Family Labour Supply and Taxes in Ireland

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Abstract

We analyse the labour supply of husband and wife in Irish families. A static structural model is used. Account is taken of nonlinearities and nonconvexities in the tax-benefit system, of fixed costs of working, of unobserved preference variation across families, of prediction errors in wages of nonworkers and of potential endogeneity of gross wage rates. Moreover, the neoclassical model is extended such that information on involuntary unemployment is incorporated in a structural way. Smooth simulated maximum likelihood is used to estimate the model, using household data from 1987.

The Irish tax system is characterized by "income splitting" so that the tax liability of the couple depends essentially on the joint income of husband and wife. We analyse the sensitivity of husbands' and wives' labour supply with respect to the own wage, the partner's wage, and other income. We compare labour supply under the actual tax regime and under alternatives involving more independent taxation, and analyse the extent to which the tax system can explain the low participation of married women in Ireland.

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1. Introduction

The impact of tax and benefit systems on work incentives has been a key theme in policy debates on employment and unemployment in many industrialised countries. (See, for example, the recent Jobs Study (OECD, 1994)). The effects of taxes and benefits on labour supply has, correspondingly, been a continuing focus for applied work. The static neoclassical model of individual labour supply provides a starting point for much of this analysis. See, for example, the articles in Moffitt (1990) for several applications to European and US datasets, with the Hausman (1985) treatment of taxation providing the prototype model. Most such studies have focused on one or two extensions of that basic model, to deal with real-world complications such as the possible interactions of husbands' and wives' labour supplies; unemployment benefits; the existence of fixed costs of employment; involuntary unemployment and/or other institutional or demand-side constraints on hours worked.

In this paper, we deal simultaneously with several of these issues, arriving at a model which incorporates simultaneous and symmetric treatment of the labour supply of husband and wife; fixed costs of working; income taxes and unemployment benefits; and the existence of involuntary unemployment. The model is applied to data for Ireland from 1987, which are particularly suited to the analysis of issues concerning family labour supply, taxation and unemployment. The approach follows that in Van Soest (1995), but extends that model in two key areas: it makes use of information in the current dataset on involuntary unemployment; and it allows for the existence of fixed costs of working, instead of assuming specific costs or difficulties associated with part-time jobs.

The basic Hausman (1985) model deals with the dependence of the tax rate faced by a single individual on hours worked by considering the complete budget constraint facing that individual. A similar approach for couples can only be rationalised by an assumption that labour supply decisions are taken in some recursive fashion e.g., the husband decides first, without taking account of the wife's wage rate, and the wife decides conditionally upon her husband's labour supply and earnings. This approach implies that the wife's earnings capacity or employment opportunities do not affect the husband's labour supply decision. In this paper we avoid imposing these restrictions. Husband and wife are treated in a symmetric way, and their labour supply is modelled simultaneously. The natural extension of the individual model, is the model based on maximizing a joint utility function, with family consumer expenditures and the husband's and the wife's leisure as its arguments. We use this framework, following, for example, Hausman and Ruud (1984), Ransom (1987, 1989), and Kapteyn et al. (1990).

In all these models, hours worked by the two spouses are treated as mixed discrete and continuous random variables. First order conditions are used to derive leisure demand. This requires that second order conditions have to be satisfied, i.e. the utility function must be quasi-concave (cf. Van Soest et al. (1993) for an extensive discussion). Moreover, utility maximisation in this type of models becomes computationally intricate in case of nonstandard restrictions. Each generalisation of the budget set (nonlinear taxation, unemployment benefits, fixed costs, hours constraints) leads to new nonstandard problems. This limits the extent to which policy measures can be analysed.

Van Soest (1995) discusses advantages and drawbacks of the continuous models. He introduces a discrete family labour supply model, which avoids some drawbacks but shares the advantages of the continuous model. The main idea is that the choice set is assumed to be finite. The family chooses the alternative yielding highest utility by comparing a finite number of utilities. This does not require convexity conditions on budget set or preferences. The model is fully structural, so that all policy simulations with the continuous model remain feasible. The model analysed in this paper is a further improvement of the model in Van Soest (1995), incorporating a "double-hurdle" model of involuntary unemployment, and fixed costs of working.

The model is applied to data for Ireland from a 1987 Survey. Married women's participation in the paid labour market is much lower in Ireland than in many other industrialized countries. The harmonized EU Labour Force Survey shows that in 1987 about 29 per cent of married women in Ireland were "economically active" (working for pay or profit, or unemployed according to the standard ILO definition). This compared with an EU average of 42 per cent. The same source shows activity rates for married men in Ireland at 81 per cent, significantly above the EU average of 73 per cent.[1] For single men and women the Irish activity rates were very close to the EU averages. Part-time work is much less common in Ireland than in many EU countries. In 1986/7 about 6 per cent of total employment in Ireland was in part-time jobs - as against 10 to 25 per cent in France, Belgium, Germany, the UK, Denmark and the Netherlands (OECD, 1988). For women the contrast is still more striking: only 14 per cent of female employment was in part-time jobs, as against 23 to 45 per cent in these other countries.

Many factors are relevant to these contrasts: differences in fertility rates, national child care policies, differences in the nature of labour demand and so on. In this paper, we focus on the possible role of the Irish income tax and social security/welfare systems in shaping the patterns of labour market participation observed. Under the Irish system, a married couple's income tax liability depends essentially on their joint income. This is often seen as a disincentive for female labour market participation. After a small "earned income allowance" the marginal tax rate on the initial earnings of the wife is equal to the marginal tax rate on the last pound earned by the (usually full-time working) husband. In the case of fully independent taxation, the average tax rate facing many women considering a job in the paid labour market would be much smaller. Changing from joint to independent

[1] While this partly reflects high participation among married men over the age of 65, higher than average participation rates (including those who are unemployed) are also recorded for all other age groups.

taxation thus might lead to increased participation by married women.

Several OECD countries have taxation systems based on the family unit, rather than the individual - including France and Germany - while others, including the US, have systems of "joint filing" which can have similar implications for labour supply. The OECD Jobs Study suggests that a shift towards independent taxation could yield large gains in terms of increased labour market flexibility. The Irish case is an interesting one in this context, as it combines a system of income-splitting with quite steeply progressive marginal tax rates (35, 48 and 58 per cent, in 1987). The extent to which labour supply of husband and wife depends on the tax system strongly depends on the sensitivity of labour supply with respect to wage rates and nonlabour income.[2] We develop a structural family labour supply model for Ireland, along the lines sketched earlier, from which these sensitivities may be derived. The estimates are used in a micro-simulation model to analyse labour supply under the actual Irish tax and benefits system and under an alternative involving more independent taxation.

The paper is organised as follows. A brief description of the theoretical model is presented in section 2. In section 3 we describe the data. Section 4 describes the main features of the Irish tax and benefits system. In section 5, we present the estimation results. Section 6 contains the results of some micro-simulations, leading to policy conclusions about the effect of taxes and benefits. Conclusions are drawn in section 7.

2. The Structural Model

Basic Model

This sub-section outlines the discrete choice model of family labour supply introduced by Van Soest (1995). Extensions to deal with fixed costs of working and involuntary unemployment are dealt with in the following sub-sections. The family decides on income (y), male leisure (l_m), and female leisure (l_f). The framework is static, savings and intertemporal consumption smoothing are not taken into account.[3] Leisure is related to working hours (h_m,h_f) through the relations l_m=TE-h_m and l_f=TE-h_f. Here TE is the time endowment, set equal to 80 hours per week. We assume that the family operates as a single decision unit and maximises a direct translog utility function:

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[2] Blomquist (1988) shows that both the wage and the nonlabour income elasticities can matter for the effect of a tax reform, depending on the exact nature of the reform.

