monetary equivalent of £ 29013 per week. That is to say, in aggregate terms the reform induces efficiency gains. Moreover, the majority of the women in the sample (53%) are better off after the reform. However, the distributional assessment of the equivalent variation within the sample indicates clearly that the gains and losses are not distributed equally among households. By income class, for instance, women in the highest group of income earners gain considerably more than the average. The same also holds for income recipients in the lower income deciles. In addition, the change to independent taxation raises the total labour supply of married women by 5.68% of the labour supply before the reform. As expected, this increase in the number of working hours is particularly sizeable in the groups of taxpayers who experience the largest reduction in marginal tax rates: non-workers, part-time workers and income recipients in the lower-income deciles and in the highest income groups.

The plan of the paper is as follows. Section I outlines the main features of the reform and describes the complexities in selecting the proper tax unit. In section II the methodological issues concerned with welfare analysis in the context of labour supply are presented. The expression of the equivalent variation is extended to the case of changes in both prices and wealth and other relevant functions for welfare analysis are also derived. Section III presents the model to be estimated and discusses the econometric issues involved. Section IV describes the data set and the variables included in the empirical estimation. Section V presents the estimation results and our main results are summarized in section VI.

I. THE TAX UNIT: FROM JOINT TO SEPARATE TAXATION

The purpose of this section is to describe briefly the way the taxation of married couples has changed in Britain in recent times. Table 1 in appendix 1 summarizes for 1989 and 1990 the tax schedule and main personal allowances for the population of our concern[1].

Before the onset of independent taxation the British tax system tended to treat married couples as a single unit for income tax purposes. Under this setting, married men enjoyed a higher (untransferable) personal allowance than single taxpayers and, in addition, wife's earnings received an extra tax relief. However, although this was the general setting, even under the dependent taxation scheme the system allowed married couples to have the wife's earnings taxed separately. This

[1] 1989 was the last tax year in which the dependent taxation took place.

possibility was known as the wife's earning election and it had to be applied for within twelve months of the end of the tax year. If the wife's earnings election applied, husband and wife were effectively taxed as two single people paying their taxes according to their own tax schedule and enjoying a single person's tax allowance. Nevertheless, even under the wife's earnings election, a wife's unearned income had to be added to her husband's income tax base. As a result, the benefit of the wife's earnings election was not obvious. In fact, in deciding whether separate taxation of the wife's earnings was worthwhile a couple had to compare the advantage of the wife paying taxes for her own earned income according to her own separate schedule (rather than facing her husband's marginal tax rate) against the disadvantage of losing the married man´s allowance.

The scarce incidence of the wife's earnings election is captured by the simulation run in our sample: using 1989 as the reference year only 10% of 3043 married women found the wife's earning election advantageous. Therefore, all in all, this limited relevance of the wife's earnings election together with its exclusive applicability to the wife's earned income made it of modest importance and it allows us to define the existing system up to 1989 as definitively based on joint taxation of married couples.

This way of taxing married couples was mainly defended on equity grounds: as married couples enjoy economies-of-scale benefits derived from common consumption their tax-paying ability was better measured by their pooled income. However, this argument was criticised from a number of points of view. Firstly,

because family income aggregation for tax purposes rested on the dubious assumption that marriage implied equal command over combined resources. Secondly, because the traditional concept of the husband-wife family in which the husband was the only breadwinner was becoming old-fashioned. Obviously, the growing number of cohabiting individuals and more-than-one-earner couples demanded a reconsideration of the definition of the unit of taxation. In addition, the enormous increase in registered unemployment rates brought to the fore the importance of efficiency considerations. In fact, the most significant objection to the joint taxation of husbands and wives arose from its effects on the efficient allocation of resources. In a progressive tax the aggregation of incomes makes the spouse's marginal tax rates dependent on the other's income. As a result, the lower-earning spouse, normally the wife, might face a higher marginal rate than she would otherwise. Therefore, accepting the general view that married women's wage elasticities are significantly large, the maintenance of dependent taxation implied that the wife's labour supply decisions, measured both as participation rates and hours of work, could be greatly distorted.

Aware of these facts, the Chancellor announced the introduction of Independent Taxation in 1988 and in 1990 it came into force. Essentially, this system meant that regardless of the nature of the income, husbands' and wives' income was taxed independently.

Using the pre-reform year (1989) as a benchmark, figure 1 shows a first hint of the consequences to tax rates of this reform. The first three charts clearly indicate

that moving toward independent taxation has induced a broad and significant cut in marginal tax rates. However, this reduction in marginal tax rates has not been equally distributed. From chart 1 and 2 it is evident that it has mainly affected non-working and low-income women. Chart 3 presents the average marginal tax rates faced by working married women broken down by hours ranges. Likewise, it also makes clear that this reduction in marginal tax rates has been markedly more important in women working less than ten hours per week. This means that, as a consequence of the introduction of separate taxation, both non-working women and women working fewer hours could have, respectively, a large incentive to participate in the labour market and an increase in their hours of work. Conversely, according to chart 4 the reform seems to have had a slight effect on average tax rates, which implies that, under the assumption of no behavioural reaction, it can be regarded as a revenue-neutral tax reform as chart 5 shows. This indicates that the move toward the individual as the proper tax unit has been designed in order to induce largely substitution effects and small income effects. Finally, the last two charts reveal that labour income (Social Security contributions included) is the type of income which has benefited the most from the reform whereas non-labour income has reduced its marginal tax rates only very slightly.

[FIGURE 1 APROXIMATELY HERE]

Although the analysis presented above sheds some light on the effects of the change from dependent to independent taxation, it is important to stress that it ignores behavioural responses and thus it can only be regarded as a first-round impact of the reform. In other words, previous analysis assumes that labour supply is fixed and therefore it gives us only a vague idea of the expected efficiency effects of this new definition of the taxable unit. Proper welfare evaluation of tax reforms, instead, requires an explicit consideration of behavioural responses. Therefore, in what follows labour supply responses are considered and in order to capture the allocative effects of the reform the Hicksian concept of Equivalent Variation (EV) is used. In the following section, welfare analysis is presented in the context of labour supply under a partial equilibrium framework.

