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by

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Abstract

In the face of complex budget constraints the assumption of rationally acting individuals having complete knowledge of the tax system is a theoretical borderline. The specific issues examined in this study are (i) "to what extent do consumers (here married women) perceive their true marginal tax rate when they make their labour supply decisions?", and (ii) "how does the perception of the marginal tax rate differ among various socio-economic groups?". Using different approaches and different data sets we consistently find that (i) against conventional wisdom the assumption of complete knowledge of the tax system does not fit the data well, and that (ii) education appears to be the main determinant of a correct perception of the marginal tax rate.

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1 Introduction

Existing tax systems imply complex budget constraints, so that the assumption of rationally acting individuals who have complete knowledge of the tax system has to be regarded as a theoretical borderline. Yet it is difficult to model the extent of the perception of tax costs, because questioning the rationality of economic agents leads the economist on unsteady ground. In this respect it is significative that Atkinson and Stiglitz (1980) address this perception problem only in connection with public goods (pp. 322-323), whereas it really applies to most of the situations they consider.

The specific issues examined in this study are (i) "to what extent do consumers (here married women) perceive their true marginal tax rate when they make their labour supply decisions?", and (ii) "how does the perception of the marginal tax rate differ among various socio-economic groups?". It is hardly necessary to dwell on the importance of this problem for investigators attempting to quantify the impact of fiscal policies on household behaviour. For instance, the idea to create economic incentives by reducing marginal taxes will only make sense to the extent that the tax reduction is perceived.

It is clear that investigating the individuals' perception of marginal taxes questions the paradigm of the rational utility-maximizing consumer. Empirical models of consumer behaviour following this paradigm incur the risk of mixing up normative and positive theory, in the sense that they are more likely to describe how the consumer should behave rather than how she does behave. Since the seminal work of Kahneman and Tversky (1979) we know that in certain well-defined situations consumers' choices under uncertainty are inconsistent with the assumption of rational acting. In these situations economic theory and econometrics will make systematic errors when predicting responses to tax changes.

In microeconometric models of labour supply it is usually assumed either that individuals have perfect knowledge about the implications of the tax system as to their marginal wage rates or that individuals only know their pre-tax wages (see for instance the survey of Hausman, 1985). From a purely theoretical point of view the latter approach is of course far less satisfactory. On the other hand, it can happen that models which adopt the perfect knowledge assumption do less well in terms of goodness of fit and diagnostic checks (see below, Subsection 5.1, for evidence from French data).

However, it is possible to think of alternative specifications of labour supply which nest the perfect knowledge case and the case of complete ignorance as parametrically extreme cases. This is the starting point for our analysis. Firstly, in using a logarithmic specification for models the wage, the latter is conveniently additively decomposed into a gross wage term and a marginal tax rate term which can be given different coefficients (see Rosen 1976a and b, and the discussion in Nakamura and Nakamura, 1981). Introducing interactions between the marginal tax rate and household characteristics is an easy way to allow for different behavioural patterns in this framework. Our empirical analysis will mainly focus on this extension of the standard labour supply framework. In a second step we try to find further evidence of systematic departures from the rational behaviour implied by the neoclassical labour supply model by allowing for different preference structures and different stochastic assumptions.

Workers in most western economies have only incomplete knowledge of their marginal wage when they make their labour supply decision. Unexpected changes in taxable income due to new collective bargaining arrangements, illness, extra bonuses, job change and overtime work produce tax uncertainty such that the exact knowledge on the true marginal tax rate is only revealed a posteriori, in the year following the one where decisions supposedly based on that knowledge are taken. Standard labour supply models under uncertainty are able to deal with this kind of uncertainty in a general manner by introducing the marginal wage rate as a stochastic price. However, by applying the usual rational expectations framework, little can be learned about which social groups have a better perception of the marginal tax rate.

Our motive for investigating differences in the perception by various social groups thus lies in the following considerations. Some individuals may have no real incentive to go to the trouble of gathering the information and knowledge necessary for the computation of their marginal tax rate, namely those who pay little tax anyway, and those who have higher costs for than anticipated benefits from gathering and processing information. This will in particular be the case for people who are relatively isolated.

In view of these points one may expect the poor, the unemployed, the less educated as well as the youngest and oldest cohorts (the latter may also fail to adjust to changes in the tax system, even if they had a good approximation of it at some point in their life cycle) to care relatively less about their marginal tax rate than the rest.