[3] Replacing income by consumption expenditures, would make the model consistent with a life cycle framework (cf. Blundell and Walker, 1986). Since the data contain no information on expenditures or savings, this approach could not be followed.

$$U(v) = v'Av + b'v \tag{1}$$

Here $v=(\log y, \log l_m, \log l_f)'$, the vector of logs of quantities. A is a symmetric 3x3 matrix with entries A_{ij} (i,j=1,2,3), and $b=(b_1,b_2,b_3)'$. Preference variation across families through observed and unobserved characteristics is incorporated as follows (the index indicating the family is suppressed):

$$b_i = \Sigma_k \beta_{ik} x_k + \varepsilon_k^r, \quad i=2,3, \tag{2}$$

where x is a vector of family characteristics, such as family composition or age. The error terms ε_k^r represent random preferences and are assumed to follow a normal distribution with mean zero.

We assume that the family always chooses a point at the edge of its budget set, i.e., for relevant values of (y,l_m,l_f), U is increasing with y. In that case, it is easy to derive a necessary and sufficient condition for quasi-concavity of preferences. Imposing quasi-concavity a priori however, is neither required for the statistical model, nor for its economic interpretation. We shall check ex post whether quasi-concavity is violated.

Before tax hourly wage rates w_m and w_f are assumed not to depend on hours worked. To each individual corresponds one wage rate. Thus, once l_m and l_f are chosen, after tax income y is completely determined by w_m and w_f and the tax and benefits system. The rules of this system vary with family composition, assumed to be exogenous. A description of the main features of the Irish tax and benefits system, is given in section 4. We denote after tax income, for given leisure, wage rates and family composition, by $y=\mathrm{Inc}(l_m,l_f; w_m,w_f,x)$.

In the standard continuous model (e.g. Hausman and Ruud, 1984), the family solves the problem

$$\mathrm{Max}\ U(y,l_m,l_f) \text{ s.t. } y \le \mathrm{Inc}(l_m,l_f;w_m,w_f,x),\ l_m \le TE,\ l_f \le TE$$

If U increases in y, this can be rewritten as

$$\mathrm{Max}\ U(\mathrm{Inc}(l_m,l_f;w_m,w_f,x),l_m,l_f) \text{ s.t. } l_m \le TE,\ l_f \le TE. \tag{3}$$

(3) can be solved using Lagrange techniques. The complexity of the solution depends on the nature of the tax and benefits rules, i.e. the form of the budget set. For a system as complex as the Irish one, many regimes would have to be distinguished, and the approach is infeasible. Instead, we replace the budget set by a finite number of points on its edge. The family then solves:

$$\mathrm{Max}\ U(y,l_m,l_f) \text{ s.t. } (y,l_m,l_f) \in CS(w_m,w_f,x),$$

where the choice set is given by

$$CS(w_m, w_f, x) =$$

$$\{(y, TE-h_m, TE-h_f); h_m, h_f \in \{0, IL, \ldots, (m_{ind}-1)IL\}, y = Inc(l_m, l_f; w_m, w_f, x)\}$$

We thus only consider working hours per week which are multiples of a fixed interval length IL. The choice set contains $m_{fam}=m^2_{ind}$ points. In the data, most integer values of working hours between 1 and 60 are present, and IL=1 seems natural. To limit the computational burden however, we use IL=8 and m_{ind}=8. Observed hours are rounded to a multiple of 8 and censored at 56. The rounding error can be seen as a drawback of this approach. Van Soest (1995) however compares results for various values of m_{ind} and finds that differences are small.

Random disturbances are added to the utilities of all choice opportunities $j=1,\ldots,m_{fam}$ in the same way as in the multinomial logit model (Maddala, 1983):

$$U_j = U(y_j, l_{mj}, l_{fj}) + e_j, \ (j=1,\ldots,m_{fam})$$
$$e_j \sim EV(I) \ (j=1,\ldots,m_{fam}); \ e_j, j=1,m_{fam}, \text{ mutually independent} \qquad (4)$$

Here EV(I) denotes the type I extreme value distribution with cumulative probability function $Pr[e_j<t]=exp(-exp(-t))$ $(t \in \mathbb{R})$. We assume that the family chooses j for which U_j is largest. The probability that j is chosen is given by

$$Pr[U_j \geq U_k \text{ for all k}] = exp(U(y_j, l_{mj}, l_{fj})) / \Sigma_k \, exp(U(y_k, l_{mk}, l_{fk})) \qquad (5)$$

The e_j $(j=1,m_{fam})$ can be interpreted as unobserved alternative specific utility components or errors in perception of the alternatives' utilities. They cannot be interpreted as random preferences due to unobserved family characteristics. Random preferences are incorporated in (2).

Unobserved wage rates

Again, we follow Van Soest (1995). A feasible way to take account of problem that wages of nonworkers are unobserved is to consider the full model consisting of labour supply equations and wage equations. The (before tax) wage equations are given by

$$\log w_m = Z_m'\pi_m + u_m; \qquad \log w_f = Z_f'\pi_f + u_f \qquad (6)$$

Z_m and Z_f are vectors of individual characteristics, such as education level and potential experience (see Table A1). The errors u_m and u_f are assumed to be normally distributed with mean zero, independent of the regressors and of each other.

Fixed costs of working

To capture participation rates as well as the distribution of hours worked, it may be necessary to allow for more flexibility in the model. A structural way to achieve this is to incorporate fixed costs of working. In this respect, the model is different from Van Soest (1995). There, hours specific constants are introduced on an ad hoc basis in the utility function. These may reflect costs of finding a part-time job. Fixed costs have a more attractive economic interpretation, although they may not capture the details of the hours distribution as well as the hours specific constants.[4]

Fixed costs can be introduced in a natural way. In accordance with the logarithmic specification, fixed costs are specified as a fraction of income: instead of $U(y_j,l_{mj},l_{fj})$, we consider $U(y_j\exp\{-\delta_m FC_m-\delta_f FC_f\},l_{mj},l_{fj})$, where $\delta_m=1$ if $h_{mj}=TE-lm_j>0$ and $\delta_m=0$ if $h_{mj}=0$, and similarly for δ_f. FC_m and FC_f are specified as follows.

$$FC_i = \Sigma_k \gamma_{ik} x_k + u_i \quad (i=m,f) \tag{7}$$

where the u_i $(i=m,f)$ are assumed to be normally distributed with mean zero and independent of each other and of explanatory variables and other error terms in the model. If utility increases with income, fixed costs decrease the utility of working, thereby increasing the probability of nonparticipation. The fixed costs are fully incorporated in the structural model. Therefore, effects of wage, tax, or benefits changes on participation can easily be taken into account in the simulations. This is an important advantage compared to the model conditional upon participation (Blundell et al, 1992, for example).

A generalised double hurdle model

We now extend the model to take account of involuntary unemployment, so that we can use information on the desired employment status of nonworkers. To all nonworkers, a question has been asked on whether they would like to work or not (cf. section 3). We use this information to construct dummy variables I_m and I_f. $I_m=1$ if the husband is involuntary unemployed, $I_m=0$ if he is employed or has no desire to work. I_f is defined likewise for females.