II. INCOME TAXATION, LABOUR SUPPLY AND WELFARE ANALYSIS

Since the seminal papers of Dupuit (1844) and Marshall (1890) were written, welfare analysis has been widely used in economics. In addition, Hick's study on Value and Capital (1939) put at economists' disposal a set of money metric measures to assess the desirability of public policies. Among these, the Compensating Variation (CV) and the Equivalent Variation (EV) have attracted most of the attention. Nevertheless, up to the late 1970's the common procedure to make welfare prescriptions was based on the Marshallian concept of Consumer Surplus (CS). The main shortcoming of the Marshallian demand approach is that for it to be

well defined the constancy of marginal utility of income (CMUI) is a requirement[2]. Moreover, if either EV or CV are the assumed correct welfare measures, the CMUI assumption is not enough and a null income effect is an additional prerequisite. Despite these limitations, the Willig analysis (1976) proved that under certain conditions CS could be considered a good aproximation to Hick's welfare measures. Hausman (1981), however, showed that for the case of one price change Willig's approximation was unnecessary since exact welfare measures could be computed[3]. Futhermore, Hausman also brought to light the fact that, even when Willig's approximations hold for the Hicksian welfare measures, the calculation of the deadweight loss using the Marshallian curve may approximate very poorly to the theoretically correct Hicksian deadweight loss. For these reasons, in evaluating the welfare implications of the independent taxation scheme, Hausman`s procedure will be implemented. Particularly, the so-called EV will be our measure for welfare change evaluation.

EV is one of the measures that "cardinalises" ordinal utility changes. In the context of tax reforms, it quantifies the monetary equivalent that should be given to (or taken away from) the taxpayer in order to make her as well off as she would be with the reform itself. Under the assumption of utility-maximizing behaviour and making use of duality theory, Hausman (1981) showed that the exact value of EV

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2 This condition is related with the problem of path dependency. For a full treatment of this issue, see Mohning (1971)and Chipman and Moore (1980). For a mathematical approach to this topic, see Apostol(1957,p. 292-297).

3 Although in a less elegant presentation, this possibility was recognized in advance by Hanemann (1980).

can be worked out. The starting point in Hausman's procedure is the market labour supply. It can be briefly summarized as follows. With separable preferences the Marshallian labour supply can be expressed as a function of a set of exogeneous

$$L_i = L(w,m,z;b)$$

variables and a single price (the wage) in the following way,

where w is a vector of net wage rates, m is a vector of non-labour income, z are socioeconomic variables and β represents the unknown vector of coefficients. Using Roy's identity and taking into account that making welfare comparisons requires keeping the utility level unchanged, we can express m as a function of w by solving

$$\frac{dm}{dw} = - L(w,m,z;b)$$

[2],

The solution of the differential equation [2] gives the indirect utility function ν(w,m), which defines completely the impact of the reform on the level of utility of the taxpayer. Futhermore, since the expenditure function, e(w,U), and the indirect utility are, respectively, strictly increasing in the level of utility and income, the inversion of the indirect utility allows us to obtain the expenditure function. Finally, the Hicksian labour supply can be recovered from the expenditure function using Shephard's lemma, from which the EV derives naturally.

This procedure can be seen graphically in figure 2. For the sake of expositional simplicity, only a single tax rate on all income is assumed. Figure 2(a)

depicts the case of a utility-maximising consumer faced with a linear budget constraint and characterized by a strictly quasi-concave direct utility function, U, defined over n-1 consumption goods and labour supply L. Under the assumption of constant relative prices the n-1 consumption commodities can be treated as a single good (here represented as consumption in the y axis). In a pre-reform situation the individual worker is assumed to have a net wage rate w_o and non-labour income equal to m_o, while her budget constraint is given by $BC(w_o,U_o)$. Her optimal choice in this context is the interior solution A. After a reduction in the personal income tax rate the new budget constraint becomes $BC(w_1,U_1)$ with B as her optimal choice. As figure 2(a) shows, EV is the money that must be added to the pre-reform nonlabour

$$EV = m_e - m_0$$

income, m_o, for the taxpayer to attain the post-reform utility level U_1. Formally,

where m_e is the equivalent income that represents the total non-labour income needed by the taxpayer at the pre-reform price vector to reach utility level U_1. Namely, EV indicates the sum of money that the taxpayer would require to forgo\accept a proposed tax reform[4].

[FIGURE 2 APROXIMATELY HERE]

[4] Some authors such as King (1983) call the compensation payment in [3] the equivalent gain (EG). Note that under such notation, EV is defined as the difference between the post-reform non-labour income, m_1,and the equivalent income, m_e; i.e. $EV=m_e-m_1$. As a result, $EG=EV+(m_1-m_o)$. Hence, King's EG will coincide with EV in [3] only when nonlabour income is tax-free, $m_o=m_1$. Our definition of EV sticks to [3] and it is akin to that of Boadway and Bruce (1984), Varian (1992), Kasier, van Essen and Spahn (1993)and Mas-colell, Whinston and Green (1995).

$$EV = e(w_0, U_1) - e(w_1, U_1) + (m_1 - m_0)$$

Alternatively, using the expenditure function, [3] can be also rewritten as

Taking into account Shephard's lemma, [4] can be expressed in terms of the

$$EV = EV(w) + EV(m) = -\int_{w_o}^{w_1} h_l(w, U_1)dw + (m_1 - m_o)$$

Hicksian labour supply as follows:

Equation [5] draws attention to an important issue underlying income taxation. Since the personal income tax is levied on all the individual's income, EV is formed of two segments: a substitution effect component, EV(w), due to taxation of labour income, and a pure income effect component, EV(m), as a result of the tax levied on non-labour income. The first of these elements is picked up by the left-hand side area to the Hicksian labour supply in the region of price change being considered. The second element is just the difference between the post-reform non-labour income, m_1, and the initial level of income, m_o. This component separation has important implications. It reveals that, even with a single price change, the calculation of the Marshallian consumer surplus will not be an exact measure of welfare change unless the restricted assumption of constant marginal utility of income for *all* prices and income can be accepted. However, as Samuelson (1942)

proved, this assumption is impossible and thus it indicates that unambiguous welfare analysis of income tax reforms can be only undertaken by making use of the Hicksian labour supply[5].

Another significant question in evaluating tax reforms concerns the efficiency gain (loss) attached to the reform. The answer to this question is the change in the deadweight loss (∇DWL) associated with the proposed tax reform. Since the excess burden of a tax reform is exclusively related to the substitution effect involved in the change, only the substitution effect component mentioned above must be taken into account in calculating the deadweight loss change. Thus, in an economy formed by n individuals the variation in the deadweight loss from a move from a distorting tax

$$\Delta DWL = - \sum_{i=1}^{n} EV_i(w) - (R^1 - R^0)$$

to another is given by

where R^0 and R^1 are original and post-reforms levels of total revenue. As figure 2(c)

$$\Delta DWL = \sum_{i=1}^{n} \int_{w_0}^{w_1} h_{l_i}(w, U_1)dw - (R^1 - R^0)$$

illustrates, [6] can be expressed in terms of the Hicksian labour supply as:

Once the change in the definition of tax unit had been defined and simulated, equations [3] and [6] will allow calculation of the equivalent variation and the

[5] For alternative interpretations of the constancy of the marginal utility of income, see Takayama (1994, p. 633-643).

deadweight loss change. Alternatively, they can also be calculated from the Hicksian labour supply by [5] and [7]. Moreover, the distributional consequences of the reform can also be evaluated by examining the distribution of EV among different types of individuals within the population (sample). Futhermore, as emphasised by King (1983), since these derived formulae are functions of parameters estimated econometrically, the covariance matrix of the parameter estimates allows construction of confidence intervals. This implies that instead of incorporating the error of the labour supply curve estimation into the approximation error, as suggested by Willig, we can calculate the precision of our estimated welfare measures.

