

Income Taxes and Married Women's Labour Supply

A Survey

by

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The paper reviews the literature on the effects of income taxes on married women's labour supply. Taxes introduce nonlinearities and nonconvexities in the budget set, creating many theoretical difficulties. Moreover, women's budget constraints have many particularities, which are often difficult to formalize. In order to deal with the endogeneity of the wage rate induced by taxes, the wage and hours functions are estimated jointly using an iterative estimation procedure, a method which relies on an explicit utility index. Labour supply theory predicts a negative effect of taxes on participation, but does not put any constraint upon the sign of the wage elasticity. Recent estimates do not give strong support to the labour supply theory. Empirical estimates lack robustness since they are subject to preferences, functional forms, simplifications on the data and on the budget set, and estimation techniques. Some recent theoretical developments are reviewed, and policy implications are discussed.

1. Introduction

The analysis of taxes and labour supply falls on the frontiers of three fields: economic theory (or labour economics), applied econometrics, and public finance. Taking taxes into account in empirical studies on labour supply can stem from two different, but not exclusive, interests: the simulation of tax effects, and the incorporation of the tax system into the budget set (BS) in order to estimate wage responses. The first task, simulating tax effects, is done through estimating the dead weight loss (DWL) due to the tax, and evaluating the response of workers to different tax reforms. The second purpose is less straightforward: since taxes modify the shape of the BS, it is necessary to take them into account if the BS is to be accurate, i.e. to reflect accurately the net wages facing the workers.

One important subfield of the analysis of taxes and labour supply is the study of the effect of taxes on married women's labour supply, a subject which has suffered from a relative neglect until the late 70s. Married women are believed to be a group particularly responsive to taxes. The present work surveys the literature on the impact of taxes, mainly income taxes, on the labour supply of married women. The next three sections cover, in order, the theoretical, econometric, and empirical aspects of the subject. Section 5 surveys some recent theoretical developments in the theory of labour supply, and section 6 discusses policy issues. Section 7 concludes.

2. The theory of labour supply and taxation

This section briefly reviews the major theoretical considerations pertaining to taxes and female labour supply. I will discuss, in order, the effects of taxes on the BS, virtual income, the particularities of women's BS, tax illusion, and implicit assumptions in labour supply modelling.

Effects of taxes on the budget set

Taxes are analyzed within the usual framework of labour supply functions, where utility is maximized subject to a constraint incorporating time, wage and prices. The difference with models ignoring taxes is that the net wage replaces the gross wage in the utility function, in the budget constraint, and in the labour supply equation¹.

An increase in the tax rate has the same effect as a decrease in the gross wage, that is, it induces a negative substitution effect and a positive income effect. The sign of the gross elasticity is unknown, and depends on the magnitudes of income and substitution effects, and on preferences (Hausman, 1981). Notwithstanding the sign of the tax elasticity, taxes always reduce utility, because an increase in labour supply has to be matched by a reduction in leisure time, which necessarily translates into a reduction in utility (Killingsworth, 1983; Blundell, 1992).

Taxes introduce important modifications in the BS. I begin the analysis with the simplest case of a proportional tax system, illustrated in Figure 1. The slope of the net wage line is constant, reflecting a constant marginal tax rate. In reality though, tax systems are progressive, so that the net wage line is more likely to look like the one in Figure 2. The progressive decline in the slope of the net wage line reflects the gradual increase in the marginal tax rate as hours worked, and thus income, increase. Nonlinearities arise from the progressivity of taxation, but also from the complexity of the

exemptions system (Glaister et al., 1981)². The first important consequence of taxes is therefore to cause the BS to be nonlinear, or at least to accentuate existing nonlinearities. However, nonlinearity is not a major problem, for a strictly quasiconcave utility function assures the existence of a unique optimum given the maximization of the function on a convex (even if not linear) BS (Hausman, 1985b).

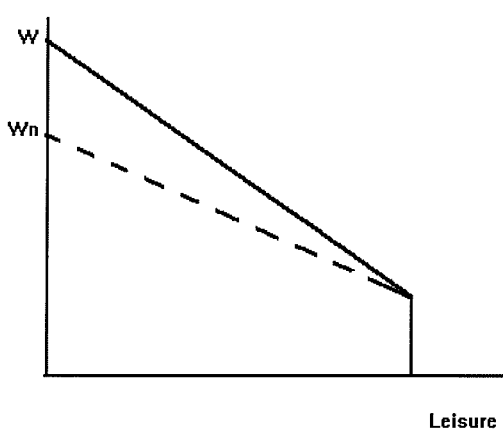


Fig.(1) A proportional tax system. The dashed line represents the net wage.
Source: Hausman, 1981, p.30.

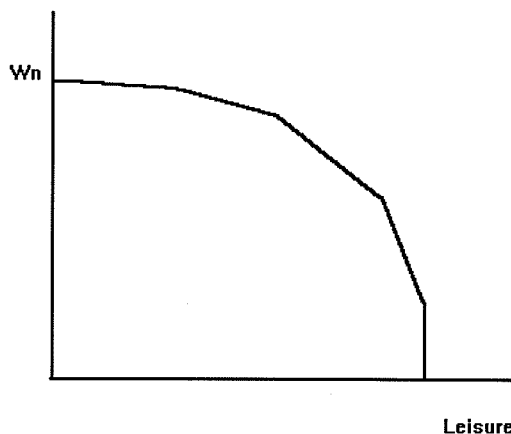


Fig.(2) A progressive tax system.
Source: Hausman, 1981, p.32.

However, actual tax systems are far more complex than depicted above. Most individuals face BS which are not only nonlinear, but also nonconvex. The sources of nonconvexities are numerous: non-uniformities in progressivity, negative income taxes (MaCurdy et al., 1990), social security benefits, child care credit (Hausman, 1981), marriage exemptions³ (Cloutier, 1986), housing benefits (Bourguignon and Magnac, 1990), and various deductions (Hausman, 1985a). Examples of nonconvex BS are illustrated in Figure 3. However, not all sources of nonconvexities have the same importance (Bourguignon and Magnac, 1990).

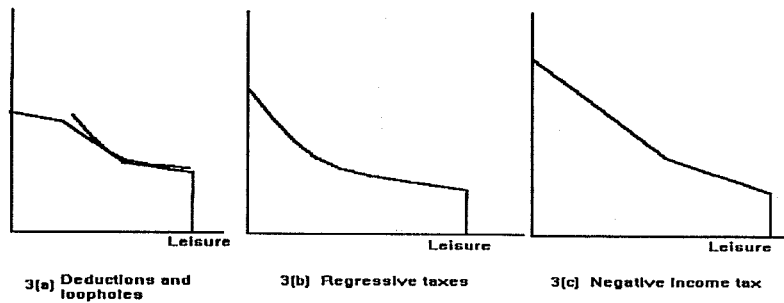


Fig.(3) Nonconvexities in the budget set
 Source: Adapted from Hausman, 1981, p.33, and Gunderson and Riddell, 1993, p.172

Nonconvexities introduce more complex problems than do nonlinearities. The first consequence is non-uniqueness: nonconvexities imply that there may be several points of tangency between indifference curves and the BS (see Figure 3a) (Hausman, 1985b; Bourguignon and Magnac, 1990). Second, regular wage and income elasticities are no longer valid in a nonconvex environment (Stelcner and Smith, 1985). Although in theory it would be possible to work with nonconvex BS, most studies proceed with a convexification of the BS (see Figure 4), replacing the actual nonconvex set by its convex envelope. This approach is valid only for minor nonconvexities.

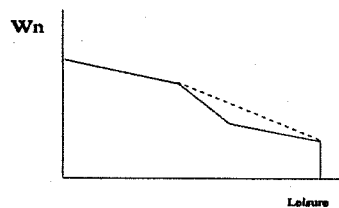


Fig.(4) Convexification of the budget set
 Source: Adapted from Bourguignon and Magnac (1990), p.363.

An alternative to the piecewise-linear (convexified) BS is the differentiable BS: "an approximation of a tax schedule around a kink point using a differentiable function can be made arbitrarily close by letting the marginal tax rate shift more sharply between the levels associated with the segments adjacent to the kink." (MaCurdy et al., 1990:443). This approach is seldom used, however.

Virtual income

A concept that is central to the modern analysis of labour supply and taxes is virtual income, coined by Burtless and Hausman (1978) and later developed by Hausman (1981). Formally, virtual income can be defined as follows (Mroz, 1987):

$$Y_v = Y_n - (1-t)wh$$

where the variables represent the following

Y_v	virtual income
w	gross wage
Y_n	family's after tax income
h	observed choice of hours of work
t	marginal tax rate

Virtual income is "the intercept on the axis measuring non-labor income that arises if the net wage line is extended to the vertical axis." (Hausman, 1981) (see Figure 5). In other words, it is the level of non-wage income that the person would have to have, in combination with the known constant market wage to yield a given level of utility associated with participating in the labour market. It can also be defined as the nonlabor income such that the optimum obtained with the nonlinear (real) budget constraint is the same as the optimum obtained with a would-be linear BS, with virtual income equal to the horizontal intercept of the linearized BS.