We add separate equations to explain I_m and I_f. The extended model is a generalisation of the double hurdle model of Blundell et al. (1987). An individual is employed if two conditions are satisfied. First, desired labour supply, denoted by h_m^* or h_f^*, must be positive. This is the outcome of the labour supply model discussed so far. Second, he or she must not be hampered by other hurdles preventing employment. These are modelled by two additional equations:

[4]Another alternative would be the approach of Dickens and Lundberg (1993), who incorporate demand-side restrictions on hours worked explicitly, but this model requires strong assumptions for identification.

$I_i^* = V_i'\lambda_i + \varepsilon_i$; $I_i=1$ if $I_i^*>0$ and $h_i^*>0$; $I_i=0$ otherwise; $\varepsilon_i \sim N(0,1)$ $(i=m,f)$ (12)

The sign of I_i^* determines whether individual i will be involuntary unemployed if desired hours are positive. For people who desire to work ($h_i^*>0$), we know whether they have a job or not, so we know the sign of I_i^*. For those who are not interested in working ($h_i^*=0$, $I_i=0$), we do not know whether they would find a job if they desired one, so the sign of I_i^* is unknown. V_i is a vector of exogenous individual characteristics. We assume that the ε_i are independent of all regressors and of other errors in the model, and that ε_m and ε_f are independent. I_i therefore does not depend on the wage rate. We include age and education level in V_i, to account for the effect of productivity on involuntary unemployment. We assume that each individual takes account of involuntary unemployment of the spouse: if $I_f^*\leq 0$, the husband maximizes family utility subject to $h_f=0$, and vice versa. This leads to an adjustment of the choice set and the probabilities in (5) for the case that $I_m^*<0$ or $I_f^*<0$. See Appendix B for details.

Estimation and coherency

The standard model, without random preferences or fixed costs, can be estimated by maximum likelihood. For observed wages, the likelihood contribution follows from (5) if involuntary unemployment is not incorporated. Likelihood contributions of the model with involuntary unemployment are given in Appendix B. If wage rates are unobserved, they have to be integrated out using (6). This requires numerical integration in two dimensions. As we also use random preferences and fixed costs, four additional error terms have to be integrated out for all observations. To avoid four five or six dimensional numerical integration, we approximate the integral by a simulated mean. For each individual we take M drawings from the distribution of the error terms, and compute the average of the M likelihood values conditional on the drawings. This method is a special case of smooth simulated maximum likelihood. If M tends to infinity at a fast enough rate with the number of observations, this method gives consistent estimates and is asymptotically equivalent to maximum likelihood, see Gourieroux and Monfort (1993).

The probabilities in (5) are always well defined and positive, which is not changed by integrating out the unobserved error terms. Therefore, statistical coherency of the model is automatically guaranteed. In contrast to the continuous model imposing Slutsky conditions (quasiconcavity of the direct utility function) is not necessary (see for instance Van Soest et al., 1993). Ex post, it can be checked whether the utility function is quasiconcave. If it is not, this does not affect the economic interpretation of the model, because this does not rely on concavity. On the other hand, however, the utility function has to be increasing with net income. Otherwise, its economic interpretation would be lost. To impose this we penalize the loglikelihood for observations at which utility of a corresponding interior point of the budget set exceeds utility of the point on the edge.

3. Data and Sample Characteristics

The data were drawn from the ESRI's 1987 Survey of Income Distribution, Poverty and Usage of State Services - a nationwide stratified, clustered random sample drawn from the Electoral Register. The survey included information on labour force status, current and usual gross (i.e. pre-tax) pay, usual hours of work and details of other income.[5] Here we concentrate on married couples, where each partner is aged between 15 and 59, and neither partner is self-employed. This gives observations on 1266 families. For some individuals however, only an abbreviated questionnaire was completed, without information on the age of the wife at marriage, chronic illness dummies or (for those not at work) the information on search activity. We limit ourselves to the sample of 1001 families in which complete information on both partners is available. The means and standard deviations of the variables used in the analysis are set out in Table 1.

Sample employment rates for married men (69 per cent) and women (21 per cent) are not directly comparable with published participation rates from the national Labour Force Survey, which include a substantial element of self-employment and farming. For 53 per cent of the sample families the husband is the only paid worker, as against 5 per cent of cases in which the wife is the sole earner. Neither partner had a paid job in 26 per cent of cases, while both partners were in paid employment in 16 per cent of families.

Gross wage rates for the analysis are computed from usual gross pay per week and usual hours per week. Both include regular paid overtime. Less than 3 per cent of the male employees work fewer than 30 hours per week. By contrast, almost 40 per cent of the female employees fall into this category.

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[5] For a full description of the survey see Callan, Nolan *et al.* (1989).

Table 1: *Sample statistics*

Variable	*Description*	*Mean*	*S.D.*
AGEH	age of husband	40.82	9.63
AGEW	age of wife	38.60	9.40
AGEMARW	age of wife at marriage	22.86	3.92
TOWN	dummy: town 1500-10000	0.15	0.36
BIGTOWN	dummy : town 10000+	0.12	0.33
CITY	dummy : city borough	0.09	0.29
DUBLIN	dummy : Dublin	0.31	0.46
DILLNF	dummy: chronic illness, wife	0.14	0.34
DILLNM	dummy: chronic illness, husband	0.14	0.35
EDLEVM	education level, husband	3.80	2.27
EDLEVF	education level, wife	3.91	2.11
EUERM	unemployment rate @ husband's EDLEV	21.51	8.47
EUERF	unemployment rate @ wife's EDLEV	9.10	4.99
GOPENM	husband's gross occupational pension/week	0.95	11.3
GOPENF	wife's gross occupational pension/week	0	0
MGEINT	annual mortgage interest	608.97	929.33
NCAPY	net capital income per week	3.88	15.77
NCHCB	no. of children eligible for Child Benefit	2.10	1.56
PEXPH	potential experience, husband	24.96	10.24
PEXPW	potential experience, wife	22.67	9.90
RUERTW	regional unemployment rate	17.37	2.06
UHRSH	usual hours per week, husband	29.85	21.41
UHRSW	usual hours per week, wife	6.44	13.87
URBAN	dummy: urban area	0.52	0.50
UWAGEH	usual pre-tax wage per hour, husband	6.23	4.27
UWAGEW	usual pre-tax wage per hour, wife	4.52	2.72
WORKH	dummy: husband is employed	0.69	0.46
WORKW	dummy: wife is employed	0.21	0.41
YNG0_4	dummy: youngest child aged 0 to 4	0.41	0.49
YNG5_12	dummy: youngest child aged 5 to 12	0.29	0.45

The variables I_m and I_f, distinguishing involuntary unemployment from nonparticipation, are constructed from the answers to some questions on search activity and desired labour supply. These are coded and summarized in Table 2. Discouraged workers, i.e., those who are not looking for work but still want a part-time or full-time job, are categorized as involuntarily unemployed, along with those who are actually looking for work. Thus, I_m and I_f are set equal to one if the individual's answer is anything but zero. This comes closest to the ILO definition. It implies that 67 per cent of males without a job, and 21 per cent of females without a job, are involuntarily unemployed. The remainder of those without jobs - amounting to 10 per cent of all married men and 67 per cent of all married women in the sample - are interested in neither full-time nor part-time work.