Another popular measure of welfare change, although more primitive and unsophisticated, is the cash gain (CG). The main difference between CG and EV is that whereas the former restricts the taxpayer to supply, after the tax reform, the original (pre-reform) hours of work, the latter does not impose any restraint on the taxpayer's behaviour as she can adjust her labour supply in response to the tax reform. Namely, the cash gain represents the difference between the disposable incomes before and after the tax reform assuming no change in labour supply. As can be seen from figure 2(a), the cash gain is graphically depicted by the vertical distance between the pre-reform and post-reform budget constraints at A. Analytically, the cash gain is defined by

where y_1 and y_0 are, respectively, post-reform and pre-reform disposable incomes under the assumption of no behavioural response of the taxpayer. Dismissing behavioural reactions has given CG a bad reputation amongst welfare analysts.

However, we will also calculate the cash gain of the independent taxation scheme since, although it ignores behavioural responses, it captures the short-term impact of the reform before taxpayers have had time to adapt their behaviour to the tax change.

III. SPECIFICATION OF THE LABOUR SUPPLY FUNCTION

the functional form

The equations stated in the previous section imply that empirical estimates of the welfare gains (losses) and deadweight variations involve the estimation of a labour supply curve. In the context of this paper, choosing the functional form for the labour supply function requires the fulfilment of two meaningful features: tractability of the relevant functional forms and flexibility in the type of response it permits with respect to changes in the marginal net wage. The first of these two claims is due to the necessity of having a functional form tractable enough so that an explicit function of EV can be constructed by taking advantage of the duality theory. The second claim is needed in order not to force the estimated wage response of the labour supply to be closely restricted. Bearing these requirements in mind, our chosen functional form is a version of the quadratic labour supply function. Specifically, the

$$l_i = g + a\, w_i + b\, m_i + l\, w_i^2 + m\, z_i + e_i$$

labour supply function that will be used in our empirical estimation is of the form

where l_i denotes weekly hours of work, w_i represents the marginal net wage rate, m_i stands for the "virtual" non-labour income, z_i is a vector of socioeconomic variables and ε_i represents $N(0,\sigma_i^2)$ stochastic taste variation.

According to the application given to [9] in this paper, the major merit of the quadratic form is its tractability. As can be seen from table 2, the relevant functions needed to implement welfare analysis of the tax reform under examination can be obtained without too much difficulty. Moreover, since [9] is quadratic in w but linear in parameters, it is easy to estimate while, at the same time, it does not impose monotonicity on the labour supply with respect to the wage. Namely, it combines ease of estimation and flexibility in the relationship between labour supply and the wage. Finally, note that consistency of [9] with utility maximisation is easily checked by looking at the wage response of the compensated labour supply, which is required to be non-negative (i.e. $\alpha+2\lambda w-\beta l\geq 0$) [see Stern (1986)][6].

[6] This coherency condition is met by all the observations in the sample, both before and after the tax reform. Hence, the fulfilment of this condition implies that the underlying utility function is concave and thus coherent with utility maximization (Slutsky properties).

Table 2

Marshallian quadratic labour supply

$$l_i = g + a\, w_i + b\, m_i + l\, w_i^2 + m\, z_i + e_i$$

Relevant elasticities

$$(a + 2l\bar{w})\frac{\bar{w}}{\bar{l}}$$

Uncompensated own-wage elasticty:

$$b\bar{w}$$

Total income elasticity:

$$[\frac{a + 2l\bar{w}}{\bar{l}} - b\,]\,\bar{w}$$

Compensated own-wage elasticity:

relevant functional forms for welfare analysis

$$n(m,w) = e^{bw}\,[m - (aw^2 + bw - c)]$$

1. Indirect utility function:

$$m(w,U) = e^{-bw}\bar{U} + aw^2 + bw - c$$

2. Expenditure function:

$$h(w,U) = -b\,e^{-bw}\bar{U} + 2aw + b$$

3. Hicksian labour supply:

$$U(l,c) = e^{bw}\,[\frac{l + 2aw + b}{b}]$$

4. Direct utility function:

$$w(l,c) \_ aw^2 + (l + \frac{2a}{b} + b)w + (\frac{l+b}{b} - c) = 0$$

where

$$EV = e^{b(w_1 - w_0)}\,[m_1 - (aw_1^2 + bw_1 - c)] + aw_0^2 + bw_0 - c - m_0$$

5. Equivalent Variation:

$$m_e = e^{b(w_1 - w_0)} [m_1 - (aw_1^2 + bw_1 - c)] + aw_0^2 + bw_0 - c$$

6. Equivalent Income:

$$\Delta DWL = \sum\_ e^{w_{0i}} [m_{1_i} - (aw_{1_i}^2 + bw_{1_i} - c)] + a(w_{1_i}^2 - w_{0_i}^2) + b(w_{1_i} - w_{0_i})\_ - (R^1 - R^0)$$

7. Deadweight loss:

where coefficients *a*, *b* and *c* in 1 to 7are given by the following expressions:

$$a = -\frac{l}{b} \qquad b = [\frac{2l}{b^2} - \frac{a}{b}] \qquad c = \frac{g}{b} + \frac{2l}{b^3} + \frac{mz}{b} - \frac{a}{b^2}$$

the econometric estimation

Assuming, as we do here, that a tax reform is fully defined by its impact on taxpayer incomes and wages, implies that wages are independent of the individual's behaviour [see King (1983)]. This independency assumption is tantamount to admitting a linear budget line. However, the progressivity of the existing tax schedule shapes non-linear budget constraints. Therefore, to control for taxes we follow the familiar Hall's method (1973) which consists of linearising the budget constraint around the observed hours level by assuming that the taxpayer faces a linear budget constraint with slope equals to her marginal net wage and intercept (virtual income) obtained from a linear extrapolation of the budget set [for example, see Killingsworth (1983)].