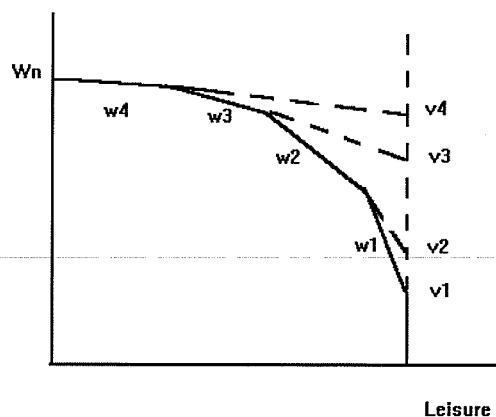


Fig.(5) Virtual income.
Source: Hausman, 1981.

Virtual income replaces nonlabour income in the labour supply function. It constitutes a useful simplification of the BS, in that it reduces and potentially eliminates nonlinearities and nonconvexities (Cloutier, 1986).

Particularities of women's Budget Sets

The wife's BS is more complex than the husband's, due to the sequential decisionmaking assumed in most studies (the husband's decision preceding the wife's), and due to the large proportion of nonparticipant females. I discuss four types of potential complications in the wife's BS: the trichotomy of time use, the constant earnings supply relationship, the exogeneity of husband's income, and the distinction between joint and separate taxation.

The trichotomy of time use Because a large proportion of women do not participate in the labour market, it is important to consider the wife's use of time outside the market. The wife's use of time can be analyzed from the perspective of the trichotomy of time use (Hunt et al., 1981)⁴. In the context of the trichotomy, the wife's time is divided between work, leisure, and, in addition, home

production- the only enjoyable occupation being, of course, leisure. Hunt et al. attempt to analyze the effect of taxation on the wife's time use within the framework of the trichotomy. The effect of a change in the wage (or tax) rate cannot be predicted without additional constraints: "Higher wages increase the price of home production [this is the substitution effect] but through income effects may also increase the demand for home goods and the time devoted to home production." (Hunt et al., 1981:429). The effect of an increase in the tax rate is a substitution of either home production or leisure for market production. This implies that the real consumption possibilities are affected by the wife's allocation of time between activities (leisure and homework) which are external to the market. This income effect can make the results obtained from traditional BS analysis misleading.

Constant earnings supply relationship This concept means that workers (husbands and wives) adjust their labour supply so as to keep total net income unchanged, notwithstanding utility maximization.

Clearly, this limits the use of traditional labour supply estimates (Macrae and Yezer, 1976). My view is that, while a constant earnings supply relationship may not be rational from a utility maximization point of view, it can apply to families who have important fixed costs (in the usual meaning of this word, and not fixed costs to work). The problem of formalizing the constant earnings-supply relationship remains unresolved.

Exogeneity of the husband's income One major difference between a change in the wage rate and a change in the tax rate is that the former does not affect nonlabour income, while the latter does (Hausman, 1985a). A decrease in the tax rate, for instance, leads to an increase in the wife's net wage, which should induce her to increase her labour supply. However, the increase in nonlabour income (husband's earnings) induced by the reduction in taxes may lead her to reduce it; the net effect cannot be predicted a priori. The increase in exogenous income (husband's earnings) can even

be such as to induce the wife to withdraw from the labour market, although her net wage has, in fact, increased! This problem exists only when the husband's income is considered as exogenous, which is an assumption made by the vast majority of studies.

Joint versus separate taxation The importance of the interdependence of spouses' behaviour varies according to the nature of the tax system. It is important for that purpose to distinguish between joint and separate taxation. Joint taxation applies when the two earners are taxed jointly, while separate taxation means that each worker is taxed separately. Figure 6 illustrates the wife's BS under joint and separate taxation. For reasons of simplicity, the tax system has only two brackets. Under separate taxation, the wife's first hour of work is taxed at a lower rate than under joint taxation. This is so because under joint taxation the wife falls into the higher tax bracket as soon as she enters the labour market.

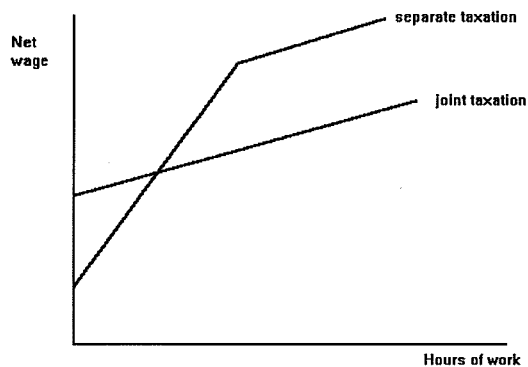


Fig.(6) Wife's budget sets under separate and joint taxation.
Source: Gustafsson, 1992.

Joint taxation is an important source of nonconvexities in the family (and also, in the individual) BS, because it can cause the tax system to be progressive over some areas and regressive over other areas. Apart from estimation problems, joint taxation is disadvantageous to secondary earners: it implies that the marginal tax rate of one spouse depends on the earnings of the other spouse (Hausman & Ruud, 1984; Rosen, 1976b). This is particularly true for the secondary earner,

usually the wife. It reveals that the marginal tax rate on the wife's earnings is very high: "the first dollar earned by the wife is in effect taxed at the same marginal rate as the last dollar earned by the husband" (Rosen, 1976b:167). The effect of joint taxation on the secondary earner can be seen as imposing a very important fixed cost (to the family) on the entry of that earner into the labour force.

Because it discourages the secondary earner, joint taxation is said to reinforce traditional sex roles. By discouraging marriage, it is also said to encourage immorality (Spahn et al., 1992). For these reasons, joint taxation is often rejected by feminist groups. In my opinion, the negative effect is particularly important for the participation decision, rather than for the number of hours worked *per se*, because most of the deductions are applicable when the secondary earner does not participate in the labour market. Joint taxation is found, for instance, in the U.S.⁵, France, and Germany, while countries such as Canada, Sweden, Australia, Japan, Austria, Denmark, Italy, and The Netherlands use separate taxation⁶ (Boskin and Sheshinski, 1979); some countries offer workers the choice of the tax system to be applied. This distinction between joint and separate taxation is probably the only particularity of women's budgets sets that has received attention in the formalization of labour supply models.

Tax illusion

The effect of taxes on labour supply is often introduced along with an indicator of *tax perception*. The pioneer in this area is Rosen (1976b). There is tax illusion when the individual reacts as if her tax rate was different from what it actually is. It would be due to the "less than perfect knowledge of the complexities of the tax-benefit system." (Beenstock and Dalziel, 1987:170). The tax perception indicator can take different forms:

$$w_n = w(1-t)^\alpha \quad (\text{Stelcner and Breslaw, 1985})$$

$$w_n = w(1-\alpha t) \quad (\text{Rosen, 1976b})$$

where w_n is the net wage, w the gross wage, t the tax rate, and α , the tax perception indicator.

If individuals were perfectly rational, we would expect an α equal to unity, that is, the individual perceives the tax rate correctly (responds to net, not gross, wages). If $\alpha < 1$, this would mean that the government is making money on the backs of workers, because the latter misperceive the tax rate by offering too many hours (as compared to what they would offer if their wage was reduced not through a tax but through a nominal cut). A limit case would be one where $\alpha = 0$, meaning that individuals do not take account of taxes in their decisions, and that they react to gross wages. Of course, this would be irrational. The other case, $\alpha > 1$ suggests that workers overestimate the tax rate.

Tax illusion is important for DWL analysis. If there is under-estimation of the tax rate by individuals, this would indicate that the actual DWL will be lower than otherwise. By the same token, if there is over-reaction, the DWL resulting from an increase in the tax rate will be larger than otherwise. It is also important because it improves the precision of estimates, since we put into the labour supply equation the adjusted (for illusion) net income, rather than net income⁷.

Tax illusion analysis was popular in the 1970s and the early 1980s, but is much less so nowadays. It has been criticized for four reasons. First, authors always test tax illusion with respect to income taxes, but omit testing the same phenomenon with respect to property income (Killingsworth, 1983).

Second, the formulation presented above does not distinguish between illusion as to the marginal tax rate (the position of a particular hours-wage locus on the BS), versus illusion as to the

average tax rate (the position of the BS itself) (Cloutier, 1986). Cloutier argues that it is plausible that individuals be subject to tax illusion with respect to the marginal tax rate, but not to the average tax rate, and that the formulations presented above force the individual off her BS, i.e., they force her to be subject to illusion in the average tax rate. Cloutier uses an alternative, rather involved, method to test for tax illusion.

Another critique is that the effective -as opposed to official- tax rates across income groups reflect a relatively proportional -rather than progressive- tax system, due to deductions and loopholes (Pechman and Okner, 1974). In these circumstances "our failure to reject the hypothesis that individuals fail to take taxes into account in their labor supply decisions is empirically indistinguishable from the hypothesis that all individuals face the same proportional tax rate" (Mroz, 1987:788)

The fourth critique is presented by Beenstock and Dalziel (1987). They argue that even if α was found to be significantly different from one, this would not be sufficient to conclude in favour of tax illusion for "the statistical techniques employed cannot discriminate between people's lack of awareness of their true work incentives, and a simple failure to act as rational economic men." (Beenstock and Dalziel, 1987:170). In this perspective, tax misperception is indistinguishable from preference errors.