Table 2: *Involuntary Unemployment*
Nonworkers only; percentage of all nonworkers

Value	*Description*	*Males*	*Females*
1	wants part-time job, discouraged	0.3	3.0
2	wants full-time job, discouraged	4.2	1.0
3	looking for a job, no specific info on search activity	12.9	2.9
4	searching: studied ads/ other search activity	21.7	4.8
5	searching: answered ads/ wrote to employers	27.5	3.3
0	none of the above	33.3	79.1
	total number of non-workers	309	792

4. Construction of Budget Sets: Taxes and Benefits

The basic budget set is constructed from information on gross hourly wage rates and non-labour incomes. The income tax system is quite closely modelled. In addition to the basic personal allowance, we take account of two smaller "earned income" allowances for employees, as well as tax relief on mortgage interest payments, the main deduction allowed. An exemption limit, somewhat above the basic allowances, and "marginal relief" for taxpayers just above that limit, are taken into account. The initial tax rate at the time of the survey was 35 per cent, which applied to the first £4,700 per annum, with a tax rate of 48 per cent applying to the next £2,800. A top rate of 58 per cent applied to income above these levels.

Married couples were entitled - irrespective of their labour force statuses - to double allowances and double rate bands, compared to a single person. Thus, their total tax liability depended essentially on their joint income, which was taxed as if each was a single person with half that income. Another way of expressing this structure is that the doubled allowances and rate bands pertaining to married couples are "fully transferable" between spouses.[6] The end result is that a potential second earner faces a marginal tax rate on initial earnings (in excess of the small "earned income allowances") which is the same as that on the last pound earned by the first earner.

A simpler approach was adopted to the modelling of social security entitlements. Under the actual system, an individual might be entitled to Unemployment Benefit (UB), if he or she had an adequate social insurance contribution record - something which would depend on the employment history. We ignore UB entitlements for two reasons. First, they depend on labour market history, and may therefore be correlated with time-persistent unobserved individual characteristics. Second, UB is of limited duration, so that ultimately an unemployed person must depend on Unemployment Assistance (UA). Given the static nature of the model, and the fact that most of the unemployed were long-term unemployed, it it will be the rate of UA for the long-term unemployed which is of greatest relevance to the

6 The "earned income" allowances were not transferable.

present analysis. If net family income from all other sources falls below this floor, then UA will bring the income back up to the safety-net level. While the actual system is considerably more complex than this representation, the simplified model captures the most important features of the system from a labour supply point of view: it provides a floor below which income cannot fall, and it imposes a high rate of benefit withdrawal.[7]

Some effects of this tax and benefit regime on the incentive to take up a job are illustrated in Table 3, which shows how the average tax rate on taking up a job depend on the circumstances of the spouse. If the spouse has zero or very low earnings, the income floor provided by UA comes into play. The pound-for-pound withdrawal of income under that system creates very high effective tax rates - close to 100% for a part-time job, and over 60% for a full-time job - on work at the average industrial wage. For those with partners in employment, UA is no longer relevant, but fully transferable allowances and rate bands mean that they face the full impact of the progressive tax rate structure. Effective tax rates of 60% can face those who are married to high-earning partners. Those with partners whose earnings are closer to average earnings can still face average effective tax rates of close to 50% on a full-time job at the average industrial wage.

Table 3 also illustrates the average effective tax rates for an alternative, fully independent tax system. Under this system, husband and wife would be taxed separately, with no transferability of allowances or of rate bands. With other tax policy parameters unchanged, this would generate additional tax revenue where husband and wife have different incomes. We estimate that for the sample of individuals used here, tax rates could be reduced by more than a quarter on a revenue-neutral basis (i.e., rates falling from 35, 48 and 58 per cent to 25.5, 36 and 43 per cent respectively). This revenue-neutral change would lead to sharp falls in the average effective tax rates facing potential second earners. For example, for someone married to an average earner, the effective tax rate on taking up a full-time job at average wages would fall from 46 to 28 per cent.

The two tax systems described thus far can be regarded as polar extremes. Many intermediate systems are also possible.[8] One which is often referred to as "independent taxation" can be regarded as deviating from the fully independent system by making "unused" allowances transferable between spouses.[9] We will

[7] In taking Unemployment Assistance as the floor to incomes for those in and out of employment, we ignore the potential entitlement of low-income employees with children to Family Income Supplement. The reason is that the estimated take-up rate of this benefit was below 30 per cent on a caseload basis (Callan, Nolan *et al.*, 1989).

[8] The actual system in Ireland is close to the French system. The alternative presented here is more similar to the Dutch and Danish systems. The present UK system represents an intermediate possibility.

[9] An alternative is to make all allowances fully transferable between spouses. This system is very similar to the quasi-independent system described here.

refer to this option as "quasi-independent taxation". The revenue-neutral tax rates for this system are about 31.5, 43.5, and 52.5 per cent. Again illustrative effective tax rates are shown in Table 3.

In most cases, effective rates for "independent taxation" are lower than those for "income splitting" while rates for "quasi-independent taxation" lie between these extremes. From the table we can see that quasi-independent taxation leads to a substantial reduction in the effective tax rate for a second earner married to a high earner, though rather less than in the case of fully independent taxation. For a potential second earner married to someone earning an average industrial wage in a full-time job, the average tax rate on taking up a job falls by just 4 percentage points. At low earnings, or with an unemployed partner, the rates are not much changed. By contrast, a fully independent tax system leads to large falls in average tax rates for (potential) second earners in most circumstances.

Table 3: *Average Effective Tax Rates on Second Earner for Alternative Tax Systems*

Tax system	*Spouse unemployed*	*Spouse in full time work at* *Half average wage*	*Average wage*	*Twice average wage*
		Full-time job at average wage		
Income-splitting	64	40	46	60
Quasi-independent	62	40	42	43
Fully independent	69	29	28	28
		Part-time job (16 hours) at average wage		
Income-splitting	100	36	34	52
Quasi-independent	100	33	37	42
Fully independent	100	15	15	15

In the present paper we do not discuss the merits and demerits of these systems. We simply wish to investigate the potential labour supply response to a fully independent tax system which would substantially reduce the effective tax rates on second earners, and to a "quasi-independent" tax system which would have more complex effects on effective tax rates, generally lying between the extremes of the "income-splitting" and fully independent systems.

5. Estimation results

In principle, the labour supply model and the wage equations can be estimated simultaneously. To limit the computational burden however, we have estimated the wage equations separately, using a reduced form participation equation to account for selectivity bias. The resulting Heckman (1979) model is estimated by maximum likelihood. Regressors and estimation results are presented in the appendix, Table A1. The wage equation estimates are similar to those of

Callan (1991). Results are in accordance with the usual findings for this type of human capital wage equations. For example, the expected log wage rises with education level, and is a concave in potential experience.

We present the estimation results for the labour supply model in Table 4. The SML estimates are based upon R=15 draws per family. The estimated utility function is increasing in family income and quasiconcave at all sample points. Since the estimates of the A_{ij} are hard to interpret, some indifference curves are drawn in Figure 1. Random preferences and fixed costs are not taken into account. We sketch curves in (y,h_m)-plane, for $h_f=20$, and curves in (y,h_f)-plane, for $h_m=40$. Individual and family characteristics are set equal to their sample averages, except for family composition: panels on the left refer to a family without children, the right-hand panels to a family with one young child. Solid lines refer to the estimates with R=15 replications, dashed lines to R=10. The small differences between the two sets of curves suggest that R=15 is large enough to obtain reasonably accurate results. At low hours, many of the curves are decreasing, implying that, ignoring fixed costs of working, people would be prepared to work a limited number of hours for a zero wage. This explains why there are relatively few part-time jobs, particularly for males. The curves have the expected convex shape. Differences according to family composition are more pronounced for females than for males. Indifference curves for females start rising at lower hours of work in the family with a young child than in the family without children, implying that labour supply will be lower in the family with a young child, ceteris paribus.