In respect to the method of estimation, following Mzov's arguments (1987) Tobit estimation is disregarded and, instead, a Heckman Selectivity model (1979) is implemented. This is a two-step procedure in which the selectivity problem is treated as an omitted variable problem. The first step involves the estimation of the probability of being employed though the inverse Mill's ratio, λ, by using the estimates of a probit equation on the whole sample. The second step consists of inserting this estimated probability as an additional regressor in a OLS regression of the structural labour supply using, only the subsample of workers. By adding λ to our structural equation not only may we test for selectivity bias but we may also correct it in case it existed. Apart from correcting for self-selection bias, an additional advantage of this selectivity approach is its consistency with the existence of search and fixed cost associated with the participation decision. Namely, as long as the instrumental variables used to identify the probit equation are correlated with the costs of working, the Heckman model allows for the possibility that the labour supply schedule may be discontinuous.

Given that we are dealing with progressive income taxation, an additional complexity in the econometric estimation of our labour supply function stems from the potential endogeneity of marginal wages, non-labour income and hours of work. Accordingly, following Smith and Blundell (1986), appropiate reduced form residuals for wages and non-labour income are also included in the structural labour supply equation.Therefore, to sum, the parameters in equation [9] will be estimated by the following Selectivity Model:

$$y_i = L^* \quad if\ P > 0$$

$$y_i = 0 \quad otherwise$$

where L^* is the

structural equation of the labour supply and P is a latent relationship for the observability of y_i. Specifically, taking into account the description above, L* and P

are expressed by

$$P_i = k'q + v_i$$

$$L_i^* = E(L_i | w_i, m_i, z_i, L_i > 0) + a_l l_i + a_w e_{w_i} + a_m e_{m_i} + u_i$$

where q is a vector of variables affecting labour force participation, E(·) is the expected value of equation [9] when $L_i>0$, ε_{wi} and ε_{mi} are, respectively, the reduced form residuals for wage and non-labour income and λ is the predicted selectivity correction term defined by $\lambda=\phi(k'q)/\Phi(k'q)$, where $\Phi(\cdot)$ indicates the probability of participation and $\phi(\cdot)$ is the corresponding density function. Moreover, joint normality of v_i and u_i is assumed.

IV. THE DATA AND THE VARIABLES

the data set used

The sample of married women used for the empirical work described in this paper is drawn from the Family Expenditure Survey for 1989 (FES 1989). The reason for taking 1989 as the reference year stems from the fact that 1989 was the last year in which the dependent taxation scheme was applied. Therefore, it seems sensible to regard it as the appropiate benchmark to estimate the labour supply as well as the welfare effects induced by the introduction of the independent taxation. In order to reduce to a minimum the complexity of tax and benefit rules to be considered, this paper exclusively focuses on non-pensioner households formed of women married to males in which both spouses are in working age range. Moreover, as households where the husband is out of work might imply wife's marginal tax rates close to, or even above, 100%, only households with employed husbands were selected[7]. This selection procedure resulted in a final sample with 3043 observations in which 2092 were working women with the remainder being out of work.

[7] This consideration is due to the fact that households where the husband is out of work would qualify for means-tested benefits which could be removed when the wife participates in the labour market. Futhermore, the risk of incorporating selection bias by eliminating unemployed husbands is small since the vast majority of married men work. Only 5% of the original sample of married women was eliminated for this reason.

variable description

Table 3 presents the legend to the variable names. It also shows the mean values, according to work status, for the variables used in the estimation of the labour supply model described in section III. Our measure of the supply of labour is given by the reported hours worked per week (Ushours). In order to get the tax variables, as mentioned above, Hall's procedure was implemented. This procedure

$$netwg89 = w_g(1-t)$$

gives a marginal net wage (netwg89) equal to

$$VINC89 = m_g + t\,w_g\,L - T$$

and a virtual non-labour income (VINC89) equal to

where m_g, t, L, T and w_g represent, respectively, the gross non-labour income, the marginal tax rate on labour income, the actual labour supply, the total tax liability and the individual's gross wage rate. In defining how household resources affect wife's labour behaviour the male *chauvinist* model is assumed. This means that, in making her labour supply decisions, the wife views her husband's earnings as part of her non-labour income. Thus, under the male *chauvinist* framework, the property income, m_g, relevant to the wife's labour supply includes not only her non-labour income but also her husband's net earnings [see Killingsworth (1983,p. 29)]. The tax variables, t and T, are obtained by simulating the tax code in 1989 in our sample. The gross wage is the hourly gross wage rate obtained by dividing the reported weekly earnings by the hours worked per week. However, as discussed above, this wage

rate is known only for those working. Therefore, for those out of work, an estimate of their potential wage rate is calculated by following the procedure described in section III.

Table 3

Acronym	Variable description	Mean value		
		All	Working	Non-Working
Ushours	hours worked per week	18.35	26.70	0
netwg89	net wage per week in 1989	2.80	2.86	0 (2.66)**
netwg892	square of net wage per week in 1989	10.34	11.57	0 (7.63)**
VINC89	virtual non-labour income in 1989 (weekly)	254.57	254.35	255.05
Sch	years of schooling	11.31	11.40	11.11
Sch2	square of years of schooling	132.70	134.42	128.93
Exp2	years of job experience	18.44	18.77	17.70
Exp22	square of years of job experience	496.18	495.46	497.76
KIDS02	number of children aged between 0-2	0.15	0.07	0.30
KIDS25	number of children aged between 2-5	0.20	0.14	0.34
KIDS518	number of children aged between 5-18	0.77	0.77	0.78
Others	number of other members of the household	0.26	0.28	0.23
agewife	age of the wife (in years)	38.91	39.19	38.31
agewife2	square of the age of the wife	1617.41	1629.88	1589.97
SICK*	health state (presence of illness)	0.02	0.0005	0.06
Area1*	Greater London	0.10	0.10	0.09
Area2*	Metropolitan districts and Central Clydeside Conurbation	0.21	0.21	0.21
Area3*	areas with 7.9 or more persons per hectare	0.21	0.20	0.22
Area4*	areas with 2.2 but less than 7.9 persons per hectare	0.22	0.22	0.21
Area5*	areas with less than 2.2 persons per hectare	0.26	0.26	0.26

* Dummy variables 0/1 (1 when the characteristic applies to the observation, 0 otherwise).

** Number in parentheses indicates estimated value.

Moreover, since the presence and age of children seem to be significant variables in determining married woman's labour supply decisions the variables KIDS02, KIDS25 and KIDS518 have been also included in the specification of the estimated equations. KIDS02, KIDS25 and KIDS518 represent the number of children in the household in each of the age groups 0-2, 2-5 and 5-18. In addition, the presence of other members of the household excluded from the concept of family

(defined as parents and children) is accommodated by the variable *Others*.