Implicit assumptions in labour supply models

A number of assumptions are often made in empirical studies in order to keep the problem manageable. Generally the interactions between taxes and the following are ignored: life-cycle considerations, constraints on hours, negative income taxes (by eliminating from the sample those

households receiving benefits), and other determinants of female labour supply (like children⁸, etc.).

Other assumptions and simplifications include:

a) The use of a static, rather than dynamic, framework (Killingsworth, 1983).

b) Ignoring the fact that different types of workers may have different reactions to a given tax change

(Brown et al., 1981). The assumption used to minimize the importance of this issue is that since the income taxes affect all workers in an homogeneous manner, this should not be a serious problem, since the 'aggregate' results we get by using large samples of data are the final outcome of different -sometimes going in opposing directions- reactions.

c) The assumption that preferences remain unchanged before and after tax reforms (Schettkat, 1989).

As we will see, this may be a rather strong assumption.

d) The assumption that taxes are the only source of simultaneousness between hours and wages.

Nonetheless, even in a world without taxes, the wage rate can depend on hours worked, in two ways (Rosen, 1976a): First, there exists a higher relative excess supply of part-time workers than excess supply of full-time workers, implying a positive relation between hours worked and the expected wage rate. This is particularly important for women, who form a majority among part-time workers. Second, the existence of quasi-fixed costs to employees denotes that they will want to impose constraints on hours demanded. Under this assumption, the employer will not set a wage that is independent of hours, he will set $w=w(h)$ such that $w'(h)>0$.

In his argument Rosen does not really think about taxes, but his point is of particular interest to our topic. Both arguments presented above suggest a positive relation between hours worked and the wage rate. But this is a counterpart to the progressivity of the tax system, in that it reduces the flattening that progressive taxes cause in the BS. So when individuals consider a situation where they

would increase their number of hours worked, they do have to take into account the penalty of a higher tax rate, but also the prospect of a higher wage⁹.

e) The fact that 'labour supply' generally refers to the number of hours worked. However, this might be a rather narrow definition of labour supply, which is much more complex: "hours of work are just the tip of an iceberg that is potentially very deep." (Rosen, 1980:175). Other than hours worked, we can think of: timing of retirement, occupational choice (Boskin, 1981), intensity of work effort, and quality of work effort (Rosen, 1976a;1980). Taxes can affect those other components of labour supply just like they affect hours worked. For instance, when using effective hours of work instead of 'gross' hours of work as the dependent variable in the labour supply function, Rosen (1980) finds that the coefficients for the wage rate and education are higher and have smaller standard errors. This suggests that tax effects could be larger than what actual models estimate they are.

f) Ignoring the impact of taxes on human capital (Rosen, 1976a). By reducing women's labour supply, higher taxes reduce the learning-by-doing, and accelerate the depreciation of market skills relative to home skills (Boskin, 1973;1981)). Taxes also reduce the return to human capital by reducing the net wage, although this is offset by publicly financed education (financed through taxes). One confirmation of the importance of taxes for human capital investment is that Heckman (1980) and Mroz (1987) reject the exogeneity of the wife's labour market experience.

g) Ignoring two issues affecting women more particularly: i) fertility is most often considered as exogenous, while in fact it could be endogenous to the labour supply decision (Gustafsson, 1992); and ii) the effect of any child care credit is generally not taken into account. But this, along with other special deductions, reduce the effect of progressivity on women (Hausman, 1985a). This suggests that real elasticities are lower than those estimated without account of such effects.

h) The use of a partial equilibrium framework, without consideration of general equilibrium effects. These include the effect on interest rates, consumption, and savings (and thus on nonlabour income, which in turn will affect labour supply) (Killingsworth, 1983). Another important general equilibrium effect is the expenditure side of the government. The use of revenue raised via income taxes can ultimately affect the effect of these taxes on labour supply. In a general equilibrium framework, it is often argued that the effect of income taxation entails only a negative substitution effect, i.e. the income effect is null, under the assumption that the government ultimately transfers back any collected taxes. But this assumption is somewhat strong (Killingsworth, 1983), and is unlikely to hold other than in a one-consumer economy (Hausman and Ruud, 1984). Government expenditures are important for another reason. Higher taxes generally mean higher government expenditures. But the public sector has a higher propensity to consume market output than the private sector, and market output is more labour-intensive, so this increases the demand for labour. Also, many government services, such as education, are labour-intensive (Rosen, 1980).

Whether these assumptions are strong enough to cast serious doubts about the reliability of estimates remains an open question. What is certain is that actual labour supply models are not equipped to integrate most of them.

3. The econometrics of female labour supply with taxes

This section covers the most important issues pertaining to estimation procedures, problems, and solutions in dealing with taxes in female labour supply models.

Standard estimation procedure

The estimation of tax effects is done within the framework of the estimation of labour supply functions, with the replacement of the gross wage figure by the net wage. I review the basic model, and then study how taxes are introduced. The procedure most often used is the following¹⁰:

a) The estimation of a function for the probability of working, using the Probit technique to prevent the values of the dependent variable from falling outside the interval [0,1]. Logit is sometimes used to approximate Probit, for computational convenience (Cloutier, 1986), since the cumulative distribution of the Probit model is in integral form, while the Logit's cumulative distribution is not. The difference between the two methods is that the Probit technique assumes that the cumulative distribution of the error term in the likelihood function is the normal distribution, whereas the Logit technique assumes that it is the logistic distribution that is relevant (Madala, 1983). Because the two distributions are very similar except at the tails, they do not yield fundamentally different results, except for very large samples where there are many observations at the tails.

b) The estimation of a wage equation depending on personal characteristics of the general form

$$\ln w = a_0 + Xa_1 + e$$

where X is a vector of personal characteristics.

c) The estimation of a labour supply function for the whole sample, depending on personal/social characteristics, and wages. Wages (gross wages) are those estimated in (b) for non-workers, and either estimated wages or real wages for workers. Using fitted wages for workers is becoming less popular, for two reasons: a) it leads to a misspecified budget constraint for all individuals, workers and non workers (Arrufat and Zabalza, 1986); b) it is equivalent to making the BS random (MaCurdy et al., 1990)¹¹. The wage and labour supply functions can take different forms: linear (Rosen, 1976b),

log-linear, and semilogarithmic (Mroz, 1987).

Female labour supply models are subject to sample selection bias, due to the high proportion of nonworkers. Working women are likely to have tastes which are biased toward work: "estimates derived from self-selected samples may be biased due to correlations between the independent variables and the stochastic disturbance induced by the sample selection rule." (Mroz, 1987:778). The bias is believed to be more important in the labor supply function than in the wage function (Heckman, 1980). Most studies continue to use the treatment of Heckman (1980) to correct for sample selection bias, at the cost of the sensitivity of the results to specification and measurement errors (Blundell, 1992). Moreover, in most cases the coefficient of the inverse of Mill ratio is not significant, and failure to control for self-selection bias does not lead to biased estimates (Mroz, 1987).

Until the mid-70s studies typically ignored the effect of taxes, that is, they used the above approach with the gross wage in the wage and the hours function. The nature of the consequences of ignoring taxes depends on the tax system. If the tax system were proportional, the bias would be absorbed in the constant term (Quester, 1977). However, tax systems are generally progressive¹². Under these circumstances the procedure introduces a downward bias on estimated coefficients, especially coefficients of wage, property income, and children¹³. This is so because studies accounting for taxes find higher substitution and lower income responses (MaCurdy et al., 1990). This indicates that wage and tax elasticities are higher when the net wage is used.

Estimation problems

Estimation problems in female labour supply models are numerous; in this work I focus on

problems created by the use of net wages. Because the tax rate is not constant, and depends on hours worked, there is a double dependence problem between the net wage and hours worked. Although the tax system itself is exogenous, the net wage is endogenous. And the more progressive the tax system, the more endogeneity becomes a problem¹⁴. This double dependence has many consequences:

a) It creates nonlinearities and nonconvexities in the BS. When the BS is nonlinear, the standard procedure of imputing a wage rate and then using it in the labour supply function does not yield consistent estimates (Blomquist and Hansson, 1990). Also, as noted earlier in the paper, the optimum is not unique in a nonconvex environment (Hausman, 1985b).

b) Since the marginal tax rate depends on hours worked, errors in hours measurement will result in errors in the estimated marginal tax rate (Triest, 1992). In this case the parameter estimates will be inconsistent.

c) Correcting for selectivity bias is made more complex by the nonlinearity induced by taxes. First, functional forms of the participation and wage equations become easily complex, as a consequence of the nonlinearity of the BS (Bourguignon, 1986). Second, when the wage rate is fully endogenous, a selection bias term cannot be included in the equilibrium (structural) equation; it can be added only to the reduced form equation (Nakamura and Nakamura, 1981).

d) We can expect multicollinearity between spouses' net wages (Leuthold, 1978a). We must recall that the labour supply function includes, as explanatory variables, both the wages of the wife and the husband. In so far as gross wages are used, no serious multicollinearity problems should occur¹⁵. When net wages are used, the multicollinearity issue becomes otherwise more serious, especially -but not exclusively- under a joint taxation system. Remember that a joint taxation system signifies

that the marginal tax rate of the wife depends on the husband's (gross and net) income. And since the net wage of the wife depends on her marginal tax rate, by transitivity, it follows that the net wage of the wife depends on the net wage of the husband.

e) Knowing the hours offered by an individual and knowing the tax system is no guarantee that the marginal tax rate will be correctly estimated (when direct information on tax payments is available this problem is automatically resolved, but this is rather rare). Bourguignon (1986) finds that taxes actually paid diverged significantly in some cases from the official tax figures. The discrepancy here is due to the large number of specific deduction schemes in the French taxation system. As a remedy, he estimated a deduction function instead of using the official figures. Another case arises when taxes vary between areas because federal taxes represent only a small portion of total taxes paid, as is the case for Switzerland (Grift and Siegers, 1993). Another type of difficulty arises in a country like the U.S. where workers are offered the choice of tax treatment, it is difficult to estimate the effective tax rate, since we cannot know which regime a worker will prefer. A possible solution is to assume that they will adopt the regime that minimizes their tax burden. In any case using tax tables to find marginal tax rates is often not sufficient. Finally, discrepancies between official and paid taxes can be due to tax evasion.

f) With nonlinear BS, wage elasticities require care in their derivation. The problem is that the hours function is not a valid representation of behaviour for the entire BS: "With nonlinear budget constraints the hours function cannot be used to derive elasticities since it is not defined at corner positions." (Arrufat and Zabalza, 1986:57). It is generally advised to derive elasticities using stochastic simulation models rather than using regression coefficients (Zabalza, 1983).