Together with fixed costs, random preferences, etc., the shape of the indifference curves determine the sensitivity of labour supply for changes in wages, taxes, benefits, other income, etc. The implied elasticities will be discussed in the next section, using simulations.

Individual characteristics affect preferences through the β_{ij}. A positive parameter implies that the variable has a positive effect on the (own) marginal utility of leisure, and a negative effect on (own) labour supply. The age terms are insignificant for males. For females, preferences for leisure increase from age 25. This may reflect a pure age effect or a cohort effect. Chronic illness dummies are insignificant. The wife's age at marriage is significantly negative for women: those who married late have larger labour supply. Children have an insignificant effect for men, but reduce women's labour supply significantly. Age categories of the children are of minor importance: young children do have a greater impact on female participation through their effects on fixed costs, to which we now turn.

The parameters of the fixed costs equations are not estimated with large precision: few of them are significant at the 5 per cent level. Estimated fixed costs are positive with probability close to one. For males, they increase with age, while for females, age plays no role. Children have little effect for males, while for females, the presence of young children increases fixed costs, thereby decreasing the probability of participation. For males, chronic illness hampers participation significantly. For females, the effect has the same sign, but is small and insignificant. According to the relatively small estimates of $\sigma(u_m)$ and $\sigma(u_f)$, the unobserved heterogeneity terms in the fixed costs do not play a large role.

The probability of involuntary unemployment is allowed to depend on potential experience, education, and a dummy for living in Dublin. We experimented with other variables, but these were not significant. As expected, the education level is significantly negative for men as well as women. The probability of involuntary unemployment decreases with potential experience until about 34 (men) or 33 (women) years of experience, i.e. during the largest part of the life cycle. In Dublin, the probability of involuntary unemployment is smaller than in the rest of the country.

The random preference terms are allowed to be correlated with errors in the (own) wage equations and with each other, according to the specification given in the table. This specification is convenient because it requires simulating from independent normals only. As can easily be checked, the results imply that the correlations with the wage equation errors are significantly positive (0.80 for males, 0.64 for females). Thus exogeneity of wages in the labour supply decision is rejected. On the other hand, the correlation between male and female random preferences is 0.22 and insignificant at the 5 per cent level.

6. Simulations and Alternative Tax Systems

The simulations serve three purposes. The first is to check whether the model is able to reproduce the main features of the data. Second, they are used to consider the sensitivity of average labour supply and participation with respect to before tax wages. Third, the simulations are repeated with alternative tax systems. Comparing labour supply under the actual tax system with that under independent or quasi-independent taxation shows to what extent the current tax system in Ireland can be held responsible for low participation rates among married females.

Table 5 refers to model performance. We partition the sample according to the wife's education level, her age, and family size. We compare simulated and actual average hours of work, and the distribution of males and females over the three states: nonparticipating, involuntarily unemployed, and working. If we consider the sample as a whole, we find that the model is able to reproduce the sample means of working hours and the state probabilities quite well. If we look at means by education level, age, or family size, differences between sample and simulated data are larger. For example, the model somewhat underestimates the differences between those with low and those with high education level.

Simulated effects of changing wages or taxes are in Table 6.[10] We only present results for the full sample. The direction and magnitude of the effects do not vary substantially with age, education level, or family size.

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[10] We also computed the elasticities using the results based upon R=10 instead of R=15. These were very similar to those in Table 6.

If before tax wage rates for men rose by 1 per cent, average hours worked by males would rise by about 0.15 per cent. This number can be interpreted as a point estimate of the males' own (gross) wage elasticity of average hours worked. By repeating the simulations for a large number of draws from the estimated asymptotic distribution of the parameter estimates, a 90 per cent confidence interval for this elasticity was obtained: (0.10; 0.20). Similarly, married womens' own wage elasticity is estimated at 0.67, with confidence interval (0.50; 0.85). Cross wage elasticities are negative but much smaller. The women's cross wage elasticity is insignificant. A one per cent rise in wage rates for women would decrease nonparticipation of married women by 0.31 per cent, i.e., 0.2 of a percentage point. Participation of women would thus increase by the same amount in percentage point terms.

The final simulations concern the two alternative tax systems described in section 4, each designed to be approximately revenue-neutral in the absence of any behavioural response. The benefits system remains unchanged. The first option, quasi-independent taxation, is a limited move towards independent taxation, whereby the transferability of rate bands between spouses is done away with, and only "unused" allowances can be transferred (see Section 4). The estimated effects for males are small. Average hours worked would fall by less than 0.25 per cent. On the other hand, the participation and employment rate would slightly increase. The effects for married women are larger. Female hours would rise by about 4.7 per cent. The increase in the employment rate would be somewhat smaller (confidence interval: between 2.6 and 4.4 per cent). Some of the women entering the labour market would not be able to find a job, resulting in a rise of involuntary unemployment of about 3 per cent.

Finally, we consider a fully independent individual tax system, which implies much lower rates of tax on second earners (See section 4). All tax rates are cut by more than one quarter: the standard rate of tax falls by almost 10 percentage points. The effects on married men are modest. Average hours would fall slightly. The employment rate would fall by about a quarter of a percentage point, due to an increase in nonparticipation. For married women, however, the effects are substantial. Hours worked would rise by almost 18 per cent. Nonparticipation would decrease by 8.7 per cent, i.e. about 5.8 percentage points. Participation would rise by the same amount in percentage point terms, i.e. from 33.1 to almost 38.9 per cent. Assuming that the individual unemployment risks would not change, this would result in an increase in the employment rate from 21.0 to 24.8 per cent. The others entering the labour market would end up being unemployed. An analysis at a more disaggregate level shows that these effects are largely due to increasing participation of females whose husband is employed. The probability that both partners take the same participation decision increases.

7. Conclusions

In this paper we have considered a static structural model to explain the labour supply of husband and wife in Irish families. By restricting our attention to a finite budget set we were able to take account of the main features of the Irish system of income taxes and benefits, key points being that safety net income is set at family level and taxes depend essentially on joint income. We extended the model of Van Soest (1995) to take account of involuntary unemployment and fixed costs of working, as well as random preferences, the fact that wage rates of nonworkers are not observed, and wage rate endogeneity. The model was estimated using the ESRI household cross-section data gathered in 1987. We applied smooth simulated maximum likelihood, to avoid six dimensional numerical integration. The results suggest that this works well for a small number of draws per family.

We find wage elasticities of labour supply that are well in line with most of the international literature. For males, the aggregate own wage elasticity is about 0.15, for females it is about 0.67. Cross-wage elasticities are quite small.

Our interpretation of the data implies that a discouraged worker is considered involuntarily unemployed. This is theoretically appropriate in the labour supply model, but leads to unemployment figures which are much larger than the official ones. As a consequence, our participation rates are not directly comparable to published data for Ireland and other countries. The direction and size of the effects identified in our sample can, however, provide some guidance on the extent to which the tax and benefits system contribute to the relatively low labour force participation rate of married women in Ireland.