In order to incorporate the individual's capacities and skills into the specification of our model, human-capital variables such as schooling (Sch) and job experience (Exp2) have been considered. *Sch* is defined as age left school minus five, whereas Exp2 has been adjusted in order to take into consideration the effects of children on wife's experience. Specifically, following Lambert (1993), our measure

$$\text{Exp}2 = age - ageleftschool - K$$

of experience is given by

where K measures the wife's average amount of time spent out of the labour market

$$K = a_1 KIDS02 + a_2(1.5)KIDS25 + a_1(2)KIDS25 + a_3(6.5)KIDS518 + a_1(2)KIDS5$$

due to children. Taking into account our children's age groups, K is given by

where a_i represents the proportion of women with children in each of the age brackets 0-2, 2-5 and 5-18 who did not participate in the labour market. Finally, the age of the wife (agewife) and dummies such as *SICK* and $Area_i$ have been also incorporated in the vector of socio-economic variables.

IV. THE ESTIMATION RESULTS

The results of the estimation procedure described in the previous section are presented and commented on here. As explained above, the Heckman model entails

two stages. Firstly, to fit a probit on the whole sample to form a measure of the inverse Mill's ratio, λ, for each observation. Secondly, with workers only, to use data on λ and on factors affecting the supply of work to estimate, via selection bias-corrected regression, the parameters of an hours-worked equation. Moreover, the probit in the first stage of this process is not only useful to form λ but also to asess the labour market participation decisions of British married women. Table 4 below displays the maximum likelihood estimates of the probit for participation rates. In order to interpret the output of this probit, the marginal effects of each regressor have been calculated at the point of means. Note that the T-statistics (third column) are evaluated at a confidence level of 95 percent.

On the basis of these results, the participation decision can be summarized as follows. The variables *Others*, *Sch2*, *ageSch* and the regional dummies ($Area_i$) are the only variables which are statistically insignificant with respect to the participation decision. The rest of the regressors are highly significant in explaining participation and they are of the expected sign and magnitude. Given a significant test, the likelihood of participation increases with the level of the educational attainment and age of the wife and decreases with the number of children, non-labour income and poor health.

Table 4

(Maximum likelihood estimation of the probit model for participation)

regressor	Parameter	T-statistic	Marginal effect (%)*
Constant	-2.25505	-2.924	******
VINC89	-0.00046	-2.496	-0.016
KIDS02	-1.12296	-14.627	-39.16
KIDS25	-0.60532	-10.730	-21.11
KIDS518	-0.16927	-5.799	-5.90
Others	-0.00720	-0.151	-0.25
agewife	0.13680	5.049	4.77
agewife2	-0.00168	-6.074	-0.059
Sch	0.17607	2.689	6.14
Sch2	-0.00252	-1.352	-0.088
ageSch	-0.00179	-1.508	-0.062
SICK	-2.8430	-6.651	-70.56
Area2	-0.10403	-1.031	-3.68
Area3	-0.12798	-1.272	-4.54
Area4	-0.10308	-1.033	-3.65
Area5	-0.13769	-1.409	-4.88
Log Likelihood = -1600.33			Model chi2(15) = 579.37
Number of obs = 3043			Prob > chi2 = 0.0000
Number of iterations = 5		Pseudo R2 = 0.1533	

*This column reports the change in the probability for an infinitesimal change in each independent variable (x_i). If the regressor is a continuous

$$\frac{\partial \Phi(\bar{x}b)}{\partial} = f(\bar{x}b)b_i$$

variable the marginal effect is given by the height of the normal density, at means of independet variables, multiplied by the corresponding coefficient (b_i); that is
For dummy variables, instead, the change in probability is discrete from 0 to 1.

If we pay attention to the marginal effects of each of the significant variables, it can be seen that whereas the marginal influence of non-labour income and the square of the age of the wife are negligible, the influence of the number and age of children, the level of education and the state of health induce a powerful marginal effect on participation.The strong impact of having poor health is remarkable (-70.56%). The number and age of children also have an important influence. For instance, the marginal effect of having kids under two years is -39.16%, suggesting that a married

woman having an extra child would induce, holding the other regressors constant, a decrease in her probability of participation of about 39%. Likewise, the marginal effect due to children aged between two and five and between five and eighteen years old is, respectively, -21.11% and -5.90%. These results hint that, the wife's likelihood to participate in the labour market will increase as the children get older, other things remaining constant. As far as education is concerned, its marginal effect indicates that for each extra year spent at school, a British married woman increases, on average, her chance of participation approximately by 6%. In respect of age, as can be seen, its marginal effect is positive and also relatively high (4.77%).

On the other hand, under the setting of this paper, carrying out welfare analysis requires complete information on wages. Nevertheless, our sample includes non-workers for whom wage information is not available. To tackle this difficulty, a predicted wage for non-working individuals has been created by using the wage information of those reported as workers. In order to account for potential sample selection bias, the inverse Mill's ratio derived from the probit model has been retrieved and included as an additional regressor in the marginal wage equation. The estimation of this equation is presented in table 5:

Table 5

(Heckman estimation for marginal wages with correction for selectivity bias)

regressor	Parameter	T-statistic	
constant	-1.183507	-4.362	
Sch	0.305533	15.795	
Exp2	0.053068	4.258	
Exp22	-0.000967	-3.479	
λ (inverse Mill's ratio)	0.115807	64 .664	
Log Likelihood = -5710.98			Model chi2(18) = 580.66
Number of obs = 3043			Prob > chi2 = 0.0000

According to these results, all coefficients in the wage equation are highly significant. The schooling coefficient provides a high estimate of the rate of return to education (30.55%). Moreover, the quadratic experience terms, the experience itself (*Exp2*) and its square (*Exp22*), whose coefficients are respectively positive and negative, confirm the concavity of the experience-earning profile as suggested by human capital theory. Likewise, it is also noteworthy that the coefficient of the inverse Mill's ratio is notably high, suggesting the presence of sample-selection bias. The estimates exhibited in table 5 have been used to predict non-workers' marginal wages.