Econometric remedies¹⁶

The endogeneity of the net wage rate implies that the standard estimation techniques need important modifications. First consider the estimation method. Previous to the consideration of nonlinear BS studies used OLS, two-stage least squares (Rosen, 1976a), weighted least squares, and instrumental variable procedures. With the introduction of taxes, the choice is restricted: OLS are rejected because the error term is heteroscedastic, and they give biased parameter estimates (Neff, 1990); with weighted least squares the error term is not normal, and no statistical inferences are permitted. The method of estimation most commonly used today is the maximum likelihood method (Hausman & Ruud, 1984). Nonetheless, in the absence of sample selection bias, least squares give very similar results to the latter method (Hausman, 1980).

An alternative to the maximum likelihood method is to make use of instrumental variables. This is appropriate when the net wage and virtual income corresponding to desired hours can be imputed correctly (Triest, 1990). Gross wage and unearned income can act as instruments for the net wage and virtual income. While this method is rarely used, it has the advantage of not being very sensitive to deviations between desired and observed hours of work (Triest, 1992).

The second important modification imposed by taxes concerns the treatment of the BS. In the 1970s and up to the early 1980s, the approach most commonly used was the linearization of the budget constraint, that is, to assume that the marginal tax rate applying to the whole BS is the one applying at the desired hours of work (Hausman, 1981), or the actual hours of work. However, this approach requires the absence of measurement errors in hours of work (Griff and Siegers, 1993). This is so because when linearization is adopted, the BS is linearized at the actual number of hours worked. Hence, if hours of work are measured incorrectly and that linearization is used, the whole

BS will be misspecified.

This simplification by linearization might have different consequences for men and women, because nonlinearities are not uniformly distributed across the BS. Most BS can be divided into three major parts: the lowest part, which is highly nonconvex and nonlinear, because of benefits and deductions; the middle part, which is close to linearity; and the last part, corresponding to higher incomes, which is highly nonlinear (Blundell et al., 1992). The lowest income groups are generally removed from the sample, so they do not constitute a serious problem. Hence the only major nonlinearities are to be found for high income groups, but few women are found there, since women's average earnings are smaller than men's. This suggests that linearization can be less of a problem for women.

A variant of this approach is to use the tax rate applying to an arbitrary number of hours for the whole BS. While this method avoids the bias induced by the least square method, it is ad hoc, and offers very little robustness (Nakamura and Nakamura, 1981). Moreover, neither method offers any solution to the nonconvexities. An alternative would be to convert the tax into a change in wage rates at the marginal tax rate; however, this is appropriate only for a proportional tax system (Macrae and Yezer, 1976). All three methods are discredited today.

The approach adopted at present to deal with taxes is the iterative estimation procedure, also known as the full information maximum likelihood method (Blomquist and Hansson, 1990)¹⁷, first used by Hausman (1981). The method recognizes the fact that nonlinearities and nonconvexities are a characteristic of any tax system, which should not be over-simplified, much less ignored. The idea behind the approach is that, given the variety of effective marginal tax rates and conditions of part time/full time work, the only meaningful operation is to "associate individual labour supply

responses with corresponding marginal tax rates" (Blundell, 1992:16) through micro-simulation analysis. The method can be summarized in four steps:

a) The participation function is estimated as in the standard case.

b) The wage and labour supply equations are estimated jointly. Various computational techniques can be used for this purpose: numerical optimization algorithms, the gradient method and/or direct search methods (Blomquist and Hansson, 1990).

c) The third step is the derivation of preferences. When the BS is nonconvex, we need to derive an explicit utility index in order to be able to compare the utility yielded by different segments of the BS and then choose the global maxima (Feenberg and Rosen, 1983; Hausman and Ruud, 1984; Zabalza, 1983). When the BS is nonlinear but convex, the use of an explicit utility index is not a necessity; although it is still useful to derive one (Arrufat and Zabalza, 1986), for two reasons. First, without a utility function, the effects of tax changes cannot be simulated (Bourguignon, 1990; Zabalza, 1983). Second, labour supply depends on observable factors such as the wage rate and personal and social characteristics, but also on unobservable factors. Stochastic variation in labour supply may be due to other factors, such as optimization errors and hours constraints, but the most important component of stochastic variation is tastes (Hausman, 1980). This indicates that introducing a stochastic component representing preferences captures a larger share of the labour supply decision.

The utility function can always be derived by virtue of the integrability condition (Hausman, 1980). By making use of Roy's identity, the indirect utility function is derived by integrating the labour supply function (Hausman, 1980). This method allows the use of empirical data to drive the utility function (Hausman, 1985).

The utility function can take various parametric forms. The choice is contingent upon the type of restrictions the researcher wishes to place upon wage and income elasticities. Gerfin (1992) uses a quadratic utility function, which has the convenience of allowing the labour supply curve to be backward bending. The CES utility function is interesting because it does not require the use of an explicit expression of hours, even if the ultimate objective is to study the determinants of hours worked¹⁸ (Zabalza, 1983). Other possible forms are Cobb-Douglas, translog, and a linear system.

Independently of the form of the utility function, the labour supply function depends on a parameter that is a taste shifter that accounts for individual heterogeneity with respect to preferences (MaCurdy et al., 1990). Even for given functional forms, there is more than one way of incorporating preferences in the labour supply function. For instance, Hausman (1980) includes the randomness of preferences in the income coefficient, while in Van Soest et al. (1990) it is included in the constant term.

d) Once preferences are known, the following step entails the search of the whole BS: "the statistical model must be able to evaluate the woman's preferences for work at all points along the BS rather than just about zero hours of work." (Mroz, 1987:786). The method has two variants, depending on the assumptions regarding convexities.

When the BS is convex, utility is maximized over the first segment of the BS, using the relevant marginal tax rate. If the number of hours of work (L) maximizing utility is negative or nil, this means that the individual will prefer not to participate in the labour market, and the solution is $L=0$. If L falls on the segment in question, then L is the solution. However, if L is larger than the maximum number of hours at which this marginal tax rate is applicable, then we have to move to the second segment on the BS, and re-do the mechanism until a number of hours maximizing utility

falls on the same segment of the BS to which the relevant marginal tax rate applies. The solution is unique. Most studies prefer to convexify the budget set and use this approach.

When the BS is nonconvex, the optimum is not unique. The approach used is to maximize utility at each segment of the BS, and then to choose the global maximum (Hausman, 1984; Hausman, 1985b). or, in other words: "the maximization of utility can be broken up into maximization over convex subsets of the budget frontier followed by maximization of utility over the entire set of solutions." (Hausman and Ruud, 1984:243).

Aside from estimation techniques, some simplifications on the data can also help reduce nonlinearities and nonconvexities. For instance, Macrae and Yezer (1976) suggest the suppression of observations on families with gross income at or near levels where marginal rates change (i.e. at tax kinks on the BS); this is expected to reduce the problem of nonconvexities. Another useful simplification is to reduce the sets of hours worked; in Gustafsson (1992) the wife is given only two options: working 10 hours or 40 hours. Another option is to use wide tax brackets (Leuthold, 1978a), thus simplifying the progressivity of the tax system. This causes more individuals to fall within, rather than between brackets, and therefore reduces nonconvexities. Finally, Rosen (1976a), Laisney et al. (1993) and Blundell et al. (1992) choose to remove individuals paying tax and simultaneously receiving benefits. The potential cost of this simplification is to end up with a sample where low-income families are under-represented.

In all cases, there is a trade-off between the efficiency of estimates on the one hand, and the simplification of the BS and the robustness of estimates, on the other hand (Blundell, 1992). Most studies seem to favour the simplification of the BS at the expense of efficiency. This may constitute part of the explanation of the wide range of empirical estimates, as we will see in the next section.

4. Empirical findings

Taxes can affect labour supply by affecting the participation decision or by altering the desired hours or worked. Theory does not inform us about the effect of an increase in the tax rate on hours of work (Hausman, 1985a; Killingsworth, 1983), only empirical studies can determine which dominates, between the negative substitution effect and the positive income effect resulting from an increase in the tax rate. Nevertheless, theory predicts that taxes will have a negative effect on participation (Nakamura and Nakamura, 1981; Schettkat, 1989). The hypotheses generally tested concern the signs and magnitudes of taxes elasticities, the estimates of DWL, and the interdependence of spouses' behaviour.