Our model estimates enabled us to consider the consequences of family-based taxation versus alternative systems with greater independence in the tax treatement of spouses. We find that changing to fully independent taxation in a revenue-neutral way could lead to an increase of the employment rate of married women in the age group considered of 3.8 percentage points, while the gross participation rate (discouraged workers included) would rise by 5.8 percentage points. The effects on male labour supply would be negligible. These results suggest that the tax system could explain a part - but only a part - of the gap between the participation rates of married women in Ireland and those for women in other EU countries which have greater independence in the tax treatment of husbands and wives.

A fuller investigation of cross-country differences in labour supply would require comparable micro data, and the construction of budget constraints for the countries involved. This is outside the scope of the present paper. But given these inputs, the model set out here can in principle be used to study the impact of differing tax and benefit systems and of other factors which may lead to labour supply differences between countries. For example, labour supply differentials could be decomposed into differences due to tax and benefit systems, real wage levels, the numbers of children and differences in age distributions.

References

Blomquist, N.S. (1988), 'Nonlinear taxes and labor supply', *European Economic Review* 32, 1213-1226.

Blundell, R. and I. Walker (1986), 'A life cycle consistent empirical model of labour supply using cross-section data', *Review of Economic Studies* 53, 539-558.

Blundell, R., J. Ham and C. Meghir (1987), 'Unemployment and female labour supply', *Economic Journal (conference papers)* 97, 44-64.

Callan, T., B. Nolan, B.J. Whelan, D.F. Hannan, and S. Creighton (1989), 'Poverty, Income and Welfare in Ireland', ESRI, Dublin.

Callan, T. (1991), 'Male-female wage differentials in Ireland', *Economic and Social Review* 23, 55-72.

Callan, T. and A. van Soest (1993), 'Female labour supply in farm households: farm and off-farm participation', *Economic and Social Review* 24 (4), 313-334.

Dickens, W. and S. Lundberg (1993), 'Hours restrictions and labor supply', *International Economic Review* 34, 169-192.

Gourieroux, C. and A. Monfort (1993), 'Simulation based inference: A survey with special reference to panel data', *Journal of Econometrics* 59 (1-2), 5-34.

Hausman, J. and P. Ruud (1984), 'Family labor supply with taxes', *American Economic Review* 74, 242-248.

Hausman, J. (1985), 'The econometrics of nonlinear budget sets', *Econometrica* 42, 679-694.

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

Heckman, J. and M. Killingsworth (1986), 'Female labor supply: a survey', in O. Ashenfelter and R. Layard (eds.), Handbook of Labor Economics, vol 1, North-Holland, Amsterdam, 103-204.

Kapteyn, A., P. Kooreman and A. van Soest (1990), 'Quantity rationing and concavity in a flexible household labor supply Model', *The Review of Economics and Statistics* 70, 55-62.

Maddala, G. (1983), *Limited dependent and qualitative variables in econometrics*, Cambridge University Press, Cambridge, Mass.

MaCurdy, T., D. Green and H. Paarsch (1990), 'Assessing empirical approaches for analyzing taxes and labor supply', *Journal of Human Resources* 25, 415-490.

Moffitt, R. (1984), 'The estimation of a joint wage hours labour supply model', *Journal of Labor Economics* 2, 550-566.

Moffitt, R. (1990), *Journal of Human Resources* 25, no. 3, special issue on 'Taxation and Labor Supply in Industrial Countries'

Nakamura, A. and M. Nakamura (1992), 'The econometrics of female labor supply and children', *Econometric Reviews* 11, 1-71.

OECD (1994) *The OECD Jobs Study: Evidence and Explanations, Part II: The Adjustment Potential of the Labour Market* Paris: OECD.

Ransom, M. (1987), 'An empirical model of discrete and continuous choice in family labor supply', *Review of Economics and Statistics* 59, 465-472.

APPENDIX A

Table A1. Estimation results Heckman (1979) model

	males par	t val	females par	t val
participation equation				
constant	-61.68	-2.32	-22.16	-1.09
potexp*0.1	0.02	0.02	-0.25	-0.35
potexp_2*0.01	0.03	0.26	0.01	0.10
dedlev_2	0.47	3.50	0.08	0.51
dedlev_3	0.77	3.71	0.34	1.90
dedlev_4	1.54	5.41	0.36	1.77
dedlev_5	2.01	4.55	0.51	1.81
dedlev_6	2.73	4.74	1.30	3.32
euer*0.01	1.84	1.61	-0.95	-0.87
ruertw*0.01	-3.59	-1.24	0.34	0.12
bigtown	0.23	1.52	0.06	0.36
city	-0.33	-2.05	0.13	0.79
dublin	0.43	3.20	0.09	0.69
log_age	33.47	2.21	12.91	1.10
log_age_2	-4.55	-2.13	-1.92	-1.12
hhlth	-1.06	-8.32	-0.32	-2.11
nchcb	-0.14	-3.54	-0.23	-4.95
yng0_4	0.15	0.84	-0.54	-3.06
yng5_12	-0.01	-0.05	-0.15	-1.00
ncapy*0.01	-0.38	-2.93	-0.39	-1.18
agemarw*0.1	0.27	2.06	0.35	2.44
wage equation				
constant	0.86	3.37	1.46	3.30
potexp*0.1	0.40	4.60	0.40	2.31
potexp_2*0.01	-0.06	-3.53	-0.08	-2.34
dedlev_2	0.19	4.35	0.15	1.19
dedlev_3	0.28	4.05	0.32	2.66
dedlev_4	0.51	6.79	0.36	2.89
dedlev_5	0.66	6.82	0.69	5.58
dedlev_6	0.92	9.23	0.97	5.43
euer*0.01	-0.36	-1.08	-0.92	-1.05
ruertw*0.01	-0.55	-0.58	-3.46	-1.57
bigtown	0.09	2.10	0.04	0.32
city	0.10	1.51	-0.03	-0.25
dublin	0.14	3.50	0.19	2.02
sigma(w)	0.37	33.02	0.47	12.60
rho	-0.48	-2.15	0.40	1.39

Table 4. Estimation results structural model

Simulated Maximum Likelihood, R=15 draws per observation; 1001 observations; see Table 1 for variable definitions

	parameter	t-value	parameter	t-value
Utility function				
A_{ij}				
log y squared	-1.286	-1.93		
log l_m squared	-9.327	-18.05		
log l_f squared	-8.561	-5.79		
log y log l_m	1.155	2.53		
log y log l_f	0.950	1.69		
log l_m log l_f	-1.312	-4.20		
log y	5.508	0.58		
	husband		wife	
constant	54.240	1.41	164.041	3.39
log age	3.999	0.19	-60.703	-2.39
log age sqd	-0.179	-0.06	9.641	2.64
dilln	1.219	1.84	-0.325	-0.33
nch	-0.069	-0.41	1.247	3.44
dch<5	-0.429	-0.57	-0.255	-0.23
dch5-12	-0.467	-0.68	0.875	0.78
agemarw * 0.1	0.051	0.16	-1.376	-2.35
involuntary unemployment	husband		wife	
constant	1.769	4.52	-0.455	-1.83
pot exp	-1.029	-3.77	0.467	-0.94
pot exp sqd	0.154	3.03	-0.070	1.16
ed level	-0.462	-7.85	-0.134	-0.80
ddublin	-0.216	-1.83	-0.342	-1.99
fixed costs	husband		wife	
constant	-134.495	-0.55	160.268	1.07
log age	75.329	1.17	-6.775	-0.17
dilln	103.720	3.13	19.995	0.94
nch	7.610	0.68	-5.294	-0.72
dch<5	42.254	0.95	65.979	2.40
dch5-12	10.801	0.28	10.065	0.41
sigma fc	16.011	0.69	22.140	1.73

Random preferences:

$$\epsilon_m^r = \lambda_1 u_1 + \lambda_2 u_m; \quad \epsilon_f^r = \lambda_3 u_2 + \lambda_4 u_f + \lambda_5 \epsilon_m^r$$

where $(u_1, u_2) \sim N_2(0, I)$ and u_m and u_f are the wage equation errors in (6).