Wahlund (1987) argues from a psychological point of view that the perception of a reduction in marginal taxes depends on various factors such as the context or background, past experience as well as attention factors such as motives, expectations, and payoff. For instance, individuals who have faced large fluctuations in income as well as individuals experienced with the management of wealth, where taking taxes into consideration is very important, are likely to evaluate their true tax rate more accurately than others do. Following prospect theoretical reasoning he argues that an increase in the marginal tax rate should be perceived as bigger than a corresponding decrease later on, because the value function for losses is steeper than the value function for gains.

Some married women may even refuse to take their marginal wage rate into account, as being discouraging and unfairly high. This is likely to happen for relatively well-off women in the case of joint taxation with the same marginal tax rate on both earners. Individuals may also appear to disregard their marginal tax rate because they are prepared to work in periods where the usual simple static labour supply models would predict that it is not profitable for them to do so. Examples of such situations could be as follows: (i) better prospects later may make it attractive to work now, even if the immediate reward seems comparatively small (for instance trainees: their wage cannot explain their current labour supply; women re-entering the labour market after a non-participation spell for raising children: for psychological reasons, they may have almost zero *current* reservation wage, yet this may increase rapidly when they regain confidence); (ii) work may enter utility positively (social contacts, prestige, self-esteem, independence, etc.). Admittedly, the standard labour supply models are not able to handle these aspects, but the direction of the effects mentioned could be that women with older children will be less inclined to take account of their marginal tax rates than women with younger children or without children.

At any rate it seems interesting to try to see what data may have to say on these points, even if the interpretation of results pointing away from rationality calls for extreme caution. In the application of the models that this paper suggests, we shall use panel data for Germany and cross-section data for France. Using the latter, we have obtained puzzling results from several different approaches (see Blundell et al., 1993, Gabler et al., 1993, and Laisney et al., 1991). We found large heterogeneity in the group of women with higher education (completed secondary school or above). Although one explanation could be found in the diverse motivations for human capital accumulation by women, especially (a posteriori) in the case of married women (mating, child quality production, etc.), another possibility might be heterogeneity with respect to the perception of the marginal wage rate.

At this stage it is perhaps worth stressing that we do not imply that households may intend not to comply with their intertemporal budget restriction (see Hammond, 1989, for the ensuing problems), although this may be of minor importance in a life cycle model of labour supply with intertemporal separability.

The paper introduces three different approaches to the problem outlined above. All three approaches nest the extreme assumptions of perfect perception of the marginal tax rate and of complete disregard parametrically. The central approach we start with rests on Rosen's (1976b) labour supply model with tax illusion which allows for differing effects (in absolute terms) of the gross wage and the tax rate on labour supply. We extend Rosen's work and focus on the determinants of tax illusion by introducing interaction effects of the log of one minus the tax rate with sociodemographic characteristics. Empirical evidence on the validity of this specification is gained from estimates on German panel data and French cross section.

Moreover, in order to obtain additional evidence we estimate two alternative models which assume Stone-Geary preferences, and different functional forms nesting the two borderline cases. In a switching regressions probit model with unknown switching point, the switching function determines the probability for each individual to act according to one of the two extreme cases. In the last approach the individual's labour force participation decision is based on "expected" wages and non-wage labour income which are defined as a weighted average of the two extreme cases. The weights are allowed to depend on observable socio-economic-characteristics, and this results in a nonlinear probit model.

The outline of the paper is as follows. In Section 2 we briefly present the model of quasi-linear preferences used for comparative treatment of the French and the German data described in Section 3. Estimation results are presented in Section 4, along with their implications for perceived retention rates. Section 5 concentrates on approaches which are feasible when consumption is observable, which is only the case for the French data. Subsection 5.1 presents the underlying preference specification and comments on estimation and tests results for the two extreme cases separately. Subsection 5.2 discusses the two alternative statistical models. Estimation results are presented in Subsection 5.3, and Section 6 gives concluding comments.

2 An Empirical Model

The motivation for our approach is based on the observation that structural empirical labour supply models usually either use the gross wage or the marginal wage rate as the price for leisure. Both approaches have in common that for a given information on (marginal) wages and hours (and sometimes additionally on expenditures), the position of the budget constraint is assumed to be known by the individual and by the econometrician. Statistical inference on the preference structure is conditional on this information set. In the sequel we relax the maintained hypothesis that the position of the budget constraint is known and we define as a misperception of the budget constraint a situation where, for a given combination of hours supplied and marginal wage rate, the marginal rate of substitution between consumption and leisure does not coincide with the real marginal wage rate.