The effect on participation

Theory predicts that taxes will have a negative effect on participation notwithstanding the sign of the wage elasticity (Schettkat, 1989). This is so because the unpredictability of the effect of taxes on labour supply comes from the opposing effects of a negative substitution effect and a positive income effect. However, since there is no income effect for non-workers (Nakamura and Nakamura, 1981), the theory predicts an unambiguous negative effect on the probability of participation. As the remainder of this section shows, findings do not yield strong support for the theory in this case.

Few studies quantify the effect of taxes on participation. Leuthold (1978a) finds a negative tax elasticity for participation of married women in the U.S. of -0.122 for white women and -0.236 for black women¹⁹. Grift and Siegers (1993) estimate that income taxes reduce the participation rate of Swiss married women by 8 percentage points, compared to 2 percentage points for single women.

Hausman (1980) also finds that a higher marginal tax rate lowers the probability of participation. The figures of these studies are not immediately comparable; we retain that they find a significant negative effect on the participation rate.

Most recent studies propose different findings; they find that taxes do not affect participation significantly. Van Soest et al. (1990) fail in attributing the lower participation rates of married women in the Netherlands to taxes. Gustafsson (1992) finds that taxes affect the participation decision of German part-time female workers, while they have no effects on full time workers. Grift and Siegers (1993) find a global weak effect on the participation of Dutch married women²⁰. In Sweden in 1971 a tax reform lowering taxes on secondary earners (mainly women) was implemented, and while theory predicts an increase in women's participation in this case, such an increase did not occur (Tegle, 1985). These studies suggest that the theory, if not refuted by the data, is not confirmed neither.

But the case of Sweden is somewhat subtle. In that country, until the recent tax reforms, marginal tax rates were among the highest in the world. At the same time, women's participation rates were also extremely high, around 85% (Gustafsson, 1992), because the return to the household from the first hour of work by the woman is much higher than the return from an additional hour of work by the man, the primary earner in most cases (Swedish workers are subject to separate taxation). This situation can be seen as the outcome of two aspects: first, high marginal tax rates should induce a lower participation rate. Second, separate taxation encourages women to participate in the labour market. And because of this separate taxation, high taxes play the opposite role they usually play: by penalizing men working too large a number of hours, they encourage women's participation. The paradox is that the two effects, while at first glance play in opposite directions,

reinforce each other (the negative effect of taxation on women's participation may still be there, however it is expected to be negligible when compared to its discouraging men's labour supply). This brings our attention to two matters: first, when comparing tax rates across countries, it is necessary to take into account the nature of the tax system (joint/separate); second, separate taxation has a strong positive influence on women's participation.

The effect on hours of work

Since there is a direct relationship between wage and tax elasticities, women are expected to react to taxes more than men, given that their labour supply is more wage elastic (Blundell, 1992). Three basic indicators serve to evaluate tax responses: the wage coefficient in the labour supply function, tax elasticities, and dead weight loss (DWL). Tax elasticity can be defined as the percentage change in hours worked induced by an increase of 1% in the tax rate (Leuthold, 1978b). DWL is the equivalent variation²¹ minus the revenue raised by the tax system (Griff and Siegers, 1993)²².

There is a strong positive relation between wage elasticities, tax elasticities, and the DWL of taxation. However, by themselves wage elasticities are a very imprecise indicator of tax effects. Paradoxically, many studies whose primary object is to evaluate tax effects do not give any synthetic measure of tax responses other than the wage effect. What is interesting is that even these studies (and even those studies not accounting for taxes at all) give us a -rough- information about tax effects, to the extent that the sign of the tax elasticity is the reverse of the sign of the wage coefficient in the labour supply function. As women have positive own-wage effects, these studies predict negative tax effects.

During the 1970s and up to the mid-80s studies used tax elasticities. However, these are discredited today because they are much too sensitive to statistical and economic assumptions and to estimation techniques. The standard measure of tax effects at present is DWL. I first analyze tax effects in the light of available estimates of tax elasticities, and then turn to DWL estimates.

Most studies find negative supply tax elasticities for married women. The results in Table 1 indicate that tax elasticities oscillate between -0.049 and 0.052. Tax elasticities are much smaller than typical wage elasticities. Nonetheless, since changes in marginal taxation rates (in percentage terms) are usually large, the real change in hours worked is higher than what these small magnitudes might suggest (Leuthold, 1978a). Also, at first glance, the range of tax elasticities is narrower than the wide ranges of estimates of wage elasticities between different studies. However, in light of Leuthold's argument, the differences between tax elasticities imply larger differences in labour supply responses than what their small magnitudes suggest. The conclusion that emerges from the first generation of studies is that taxes affect women's labour supply negatively and significantly.

Table 1- Tax Elasticities

Study	Tax Elasticity	Race	Country
Leuthold (1978b)	-0.027	White	U.S.
Leuthold (1978b)	-0.024	Black	U.S.
Leuthold (1979)	0.052	White	U.S.
Leuthold (1979)	-0.001	Black	U.S.
Hausman & Ruud (1984)	-0.038		U.S.
Cloutier (1986)	-0.049		Canada

Source: Author

I now turn to the second measure of tax effects, the DWL. Table 2 shows estimates from a sample of studies suggesting that the effect is definitively negative and significant. The DWL relating to married women's work oscillates between 15% and 58%, and is generally larger than men's DWL. But DWL tends to overestimate the efficiency loss, since it is based on an unrealistic

lump sum tax (Van Soest et al., 1990). At the same time, numerous other studies find negligible tax effects: Grift and Siegers (1993) for Switzerland, Triest (1990) for the U.S., Colombino and Del Boca (1990) for Italy, and Bourguignon (1986) for France.

Table 2- Dead Weight Loss estimates

Study	DWL		Country	Hours restrictions
	Women	Men		
Hausman (1981)	58.0%	28.7%	U.S.	
Hausman & Ruud (1984)	29.6% ^a	—	U.S.	
Grift (1988)	27%	—	Netherlands	Yes
Grift (1988)	37%	—	Netherlands	
Van Soest et al. (1990)	30.3%	32.6%	Netherlands	
Van Soest et al. (1990)	15.4%	10.7%	Netherlands	
Blomquist & Hans.(1990)	25.8%	15.7%	Sweden	
Gerfin (1992)	26%	—	Switzerland	
Gerfin (1992)	12% ^b	—	Switzerland	
Gerfin (1992)	20%	—	Switzerland	Yes
Gerfin (1992)	2% ^b	—	Switzerland	Yes

Source: Author

a.couples

b.single women

In order to complete the analysis of DWL it is necessary to look at the estimates of tax illusion, since the effective DWL could be smaller or larger than what is presented in Table 2 if individuals were subject to tax illusion. Rosen (1976b), Nakamura and Nakamura (1981), and Stelcner and Breslaw (1985) conclude that individuals are not subject to tax illusion, while Cloutier (1986) conclude in favour of tax illusion: he finds that individuals under-estimate their effective tax rates, suggesting that the DWL would be smaller than otherwise. Mroz (1987) cannot conclude in favour or against tax illusion. Tax illusion analysis belongs to the first generation of studies on labour supply and taxes; it is likely that the failure of most studies to conclude in favour of tax illusion is the most important cause of its dismissal.

Taxes affect social groups of women differently. Hereafter the results are decomposed by age, income, and hours groups. There seems to be a negative relationship between wage -and therefore, tax- elasticities and age. Table 3 shows wage elasticities by age group for a sample of

studies. What is important in this table is not the differences in estimates between studies, but rather the decrease in the wage elasticity for older women for a given study. This negative relationship suggests that taxes can alter the age composition of working women (Schultz, 1980).

Table 3- Female wage elasticities decomposed by age group

Study	Uncompensated wage elasticity by age group	
	20-34	35-54
Stelcner and Smith (1985) ²³	0.0133	0.0304
Nakamura and Nakamura (1981) ²⁴	-0.317	-0.071
Nakamura and Nakamura (1981)	-0.320	-0.083
Schultz (1980) ²⁵	0.0595	0.0136

Source: Author

None of the studies examined attempted to provide a theoretical justification of this relation. One possible explanation can be related to human capital considerations. Younger workers have a lower opportunity cost to withdrawing from the labor market, since the foregone (net) wage is lower, and since they can substitute human capital investments for immediate work. Whereas for older workers human capital investment is less appealing, and hence leaving the market place in reaction to a reduction in the net wage has a higher opportunity cost. A second explanation can be found in the fact that pension accruals become important in the pre-retirement years. In this context, pension benefits can be considered part of a deferred compensation package, which motivates older workers to accept net wage reductions without notable reductions in their labor supply.

There also seems to be a relation between income and tax elasticities. Studies typically find that the labour supply of the highest income groups is less responsive to taxes (Hausman, 1981; Bourguignon, 1986; Gerfin, 1992). One explanation is that for high income families, women's income represents a lesser proportion of total income (Bourguignon, 1986). However, Grift and Siegers (1993) find that the relation between tax effects and income is positive (but weak).