λ_1	0.152	0.40
λ_2	1.234	2.10
λ_3	0.553	2.77
λ_4	2.307	5.96
λ_5	1.466	1.75

NB: age, pot exp, dilln, and ed level refer to the husband's age, pot exp, etc. in the husband's equation and to the wife's in the wife's equation.

Table 5. Model fit

Actual and simulated sample means of hours worked (h_m and h_f), rates of nonparticipation (np) and involuntary unemployment (iu)

			males		females	
	h_m	h_f	np	iu	np	iu
Sample distribution						
all	29.5	6.5	10.4	20.5	67.3	11.9
education level						
low (1,2)	24.2	3.5	15.1	27.9	75.5	12.5
high (>2)	35.7	9.9	5.0	11.9	57.9	11.3
age						
<40	30.9	8.3	5.5	22.8	62.6	12.2
≥40	27.8	4.2	16.4	17.6	73.2	11.5
family size						
≤3	30.1	10.8	12.9	15.4	57.1	11.0
>3	29.2	4.0	8.9	23.5	73.4	12.4
Simulated distribution						
all	29.6	6.2	10.5	20.6	67.5	11.8
education level						
low (1,2)	26.0	4.0	14.6	25.0	74.6	11.8
high (>2)	33.7	8.8	5.8	15.5	59.2	11.8
age						
<40	30.7	7.9	5.9	23.3	63.6	11.8
≥40	28.2	4.0	16.3	17.2	72.4	11.9
family size						
≤3	28.9	8.8	12.3	19.8	57.9	15.0
>3	30.0	4.6	9.6	21.0	73.1	10.0

Table 6. Elasticities and effects of changing the tax system

Percentage changes; point estimates and 90 percent confidence intervals

I: gross wage rates of males increased by 1 per cent
II: gross wage rates of females increased by 1 per cent
III: quasi independent taxation
IV: independent taxation

	males hours	females hours	males np	iu	females np	iu
I	0.15	-0.02	-1.26	0.18	-0.07	0.14
lower bound	0.10	-0.11	-1.49	0.14	-0.10	0.08
upper bound	0.20	0.05	-1.04	0.24	-0.03	0.21
II	-0.01	0.67	-0.03	0.01	-0.31	0.65
lower bound	-0.02	0.50	-0.07	0.00	-0.37	0.50
upper bound	-0.01	0.86	0.02	0.01	-0.25	0.81
III	-0.18	4.66	-0.93	0.18	-1.62	2.99
lower bound	-0.24	3.11	-1.39	0.13	-2.30	2.02
upper bound	-0.10	6.42	-0.58	0.26	-1.14	4.27
IV	-0.17	17.89	3.18	-0.55	-8.69	17.22
lower bound	-0.36	12.80	1.67	-0.79	-10.83	13.21
upper bound	0.07	24.30	4.77	-0.37	-6.75	22.55

APPENDIX B: LIKELIHOOD CONTRIBUTIONS

The (simulated) likelihood contribution LC of each household can be adjusted to account for involuntary unemployment. The main point is that not working can reflect labour supply or involuntary unemployment. Observed values of I_m and I_f distinguish between the regimes, but only if desired hours are positive. Moreover, Nine cases are to be considered.

I. $h_m>0,\ h_f>0$: $LC = P[I_m^*\leq 0]\ P[I_f^*\leq 0]\ LC^*$

LC* is the likelihood in the labour supply model without second hurdle, for this case given in (7).

II. $h_m>0,\ h_f=0,\ I_f=0$: $LC = P[I_m^*\leq 0]\ LCS^*$

LCS* denotes the simulated likelihood contribution, based on draws of w_f. Since the wife is not interested in working, we do not know whether she would find a job if she desired one: The sign of I_f^* is not known.

III. $h_m>0,\ h_f=0,\ I_f=1$: $LC = P[I_m^*\leq 0]\ P[I_f^*>0]\ LCSWU^*$

LCSWU* denotes the (simulated) probability that the wife's desired hours are positive, and that the husband's hours equal his observed hours, given the rationing $h_f=0$.[12]

IV. $h_m=0,\ h_f>0,\ I_m=0$: $LC = P[I_f^*\leq 0]\ LCS^*$

This is the same as II, with husband and wife interchanged.

V. $h_m=0,\ h_f>0,\ I_m=1$: $LC = P[I_m^*>0]\ P[I_f^*\leq 0]\ LCSHU^*$

This is the same as III, with husband and wife interchanged.

VI. $h_m=0,\ h_f=0,\ I_m=0,\ I_f=0$:

$$LC = \{1-P[I_m^*>0]P[I_f^*>0]\}\ LCS^* + P[I_m^*>0]P[I_f^*>0]\ LCSHWU^*$$

LCSHWU* denotes the (simulated) probability that, conditional upon $h_f=0$, the husband prefers not to work, and, conditional upon $h_m=0$, the wife does not want to work.[13]

VII. $h_m=0,\ h_f=0,\ I_m=0,\ I_f=1$:

$$LC = P[I_f^*>0]\{P[I_m^*\leq 0]\ LCSWU^* + P[I_m^*>0]\ LCSHWU^*\}$$

LCSHWU* is the probability that, given that $h_f=0$, the husband has no desire to work, while, given that $h_m=0$, the wife would like to work.[14]

VIII. $h_m=0,\ h_f=0,\ I_m=1,\ I_f=0$:

---

[12] For given wage rates and observed hours $h_m>0$ of the male, this probability is given by the probability that $(h_m,0)$ is preferred to all other pairs $(h,0)$ (with corresponding family income), minus the probability that $(h_m,0)$ is preferred to all other pairs (h_1,h_2). These are both multinomial logit probabilities, with m_{ind} and m_{fam} alternatives, respectively.

[13] It implies that (0,0) is preferred to all other pairs (h,0) and (0,h). This is a multinomial logit probability with $2m_{ind}$-1 alternatives.