Finally, in order to obtain the required coefficients to implement welfare analysis, the labour supply function has been estimated. Table 6 shows the results of this estimation:

Table 6

(Heckman estimation for hours of work with correction for selectivity bias and endogeneity)

regressor	Parameter	T-statistic
constant	34.93947	18.767
VINC89	-0.02288	-6.032
netwg89	10.92619	15.868
netwg892	-0.02414	-2.413
KIDS02	-6.27377	-4.762
KIDS25	-7.89070	-9.896
KIDS518	-3.09478	-9.789
Sch	-2.17753	-9.593
Exp2	-0.275563	-9.424
Residw (reduced-form res.)	-11.02641	-15.794
Residm (reduced-form res.)	0.013643	3.207
λ (inverse Mill's ratio)	2.0789648	1.446
Log Likelihood = -9493.89		Model chi2(26) = 587.25
Number of obs = 3043		Prob > chi2 = 0.0000

On the basis of the preceding results, all the regressors but the inverse Mill's ratio are significant in affecting hours of work. The no significance of λ indicates that the null hypothesis that there is no self-selection is not rejected. On the contrary, the significance of the reduced-form residual coefficients indicates that econometric procedures which do not take into account the endogeneity problem of both wages and non-labour income will result in biased parameter estimates . Moreover, the negative sign of the virtual non-labour income parameter reflects that leisure is a normal good. Additionally, in the same way as on participation, the marginal effects due to the number and age of children, represented now by their coefficients themselves, induces a negative influence on the quantity of worked hours. However, the absolute value of these marginal effects is clearly more reduced than that of those on participation. This result suggests that while the number and age of

children limit strongly the British wives' participation in the labour market, once they decide to participate, the number of children (at any age) does not restrict the supplied hours that much.

With respect to the marginal wage, its coefficient is positive and highly significant, stressing the fact that British wives' labour supply is intensively affected by this variable. To confirm this fact, table 7 below presents the breakdown of the total wage elasticity into the income and substitution effects. These figures imply that British married women's labour supply reactions are coherent with what is expected. On the one hand, the negative, although small, income elasticity ensures that leisure is a normal good. On the other hand, the strong substitution effect denotes that married women tend to react heavily to marginal wage changes.

Table 7

Uncompensated wage elasticity (Total effect)	Compensated wage elasticity (Substitution effect)	Income elasticity (Income effect)
1.649	1.713	-0.064

*Elasticities at point of means

V.IMPLICATIONS OF THE REFORM

The results exhibited in the preceding section support the suitability of exploring the welfare implications on British married women derived from tax reforms which induce changes in marginal tax rates. According to the analysis presented in this paper, table 8 depicts the impact of the removal of the dependent taxation scheme on the well-being of British wives. The referred table contains information on the changes induced on the labour supply together with information on cash

gains and EV. The total deadweight loss caused by the reform is also reported[8]. Moreover, the summary table not only contains the main statistics for the whole sample but it also encloses the distribution of gains and losses within groups of original worked hours and gross income deciles.Using microdata has allowed us to carry out the examination of the distributional impact of the reform by determining who are the gainers and who are the losers. As stated by King (1983), this is precisely one of the main advantages of using individual household data sets.

Table 8

(Summary of labour-supply changes and welfare effects of the reform on British married women)

OVERALL EFFECTS

	Change hours		**Cash gain**	**EV**					**∇DWL**	
	AB*	RE*	Mean	Total	Mean	dispersion**	SE***	Losers(%)	Total	(%)****
Whole sample	3174	5.68%	0.51	25513.1	8.38	16.84	0.2455	47.00%	-29013.6	-10.61%
non-workers	284	*****	2.93	26083.1	27.43	26.06	0.8893	0.007%	********	********
workers	2890	5.17%	-0.58	-570.0	-0.27	4.89	0.0453	68.02%	********	*********

DISTRIBUTION BY RANGE OF ORIGINAL WORKED HOURS (WEEKLY)

	Change hours		**Cash gain**	**EV**				
RANGE	AB*	RE*	Mean	Total	Mean	dispersion**	SE***	Losers(%)
1 - 10	1340.4	74.4%	1.88	1236.4	4.95	6.94	0.1061	22.8%
11 - 15	435.5	15.6%	0.43	374.4	1.83	3.75	0.0792	43.1%
16 - 20	326.7	4.9%	-1.68	-482.8	-1.36	2.38	0.0447	83.7%
21 - 25	210.2	4.6%	-1.49	-257.9	-1.31	3.50	0.0568	82.2%
26 - 30	85.6	1.8%	-1.78	-444.4	-2.73	3.75	0.0286	85.3%
31 - 35	174.3	2.4%	-0.51	-23.0	- 0.11	6.59	0.0422	69.8%
36 - 40	338.5	1.4%	-1.02	-906.1	-1.44	5.09	0.0338	77.9%
>40	-21	-0.005%	1.95	-66.6	-0.84	6.60	0.0048	50.6%

[8] Due to the lack of a programmed microsimulation model, the behavioural reactions have been simulated by assuming a fixed random term in the labour supply function for each observation. This procedure is just an approximation and must be taken with caution since, as is known, the effects of tax changes on labour supply should not be predicted only from the use of labour supply estimates.

DISTRIBUTION BY DECILES OF ORIGINAL TOTAL GROSS INCOME (WEEKLY STERLING POUNDS)

	Change hours		Cash gain		EV			
DECILES	AB*	RE*	Mean	Total	Mean	dispersion**	SE***	Losers(%)
Decile 1 258.2	15.7%	1.22	2902.4	9.55	14.57	0.2904	6.6%	
Decile 2 247.5	7.2%	0.75	3346.4	10.97	16.79	0.3459	32.8%	
Decile 3 230	5.3%	0.17	2841.9	9.38	16.64	0.2870	45.2%	
Decile 4 238.9	4.6%	-0.26	2062.8	6.76	15.82	0.2089	51.1%	
Decile 5 131.3	2.3%	-1.20	1653.5	5.44	15.77	0.1849	65.5%	
Decile 6 114.9	1.8%	-1.36	1129.8	3.72	14.52	0.1405	65.1%	
Decile 7 134.3	2.0%	-1.44	810.2	2.66	13.57	0.1286	71.5%	
Decile 8 70.6	0.01%	-1.67	1593.3	5.22	16.57	0.1748	76.4%	
Decile 9 1164.9	15.54%	1.79	3928.8	12.97	31.12	0.4890	41.9%	
Decile 10	583.6	7.71%	7.13	5244.0	17.19	31.70	0.5884	13.8%