Finally, taxes seem to have a larger effect on the participation and labour supply decisions of full-time workers than on that of part-time workers (Grift and Siegers, 1993; Blundell, 1992; Cloutier, 1986). Only Gustafsson (1992) finds substantial wage and tax effects for part-time workers.

One way of analyzing tax effects is within a household framework. The most obvious question is the effect of taxes on total family labour supply. Kusters (1969) finds that families are on a backward bending supply curve, while Hausman and Ruud (1984) estimate that families are on an upward bending supply curve. Leuthold (1979) has mixed findings: white couples would be on a backward bending curve, while black couples would be on an upward bending curve.

In household models we are also interested in the redistribution of work across the two earners. Leuthold (1979) provides the only estimate that could be found for this phenomenon. He uses the concept of labour-share elasticity, which is the percentage of change in one spouse's share of total family labour resulting from a change in the marginal tax rate. He finds that an increase in the spouse's money wage (or a decrease in the spouse's marginal tax rate) reduces the wife's share in family labour.

The third issue in household models is cross effects: how do changes in a spouse's hours of work (and hence his marginal tax rate) affect the behaviour of the other spouse. The effects are in the same line as the cross wage effects: changes in the wife's tax rate have little effect on the husband's labour supply, but the converse is not true. Moreover, there seems to be negative correlation across households between husband's income and either wife's labour force participation probability or wife's hours of market work (Qeuster, 1977). This asymmetry of cross-effects can be traced back to three factors: a) the adoption of some households of a traditional division of responsibilities; b) the husband has a comparative advantage in the labour market in most of the

cases (Hunt et al., 1981); and c) husbands have weak wage effects.

During the early 1980s it seemed that it would soon become necessary to analyze married women's labour supply within explicit household models rather than by considering the husband's work behaviour as exogenous. The fact that the findings from household models are not significantly different from individual labour supply models, and that cross effects are not symmetric, explains why household models are less popular today: the similarity of the results obtained from the two families of models allow us to accept the assumption of sequential decisionmaking. The assumption may have remained the same, nevertheless its economic foundation has dramatically changed: while before it was based on the traditional sequential decision-making, it is now based on an observable fact, that is, men's weak response to changes in wages and taxes.

Discussion of empirical findings

The reliability of the estimates presented above has been subject to debate, for three major reasons. First, the results are very sensitive to estimations methods, to economic and statistical assumptions, and to the instruments used (Mroz, 1987), and this sensitivity is accentuated by taxes (Feenberg and Rosen, 1983; Blundell, 1992). To test the extent of this sensitivity, in a seminal work Mroz (1987) shows that by using alternative economic and statistical assumptions, a single data set can yield most of the estimates found in the literature on married women's own-wage effects. This casts doubts on the robustness of such estimates, and, of course, on tax effects which are based on wage effects.

Second, when the labour supply curve is nonlinear, the wage elasticity is very sensitive to the point at which it is evaluated (Blundell, 1992), and is valid only for local movements along a

given budget segment (Triest, 1990). This suggests that the models can serve as simulations only for small changes in the tax rates (i.e. locally). Hausman (1980) goes even further, suggesting that with nonlinearities elasticities are not meaningful, because the nonlinearity of the BS can lead to large changes in labour supply in response to small tax rate changes. That is, the response to a given tax change can be negligible for individual a, but important for individual b, although a and b are identical from all points of view, except that b is closer to a kink in the BS (Hausman, 1985a). The higher the progressivity (i.e. the higher the number of kinks in the BS), the more important this problem is.

Third, even if this last problem were overcome, elasticities would still be subject to at least one other limitation. One implicit assumption underlying elasticities is the symmetry of entry into and withdrawal from the labour market. But this need not be the case:

... this [entry into the labour market] constitutes a new situation for them [the workers] to which they will adapt by changes in their standard of living and habits. Thus, even if people were drawn into the labour market by high real wage rates, their reaction to a subsequent reduction in wages will not be symmetrical. The decision whether or not to withdraw from the labour market is based on a different experience and is taken in a different situation than the decision to enter the labour market. (Schettkat, 1989:5)

In other words, moving in one direction along the labour supply curve might be easier than moving in the other direction. Theoretically, this is equivalent to a change in preferences.

Another issue in the debate on the estimates is the large differences in wage responses between married women and all other social groups, including men and single women. Traditionally, married women were thought to be among the rare groups in society whose labour supply is significantly affected by taxes. What is interesting is that *nearly* all estimation methods yield higher wage and tax effects for married women, making of the importance of wage and tax effects one of the more secure facts in empirical economics (James, 1992). But since the late 1970s a number of

studies have challenged these findings by estimating very weak (sometimes negative²⁶) wage effects, suggesting that married women's response to wages and taxes is not any different from prime aged males' behaviour. The discrepancy between the earlier large estimates and the recent more conservative ones can be traced back to three common econometric "errors":

First, the strong wage effects for married women would come from what happens at the participation, rather than the hours, level. Because married women have a lower participation rate, small variations in wages will induce labour market entry for a large number of women, and hence an increase in total hours. Whereas, for men, participation not being sensitive to wages, the net result is dominated by the reduction in hours by working men (Robinson and Tomes, 1985; Nakamura and Nakamura, 1981)). Hence the high wage effects would be but an extrapolation of participation effects while, in fact, wage effects for *working* women are smaller than what they are thought to be (Bourguignon and Magnac, 1990; Blundell, 1992; Mroz, 1987). This is confirmed by the finding that, for men, when only working men are taken into account, the wage response is negative, while when nonworking men are taken into account the global response is positive (Nakamura and Nakamura, 1981).

While the two-step method controls for this problem, the Tobit method does not. The problem with the Tobit model is that it exaggerates the income and wage effects (Mroz, 1987). This is so because the impact of experience on participation can only take place through the wage effect in the labour supply equation. The Tobit model has many other defects when used in labour supply models: it imposes a proportionality between the spread between the market wage and the reservation wage on the one hand, and preferred hours of work on the other hand (Nakamura and Nakamura, 1981); it does not allow for fixed costs to work, for it assumes that the labour supply

schedule is continuous (Killingsworth, 1983); and it assumes that the participation decision and the hours of work decision are determined by the same factors (Killingsworth, 1983), a view that is largely discredited today (Mroz, 1987). These constitute strong constraints imposed upon the data, which all contribute to forcing the participation effects to take place through the wage effect, and to the estimation of upward biased coefficients.

The second source of bias resides in the treatment of the wife's past labour market experience. Traditionally, this variable was considered exogenous, and in consequence was an acceptable instrument for the wage rate. However, there is strong evidence that the wife's labour market experience is endogenous to the labour supply decision, implying that it is an invalid instrument (Nakamura and Nakamura, 1981; Mroz, 1987). The problem is that experience captures "not only some of the effects on hours of work of experience related differences in the offered wage rate, but also unmeasured tastes and preferences for work reflected in the work histories of each wife." (Nakamura and Nakamura, 1981:480). This erroneous treatment of experience as exogenous has led to a large number of upward biased estimates.

The third argument is concerned with the point of evaluation of elasticities. Usually female elasticities are evaluated either at the mean of working females or at the mean of all females in the sample. By evaluating female elasticities at the mean for *males*, Blomquist and Hansson (1990) find that male and female elasticities are very close. They claim that the differential response is merely due to the practice of evaluating elasticities at different points. Blundell (1992) also notes that wage elasticity is sensitive to the point of evaluation, and that this sensitivity is accentuated by nonlinearities in the BS.

These recent findings go against "a stylized fact that has generally been an article of faith

among researchers." (Killingsworth, 1983:401), and needless to say that this line of thought has entirely different implications for the analysis of tax effects on married women. In any case, more recent studies, adopting more robust estimation methods, and correcting for the errors presented above (except the third one, which is rarely discussed) tend to find smaller wage and tax effects (Blundell, 1992; Mroz, 1987). This suggests that the high estimates of tax elasticities and DWL for married women are not accurate.

5. Recent theoretical developments

Recent studies have attempted to reduce the number of implicit assumptions. In this section I discuss the introduction of hours restrictions and deductible expenditures into the labour supply model.

Hours Restrictions

The standard model assumes that hours restrictions are not important. However, in most of the cases the data seem to support hours restrictions: First, the fact that some work durations have spikes suggests that hours restrictions are binding²⁷ (Van Soest et al., 1990). Second, the models with hours restrictions have a better fit (Van Soest et al., 1990; Grift and Siegers, 1993). Third, with hours restrictions, desired hours of work for women are greater, suggesting that many women would like to work a larger number of hours (Van Soest et al., 1990).

The results obtained with hours restrictions usually indicate smaller DWL (see Table 2 above). This is so because hours restrictions imply that women will not always be in a utility maximizing position, in which case the introduction of a hypothetical lump sum tax (in order to

calculate the DWL) hardly has an influence on their work behaviour (Gerfin, 1992). We can hence say that hours restrictions cause taxes to be less important for working women. Not only do hours restrictions reduce the DWL of taxes, they replace them as a source of welfare loss: Grift and Siegers (1993) conclude that hours restrictions impose a higher welfare loss than taxes, and that policy should be aimed at increasing hours flexibility (part-time jobs) rather than massive tax reforms which outcome is doubtful.