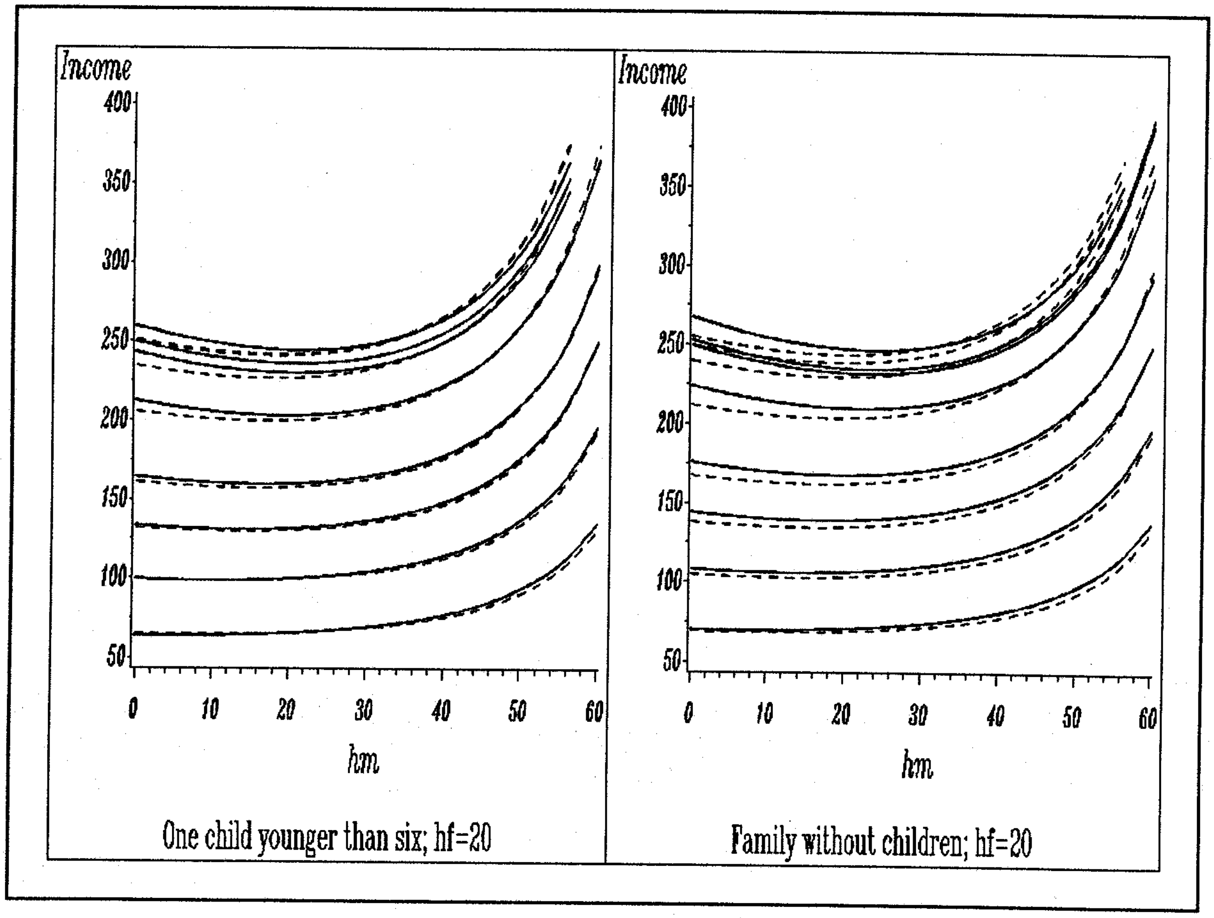
[14] This means that (0,0) is preferred to all other pairs (h,0), but not to all other pairs (0,h). It can be computed as the probability that (0,0) is preferred to all (h,0), minus the probability that (0,0) is preferred to all (0,h) and all (h,0).

$LC = P[I_m^*>0]\{P[I_f^*\leq 0]\ LCSHU^* + P[I_f^*>0]\ LCSHWU^*\}$

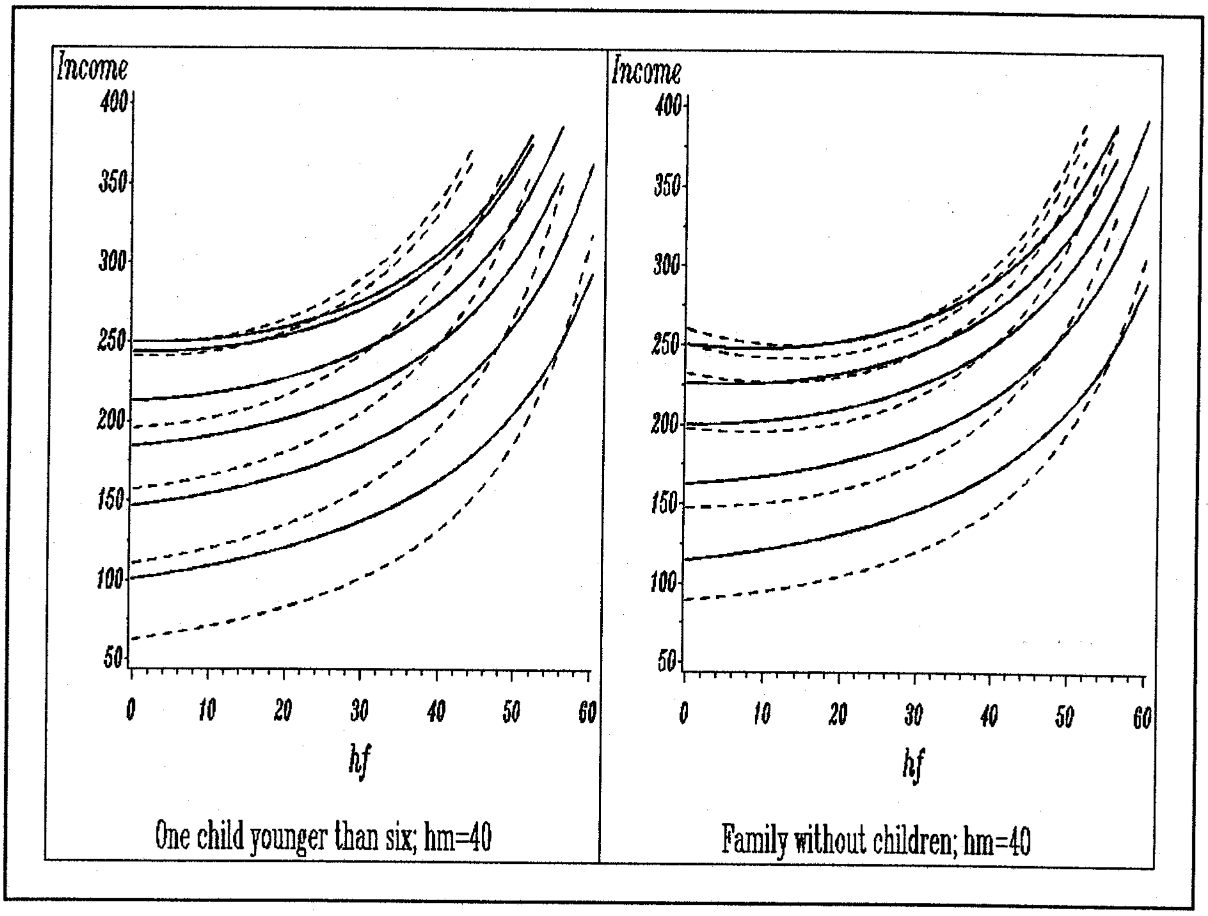
The same as VII, with husband and wife interchanged.

IX. $h_m=0$, $h_f=0$, $I_m=1$, $I_f=1$: $LC = P[I_m^*>0]P[I_f^*>0]LCSHWU^*$

LCSHWU* is the probability that, conditional upon $h_f=0$, the husband prefers to work, and, conditional upon $h_m=0$, the wife prefers to work.[15]



[15] This means that (0,0) is neither preferred to all (0,h), nor to all (h,0). The probability can be computed as 1 - P[(0,0) preferred to all (0,h)] - P[(0,0) preferred to all (h,0)] + P[(0,0) preferred to all (0,h) and all (h,0)].



Income
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
hf
One child younger than six; hm=40
Income
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
hf
Family without children; hm=40