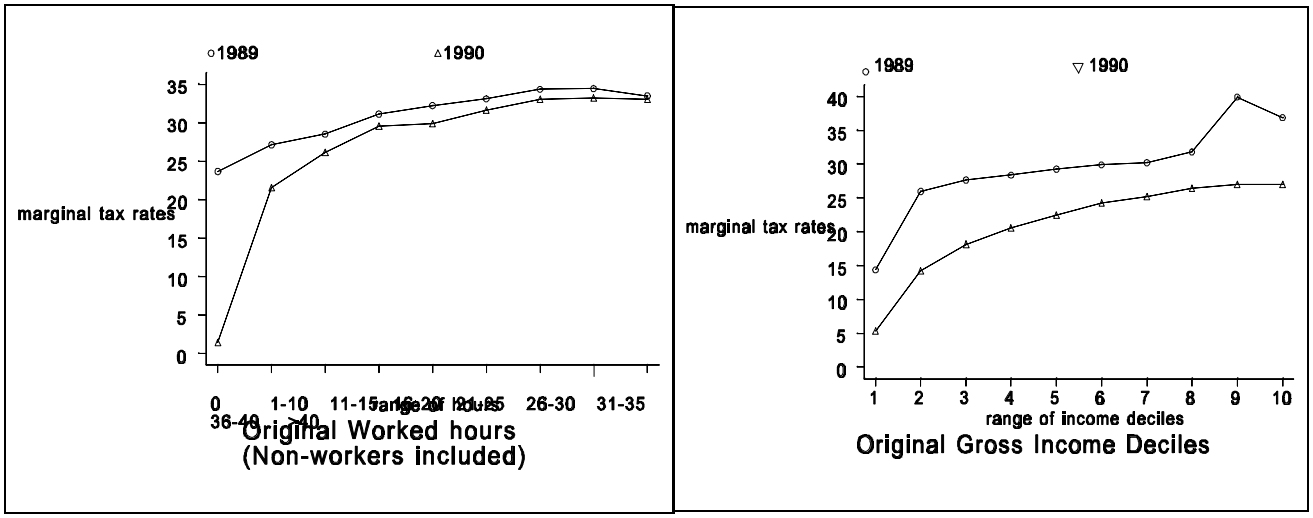
* AB represents the absolute increase in hours worked in 1990 in comparison with 1989. RE expresses the same change but in percentage. Both AB and RE are calculated in weekly terms.
**The measure of variability included in this column is the quartile deviation, defined as the interquartile range divided by 2.
***This column contains the standard errors (SE) for EV. The computation of the ES is based on the covariance matrix of the parameters and the vector of the first derivatives of the EV with respect to the regressors included in the labour supply function.
**** This figure is the ratio of the deadweight loss with respect to the tax collected under dependent taxation.

V.1 Changes in the labour supply

If we focus on the change of labour supply (first two columns), it can be seen that, on average, the reform increases the weekly supply of work by 3.174 hours, corresponding to 5.68% of the labour supply before the reform. This increase in the number of hours of work is not only due to those already working before the reform (increased by 2890 hours) but also to the incorporation into the labour market of non-workers (increased by 284 hours). Futhermore, the distribution of this change by original worked hours indicates that those women working less than 15 hours per week are the taxpayers who increase their labour supply more intensively, particularly non-workers and wives in the 1-10 range. This is an interesting result, because such an impact is precisely the type of effect this reform was designed to have, i.e. to stimulate participation of wives in the labour market. It is also noteworthy that women working over 40 hours per week are the only ones who reduce their

supply of working time after the reform. Likewise, labour supply reactions by income class also suggest that both wives in the lower-income deciles (first and second) and wives in highest income groups (ninth and tenth deciles) tend to work more hours than those wives in the intermediate deciles. As figure 3 shows, these results are in accordance with the change in marginal tax rates derived from the reform.

FIGURE 3
(Marginal tax rate patterns before and after the reform taking into account behavioural responses)



V.2 The welfare assessment

With regard to cash gains and EV, the first thing to note is that the cash gain underestimates the gains obtained from the reform. This fact emphasizes the necessity of taking into account behavioural reactions. That is, for evaluating the efficiency gains/losses involved in the removal of the dependent taxation the EV is superior to cash gains. Therefore, the discussion that follows is centred around the EV. For the EV, we have computed the total

and mean values as well as the quartile deviation (dispersion) and standard errors (ES). These ES are of great importance in policy analysis since they permit analysts to work out confidence intervals for the calculated EV. Namely, we learn about both the magnitude of the welfare measure and the error made in its calculation. Now, based on table 8, a distributional examination of the induced welfare effects of the reform follows.

The overall effects

As shown in table 8, both the total and mean EV per week are positive: the overall EV amounts to £ 25.513,1 and the mean EV reaches £ 8,38. Moreover, the majority of the wives gain from the reform (53%). Despite this, the differences between workers and non-workers are remarkable: whereas the preponderance of workers lose (68.02%), virtually every non-worker gains. That is to say, on average, non-workers constitute the taxpayer group that benefits the most from the reform (their mean EV gets to £ 27.43 p.w.). In addition, the reduction in the total deadweight loss (last column) is important, £ 29.013,6 p.w., which represents about 11% of the tax revenue collected before the reform.

Effects by worked hours

Turning to the distribution of EV by worked hours, we observe that women working less than 15 hours a week get, on an average, a positive EV. In the same manner, these part-time workers belong to the brackets in which the number of gainers exceeds the number of losers. On the contrary, for brackets over 15 hours the aggregate welfare change is negative and the losers outnumber the gainers, particularly for those working between 26 and 30

hours. In other words, we can conclude that the move towards independent taxation has favoured part-time workers working a few hours a week.

Effects by income deciles

As far as income distribution is concerned, the overall EV is highly positive for every income group. However, the gains are not equally distributed among deciles: whereas the mean EV for intermediate deciles moves from £2.66 to £6.76 per week, the bottom three deciles and the top two deciles obtain a mean EV that is above £9, getting even to £17.19 as is the case of the last decile. Thus, on these grounds lower-income groups and highest-income recipients benefit much more from the reform than the average.

To confirm this prediction and to give a flavour of the variability in the distribution of gains a losses within income deciles, a set of charts has been depicted in figure 4. In chart1, the vertical lines connect the tenth and the ninth percentiles of the distribution of the EV within each decile. From this picture, it is clear that the EV in the top two deciles spread over a bigger range than in the rest of the income groups. In addition, chart 2 depicts the median and mean EV for each income decile. On the one hand, the line connecting the means gives an impression of the vertical redistribution between income groups. Again, this picture proves that the income groups in the extremes end up in a better position than intermediate income recipients. On the other hand, the line for the medians illustrates the popularity of the reform, indicating that the income recipients in the 4-8 deciles will be against the reform while those in the remaining deciles will support it. Finally, charts 3 and 4 show a box-plot and a scatter-

box plot for the EV. This type of graphs gives a quick impression of prominent features of the EV distribution[9]. As can be seen, with the only exception of the sixth, seventh and eighth deciles, the interquartiles lie well above the zero-EV-line. Moreover, from the sixth decile on, the numerous high outliers reflect a positive skew of the distribution of the EV in these income groups, implying the presence of observations with extremely high gains.