Deductions

One of the apparently most innocent simplifications in labour supply models is the representation of the total amount of consumer goods by available income in the utility function. Triest (1992) notes that implicit to this approach is a neglect of a fundamental aspect of labour supply decisions: deductible expenditures. The issue of deductions and labour supply is not entirely new, since it has been pointed out by Boskin (1973).

The idea behind the traditional approach is Hicksian separability: when the relative prices of a group of commodities are constant, then that group of goods can be treated as a single commodity. In the absence of deductions, all commodities can be treated as a single commodity, except leisure, which price (the net wage) varies with changes in labour supply. When deductions are applicable to some goods, we need to consider two composite goods: the group of nondeductible expenditures, and the group of deductible expenditures (and, of course, leisure). Because the price of deductible consumption is one minus the marginal tax rate, this price varies with labour supply, and is no longer constant with respect to the price of non-deductible expenditures (Triest, 1992). Deductible expenditures imply that the effective marginal tax rate is lower than the statutory

marginal tax rate (Triest, 1992).

In terms of estimation the problem is that the marginal tax rate is not independent of either hours worked or deductions: "when the commonly used linear labour supply model is modified to allow for endogenous deductions, the coefficients on both the net wage and income terms may depend on the marginal tax rate." (Triest, 1992:91). In this context the labour supply function is linear in the wage and virtual income, but is nonlinear in the marginal tax rate.

Naturally, the effect of taxes on labour supply is complicated further. While previously changes in the marginal tax rate affected labour supply only through the net wage and nonlabour income, now we have to consider also the effect through the price of deductible consumption (Triest, 1992). For instance, decreasing the tax rate increases the net wage, and increases the relative price of deductible consumption. The effect of the former depends on the sign of wage elasticity, while the latter will always have a negative effect on the supply of labour, because deductible consumption is an uncompensated substitute for leisure.

The question remains whether the magnitude of the effects of deductions is important enough to alter the results. The only such estimates available are those of Triest, and they suggest that deductibles are indeed an important aspect in the labour supply decision. Triest finds an uncompensated wage elasticity of -0.081, and a uncompensated elasticity for deductions of -0.632²⁸. This means that the effect of a change in taxation on labour supply is much more important through deductions than through the net wage.

Triest does not extend his analysis to women. Here, the uncompensated wage elasticity is positive, while the deductions elasticity is negative. In this context, decreasing the marginal tax rate will lead to: a) an increase in the net wage, and thus an increase in labour supply; b) an increase in

the relative price of deductible consumption, and thus a decrease in labour supply. A large number of studies not considering deductions find positive wage elasticities, suggesting that for women the (positive) wage elasticity is larger than the (negative) deductions elasticity. Surprisingly, no studies developing the analysis of deductions further could be found; the lack of data is one possible cause.

In any case, considering deductions as endogenous is one step toward the integration of the multi-dimensional aspects of taxation in the basic labour supply model.

6. Policy implications

This work is not directly concerned with optimal taxation theory. Nevertheless, the results presented up to now have important policy implications. Even if the lack of robustness of the results makes them rather unreliable for quantitative policy analysis, they can still serve as general guidelines. In this section I discuss four policy implications: the relation between taxation and unemployment, the relative tax rates between men and women, the use of DWL estimates, and the overall importance of taxes.

Taxation and unemployment Taxes are often said to depress the economy by, among other things, decreasing labour supply. However, in light of the foregoing analysis, taxes can also have a positive impact on labour supply, at three levels (in a partial equilibrium framework). First, the finding of almost nil wage effects suggests that taxes do not reduce labour supply significantly; moreover, the finding of negative wage effects for married women suggests that taxes can stimulate labour supply. Second, higher unemployment (caused by taxes) signifies that a larger number of men are unemployed, hence reducing women's nonlabour income, and causing an increase in women's labour supply (Rosen, 1976a; Grift and Siegers, 1993). Nonetheless, this argument is weakened by the

finding that women married to unemployed men are less likely to participate in the labour market (Blundell, 1992). Finally, the effect on aggregate labour supply is complex. Consider the following example: an increase in the tax rate leading to a reduction in labour supply, which in turn creates certain scarcities in some occupations, thus putting upward pressures on wages in these sectors, and increasing labour supply (while it has decreased it in the first place)²⁹.

Female's and male's tax rates Common sense suggests that equal tax rates for men and women is a fair policy. However, many arguments favour taxing women at lower rates. First, a higher wage (and hence tax) elasticity of labour supply translates into a higher DWL, implying that in order to minimize the latter the rate of income taxes must vary inversely with wage elasticity (Cigno, 1991; Boskin and Sheshinski, 1979). Now, we know that women's labour supply is more wage elastic than men's (although this is more doubtful today), suggesting that taxing women at a lower rate reduces the DWL of taxation. However, this argument ignores the fact that although the DWL for women is higher in relative terms, it is smaller in absolute terms, since men face higher marginal tax rates (Van Soest et al., 1990).

Second, apart from own-wage effects, cross-substitution effects (not gross cross effects) are also important. It is efficient to tax the earner with smaller cross-substitution effects at lower rates (Boskin and Sheshinski, 1979). Empirical findings show that wives have smaller cross-substitution effects (even though they have larger gross cross effects). Third, it is optimal to tax the worker with lower earnings variance at a higher tax rate (Boskin and Sheshinski, 1979). It is well known that men's jobs are on average more stable and that their participation to the labour market is less subject to conjunctural factors. Fourth, the tax rate should be proportional to the elasticity of the government revenue to that tax (Cigno, 1991:177). But the elasticity of governments' revenues with respect to

women's income is less than for men, given that women contribute less to government tax revenues.

This suggests that if the preferences of the social policy-maker are egalitarian, women's income should be taxed at a lower rate than men's. The fifth argument in favour of lowering women's tax rates is that taxing the husband at a higher rate can simulate economic activity in two ways: i)

because men are on a backward bending supply curve, higher taxes should stimulate their labour supply; ii) because the husband's income is considered as exogenous income for the wife, taxing this exogenous income at a higher rate implies that the wife will be induced to increase her labour supply and her likeliness to participate into the labour market (James, 1992). Sixth, the actual tax system implicitly discriminates against women, since the exemption of home production from taxation reinforces traditional sex roles (Spahn et al., 1992). In this perspective, lowering women's tax rates can help counterpart this discrimination. Finally, because lowering taxes reduces men's labour supply and increases women's labour supply, decreasing women's tax rates can constitute a positive action measure in favour of women^{30 31}. Clearly, all seven arguments argue in favour of lower tax rates for women³². Just like equal shares are not always desirable under heterogeneous preferences, equal tax rates do not mean that the tax system is fair. Nonetheless, it is easy to conceive the difficulties of implementing such a policy.

The use of DWL estimates Even if empirical studies could show that the effect of taxes on labour supply is negligible, this might be due to the effect of compensating income and substitution effects. Consequently, it is not only gross tax elasticity that matters, but also compensated and income tax elasticities. The former gives the response to a higher tax with the amount collected being refunded to workers (this would be of particular interest if one believes in the assumption that in a general equilibrium analysis the income effect is nil), while the latter measures the response to a lump sum

tax (Killingsworth, 1983). Hence, the finer the tax policy is, the more details we need to know about tax elasticities, in order to estimate the response.

Do taxes really matter? Because married women have lower participation rates and that participation seems to be more responsive to taxes than hours worked (Colombino and Del Boca, 1990), and because married women have higher wage elasticities than most other social groups, the analysis of tax effects for that group seems important. However, recent more conservative estimates suggest that taxes are not that important. Apart from small wage effects found in such studies, five other factors support this proposition. First, Mroz (1987) finds that wage coefficients which control for taxes lie within one-fifth of one standard deviation of the estimates without taxes. Hence, the influence of taxes appears to be insignificant, especially when compared with the other potential sources of bias. Second, when hours restrictions are taken into account (most studies don't consider hours restrictions), the estimated DWL is smaller. Third, the decreasing role differentiation between women and men implies that more and more women will have their preferences biased in favour of market work, indicating that wages, and hence taxes, could become less important with time. Fourth, some implicit assumptions, like the exogeneity of fertility, the omission of child care credit, and the overlooking of the fact that demand side considerations imply that often employers will set $w=w(h)$ with $w'(h)>0$, induce an upward bias on the estimated wage effects. Finally, loopholes and deductions reduce the progressivity of the tax system, making it closer to a proportional scheme (Pechman and Okner, 1974). In this context, taxes will affect only the participation decision, while their effect on the preferred number of hours of work will be secondary.

7. Summary and Conclusions

In this work the major theoretical, econometric, and empirical aspects of taxation in female labour supply models were discussed.

Taxes introduce important nonlinearities and nonconvexities in the budget set, creating many theoretical difficulties, the most important being the nonuniqueness of the optimum, and the invalidation of standard wage and income elasticities. Moreover, women's budget constraints have many particularities, which are often difficult to formalize: these particularities relate to the wife's use of time outside the market, to the constant earning supply relationship, to the exogeneity of the husband's income, and to the existence of joint taxation systems. The 1970s and 1980s have seen the development of many tools proper to tax analysis in labour supply models, the two most common being virtual income and tax illusion analysis. But the large number of implicit assumptions in labour supply models put serious constraints on the realism of the models.

Tax effects are estimated within the standard labour supply model, with the use of the Probit participation function or the Tobit method, and Heckman's correction for sample selection bias. The endogeneity of the net wage induced by taxes creates many econometric problems: inconsistency of estimates obtained from the standard procedure; multicollinearity; difficulty of accurately estimating the effective marginal tax rate faced by the individual; and invalidation of the usual method of deriving elasticities. OLS and 2-stage least squares are not appropriate when the budget set is nonlinear; the only valid procedures are the maximum likelihood method and instrumental variables. The major difference with the traditional procedure is that the wage equation and the hours equation are estimated jointly using an iterative estimation method, a method relying on an explicit utility index. The BS is simplified by some adjustments on the data. There is a trade-off between the

efficiency of estimates on the one hand, and the simplification of the BS and the robustness of estimates, on the other.

Labour supply theory predicts a negative effect of taxes on participation, but does not put any constraint upon the sign of the wage elasticity. Earlier studies found important participation and labour supply effects, hence giving support for the theory. More recent estimates find weak participation and labour supply effects; a number of studies even find negative own wage effects. The results are strongly dependent on social groups. There seems to be a negative relation between wage elasticities on the one hand and age and hours worked on the other hand; also, there is a negative relation between wage elasticities and hours worked. Empirical estimates lack robustness, being subject to preferences, functional forms, simplifications on the data and on the budget set, and estimation techniques.

How well does labour supply theory perform in predicting and explaining the labour supply of married women? Not very well, it has to be said, and certainly less well than for men whose estimates are more robust and suffer less variation across studies (Blundell, 1992; Triest, 1990). On the participation side, the estimates do not either confirm or refute the theory. As for labour supply, it remains, to some extent, an untestable theory, since any response can be explained within the framework of compensating income and substitution elasticities.

Maybe the difficulty lies in the fact that the implicit assumptions are too strong, and many of them need to be relaxed. In section 5 we have seen examples of relaxation of the assumptions of hours restrictions and Hicksian separability. The problem is that actual models are capable of relaxing one assumption at a time, and it is not conceivable with the actual state of knowledge to build a *complete* labour supply model. This complete model would comprise: taxation, hours

constraints (Grift and Siegers, 1993), fixed costs (Hausman, 1980), negative income taxes, deductibles (Triest, 1992), richer measures of labour supply (Rosen, 1980), life-cycle considerations, and interdependent preferences (Blomquist, 1993). When we know that each study incorporating one of these elements along with taxation claims that neglecting this or that aspect yields biased and/or inconsistent estimates, it is legitimate to ask (if these claims are valid, and they probably are) what is the size of the bias in each of those studies induced by the neglect of all the other 'important' aspects. Nonetheless, the aim is not imperatively to converge toward a 'correct' model, for "Different assumptions are likely to be appropriate for different problems and data sets." (Heckman, 1993:119).

Notes

1. The modern theory of labour supply and taxation owes a lot to Hausman's (1981) seminal work. His contribution was two fold. First, he developed the final version of the concept of virtual income, which will be discussed later in the paper. Second, before his work most studies estimated that taxes had little effect on labour supply. He did find, like previous research, that the uncompensated wage elasticity was close to zero. The novelty is that he estimated a large negative income elasticity (for men). Knowing that progressive income taxation combines reductions in the net wage with lump sum subsidies for upper bracket tax-payers, the excess burden and the reduction in labour supply are more important than what is estimated from considering solely gross elasticities.

2. Other sources of nonlinearities are overtime, constraints on hours worked, and moonlighting.

3. Marriage exemptions point to deductions when the second worker is not participating in the labour market. Obviously, this rule increases the wife's marginal tax rate.

4. The concept is not new, for it is found in Quester (1977), and can be traced back to Mincer (1962) and Becker (1965). Nevertheless, its specific application to tax analysis was pioneered by Hunt et al. (1981).

5. In that country husbands and wives are allowed to pool their income and file a joint return (Boskin and Sheshinski, 1979).

6. Joint taxation is almost non-existent in Canada (Stelcner and Breslaw, 1985:1055). Still, some authors demand the abolition of marital unit taxation in Canada: "Marital unit taxation [in Canada] is shown to be discriminatory to women, by reinforcing the economic dependency of wives on husbands and by increasing the opportunity costs of work outside the home." (Maloney, 1987:1). What such critiques have in mind is not exactly joint taxation. The problem is that the distinction between joint and separate taxation is not clear cut: the effective tax rates of workers are not necessarily independent under separate taxation. This is so because separate taxation applies only for earnings, while other deductions and particular taxes may still create dependence of the marginal tax rate of the primary earner on the behaviour of the secondary earner. For instance, in Canada, a working spouse is granted tax relief if his/her spouse earns less than a certain amount (Maloney, 1987). Of course, this imposes a very large fixed cost on the entry of the second spouse on the labour market.

7. Omitting the tax perception parameter and using net wages is equivalent to imposing the constraint $\alpha=1$ (no tax illusion) (Rosen, 1976b).

8. This is not to say that children are not included in the labour supply equation. What it means is that the interactions between children and taxes, which might require secondary or important modifications in the specification of the equation (through dummy variables, for instance), are overlooked.

9. This positive relation between hours and wages is a potential source of nonconvexities (Hausman, 1981).

10. An alternative approach that is commonly used is the Tobit method. However, this method constrains the participation decision and the hours of work decision to have the same determinants, which is a strong assumption (Killingsworth, 1983; Mroz, 1987).

11. Triest (1990) estimates a model with both methods and finds that they yield very similar results. However, when the instrumental variables method is used, a smaller wage elasticity is estimated with the reported gross wage. This is an example of sensitivity of the results to specifications, since there is no theoretical reason a priori why fitted wages should be preferred over reported wages or the converse.

12. Although tax systems as such are progressive, Pechman and Okner (1974) have argued that, when all deductions and loopholes are taken into account, the actual tax burden reflects a proportional scheme. This suggests that not accounting for taxes does not introduce an important bias, or at least not as important as is generally thought, on wage, income and children coefficients, since the bias would be absorbed in the constant term.

13. There is a widespread consensus on this issue: Quester (1977), Leuthold (1978b), Nakamura and Nakamura (1981), Hunt et al. (1981), Bourguignon and Magnac (1990), and Stelcner and Breslaw (1985). Only Mroz (1987) finds that the bias goes in the opposite direction.

14. Ignoring taxes has more serious consequences for Europe than for the U.S., because European countries generally have higher tax rates and a greater degree of progressivity (Colombino and Del Boca, 1990). However, this does not apply to the U.K., whose tax system is less progressive than the American one (Brown et al., 1981).

15. It can be argued that even with gross wages there is some multicollinearity, to the extent that couples tend to have akin degrees of education and income. For instance, Smith (in *The Distribution of Family Earnings*, Rand Corporation mimeo, 1978) finds a substantial positive correlation between husband's and wife's wage rates.

16. The remedies discussed concern problems (a) and (b) of the last section; not much can be said at a general level about the other problems.

17. Even within a linear framework the full information maximum likelihood method is superior (Blomquist and Hansson, 1990).

18. In this case, individuals, instead of choosing a number of hours of work, determine an income/leisure ratio.

19. In the latter case, for instance, an increase of one percentage point in the tax rate would lead to a decrease of 2.36% in the probability of participation.

20. This global effect seems to be the sum of opposing effects for sub-groups: negative for 25-34 hours, positive for 15-24, and null for 1-14 hours. Traditionally, only the effect on labour supply could be decomposed by hour, income range group, and only a global participation effect could be estimated. More recent studies attempted to estimate participation effects by hours groups.

21. Equivalent variation is the maximum lump sum the individual is willing to pay instead of taxes without reducing her utility.

22. Suppose it is proposed to replace the tax system with a lump sum tax where the lump sum is equal to the tax paid now. The DWL is the maximum amount an individual is willing to pay in excess to the lump sum in order to get the lump sum tax system. This measure is based on the maximum utility level that can be attained now and does not rely on the imaginary utility level which could be attained in a world without income taxes (Gerfin, 1992).

23. In this case a Chow test was used, and the hypothesis that the two age groups have equal structures was rejected.

24. In this case the results are less negative for older women. The results of this study are averages of results for more detailed age groups.

25. The results of Schultz are less reliable because he uses OLS.

26. Studies having found negative wage effects include Nakamura et al., 1979; Nakamura and Nakamura, 1981; Robinson and Tomes, 1985; Stelcner and Smith, 1985. Interestingly, all these studies are based on Canadian data.

27. Blomquist (1993) notes that spikes in hours of work can also be attributed to interdependent behaviour, in the sense that individuals have a utility function with a quadratic loss in deviating from average hours (worked by other individuals).

28. These results concern men, which is clear from the negative uncompensated wage elasticity.

29. This argument suggests that taxes can affect the inter-sectoral wage structure. But it probably requires the response of labour supply to taxes to be more important than what it actually is, and is valid only for important changes in marginal tax rates.

30. A corollary is that a decrease in the overall (absolute) tax rate -independently of relative tax rates- also constitutes a positive discrimination measure in favour of women.

31. Discriminating positively in favour of increasing women's labour supply is equivalent to heterogeneous preferences of social policy, where women receive a larger weight than men.

32. If the argument for lower tax rates for women is valid, then joint taxation, especially without splitting, is rejected from the outset, since it imposes higher tax rates on women.

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