[FIGURE 4 APPROXIMATELY HERE]

[9] A box-plot displays information about center, spread, symmetry and outliers in the distribution: the lenght of the box represents the interquartile range, the horizontal line within the box indicates the median and the vertical lines coming out from the box express how stretched the tails of the distribution are. Moreover, the individual points beyond the vertical lines show the outliers (observations that lie beyond 1.5 times the interquartile range).

CONCLUSIONS

This paper has described the way labour supply models can be used to implement welfare analysis within personal income tax reforms. As an empirical illustration, we have assessed the allocative and redistributive effects on British wives of the independent taxation scheme taking into account behavioural responses. The analysis has been covered by using Hausman and King´s seminal contributions. To implement this procedure, we have estimated a quadratic labour supply in order to obtain the required parameters to construct the explicit functions for the equivalent variation and the deadweight loss.

The main effects of the recent move towards the individual in the definition of the taxable unit can be briefly summarized as follows. Firstly, the tax reform has increased wives' labour supply significantly. Particularly, for non-workers and part-time workers. Secondly, the reform has reduced the excess burden by inducing, in aggregate terms, apparent welfare gains for married women. However, distributional assesment of the EV by income class and labour status has shown that both gains and losses have been distributed very unequally among households. Finally, it is important to note that, in line with other tax reforms undertaken in recent times, the new definition of the taxable unit has been influenced by the desire to minimise tax-induced distorsions and to improve the role of markets in allocating resources.

Appendix 1

Table 1[10]

1989 (Dependent taxation)	1990 (Independent taxation)
Tax Schedule 25% if taxable income ≤ £ 20.700 per annum 40% if taxable income > £ 20.700 per annum	
* Allowances*: -Married man's allowance: £ 4.375 p.a. -Wife's earned income: £ 2.785 p.a. person's allowance: £ 2.785 p.a-single	* Allowances**: -Married couple's allowance: £ 3005 p.a. - Personal allowance: £ 1.720 p.a.
National Insurance Contributions*** less than £42 0% from £42 to £73.99 5% from £74 to £113.99 7% from £114 to £323.99 9% 0ver £324 0%	

* The married man´s allowance is that for a full year. The wife´s earned income allowance has as its maximum value the amount shown. In the case that the earnings are less, the allowance is reduced to the actual amount of earned income. Both the married man´s allowance and the wife´s allowance are untransferable.

** Under independent taxation, every individual taxpayer is entilted to a personal allowance which can be set against any type of income. If the net income is less than the allowance, the personal allowance is reduced to the actual amount of total net income. The unused remainder of the personal allowance can not be transferred to any other taxpayer. Moreover, under this setting, married men can claim the married couple´s allowance in addition to his personal allowance. However, in this case, if the husband´s total income is too small to use the whole of the married couple´s allowance the unused part of it is allowed to be transferred to his wife.

*** To isolate the effects due to independent taxation, the National Insurance Contributions for 1989 have been assumed to be applicable for 1990. Therefore, the results presented in this paper are exclusively associated to the change in the definition of the tax unit (i.e. the move from dependent taxation to independent taxation).

[10] Our interest is households consisting of working age couples in which a working or non-working wife is married to an employed male. On these grounds, the content of this table refers only to this type of taxpayer.

References

Apostol, T.M. (1957): *Mathematical Analysis* (Addison-Wesley).

Dupuit, J. (1844): 1969, <<On the measurement of the utility of public works>>, in: K.J. Arrow and T. Satovsky, eds., *Readings in welfare economics* (Trans. R.H. Barback) 255-283.

Boadway, R.W. and N. Bruce (1984): *Welfare economics* (Basil Blackwell, New York).

Chipman, J.S. and J.C. Moore (1980): <<Compensating variation, consumer's surplus, and welfare>>, *The American Economic Review* 70, 933-949.

Hall, R.E. (1973): <<Wages, income and hours of work in the U.S. labor force>>, in: G.C. Cain and H.W. Watts, eds., *Income maintenance and labor supply*, (Chicago:Rand McNally) 102-162.

Hanemann, W.M. (1980): <<Measuring the worth of natural resource facilities: comment>>, *Land Economics* 56, 482-486.

Hausman, J. A. (1981): <<Exact consumer's surplus and deadweight loss>>, *The American Economic Review* 71, 662-676.

Heckman, J. (1979): <<Sample selection bias as a specification error>>, *Econometrica* 47, 153-161.

Hicks, J.R. (1939): *Value and capital* (Clarendon press, Oxford).

Keiser, H., U. van Essen and P.B. Spahn (1993): <<Income taxation and the supply of labour in west germany: a microeconometric analysis with special reference to the west german income tax reforms 1986-1990>>, in: A. Heimler and D. Meulders, eds., *Empirical approaches to fiscal policy modelling* (Chapman and Hall, London) 163-182.

Killingsworth, M. (1983): *Labor supply* (Cambridge University Press).

King, M.A. (1983): <<Welfare analysis of tax reforms using household data>>, *Journal of Public Economics* 21, 183-214.

Lambert, S.F. (1993): <<Labour market experience in female wage equations: does the experience measure matter?>>, *Applied Economics* 25, 1439-1449.

Marshall, A. (1920): *Principles of Economics* (Macmillan, London) 8th edition (1st edition in 1890).

Mas-Colell A., M.D. Whinston and J.R. Green (1995): *Microeconomic theory* (Oxford

University Press).

Mohring, H. (1971): <<Alternative welfare and loss measures>>, *Western Economic Journal* 9, 349-368.

Mroz, T.A. (1987): <<The sensitivity of an empirical model of married women's hours of work to economic and statistical assumptions>>, *Econometrica* 55, 765-799.

Samuelson, P.A. (1942): <<Constance of the marginal utility of income>>, in: O. Lange, F. McIntyre and T.O. Yatema, eds., *Studies in mathematical economics and econometrics: In memory of Henry Schultz* (University of Chicago Press) 75-91.

Smith, R.J. and R.W. Blundell (1986): <<An exogeneity test for a simultaneous equation tobit model with an application to labor supply>>, *Econometrica* 54, 679-685.

Stern, N. (1986): <<On the specification of labour supply functions>>, in: R. Blundell and I. Walker, eds., *Unemployment, search and labour supply* (University of Cambridge) 267-293.

Takayama, A. (1994): *Analytical methods in economics* (Harvester Wheatsheaf, Hertfordshire).

Varian, H.R. (1992): *Microeconomic analysis* (Norton and Company, third edition).

Willig, R.D. (1976): <<Consumer's surplus without apology>>, *The American Economic Review* 66, 589-597.