Figure 1 will help understand what we have in mind when we combine a potential misperception of the budget constraint with the choice of a point that does not violate that constraint. The situation of a woman who takes her marginal tax rate into account is described by the solid lines. These are the true and the linearized budget lines, as well as the indifference curve which is tangent to the linearized budget line at the observed (pc, h) point. The interrupted lines picture our representation of a misperception of the budget restriction. This cuts the true budget line at the observed (pc, h) point but has the wrong slope there. Of course this is quite involved since it is difficult to see what mechanisms ensure a posteriori the consistency of the 'mistaken' behaviour with the true budget restriction. But, loosely speaking, such mechanisms may be at work in the timing of the savings decisions and of the tax payment itself. What is important here is that if we wrongly assume that an individual behaves according to the solid rather than the interrupted lines in Figure 1 (or vice versa), we will obtain biased estimates of her preference parameters. We shall assume that, given a set of observable characteristics, agents have the same preferences up to a stochastic component which does not depend on whether their perception of the budget constraint is correct or not, but that they can differ in the latter respect, according to another set of characteristics and, possibly, another stochastic component.

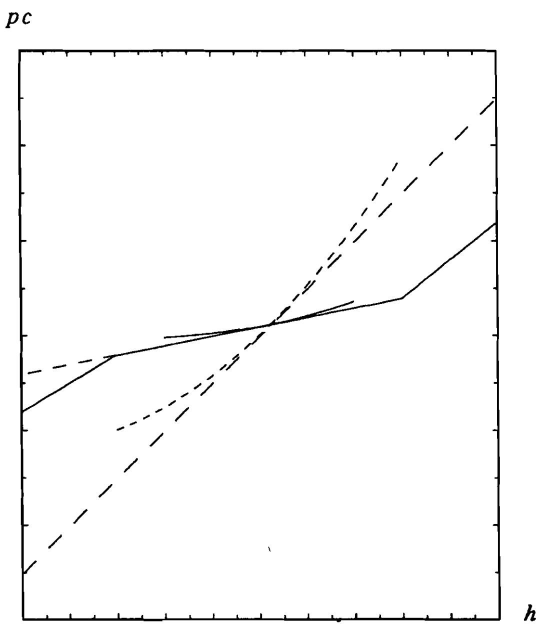


Figure 1: Perception and misperception of the marginal tax rate

In terms of our definition of perception of marginal taxes the following empirical approaches have three common features: (i) They give up the maintained hypothesis that the true position of the budget constraint is known, (ii) the perceived budget constrained is endogenous and depends on individual characteristics and (iii) the approaches nest the two extreme cases of perfect knowledge case and the complete ignorance. The differences lie in the assumptions about the underlying preference structure, in the stochastics and in the computational burden.

An appealing and simple way to extend the neoclassical labour supply framework in the direction sketched above is to introduce interaction terms with the marginal tax rate. Given the situation in the German data, where consumption is not observed, an interesting starting point which is described in more detail by Laisney et al. (1993) is a life cycle labour supply model based on additive intertemporal preferences where contemporaneous preferences are quasi-linear (indifference curves are parallel). This implies that there is no income effect on leisure. Moreover, regardless of the normalization chosen for within-period preferences, hours supplied will be independent of assets in period 0, interest rates and the rate of time preference. This is of course an extremely restrictive set of assumptions, but given the complexity of the estimation strategy pursued here, it will provide a convenient benchmark. In that case Frisch demands for leisure correspond exactly with Hicksian and with Marshallian demands and depend only on the real wage. Yet, since static models of female labour supply typically yield small income elasticities, this may not be such a bad model. In detail, the period t utility function is specified as

$$U_t(C_t, L_t) = F_t[C_t + V_t(L_t)] =: F_t[U_t^*(C_t, L_t)],$$

for some increasing functions F_t and V_t, where C_t: denotes household aggregate consumption in period t, and L_t denotes the desired leisure of the female in period t. We specify the parsimonious parametric form Box-Cox functional form $V_t(L_t) = \gamma_t L_t^{\{\beta\}}$, with $L^{\{\beta\}} := (L^\beta - 1)/\beta$ if $\beta \neq 0$, $\ln L$ otherwise. Utility increasing in leisure requires $\gamma_t > 0$. This is easily achieved in estimation by specifying a logarithmic equation for this taste shifter. Convexity of indifference curves requires $\beta < 1$. Using the following specification for the taste shifter and the gross wage

$$\ln \gamma_t = Z_t \underline{\phi} + \varepsilon_{1t},$$

$$\ln W_t = X_t \underline{\psi} + \varepsilon_{2t},$$

and the condition that a woman chooses hours equating her MRS and her perceived net wage, this results in the following form for an interior solution in desired leisure:

$$Z\underline{\phi} + \varepsilon_1 = -(\beta - 1)\ln(\overline{L} - N) + \ln W + \alpha \ln\{1 - \tau(Y, WN)\}. \tag{2.1}$$

Here $\overline{L}$ denotes the amount of time available for allocation between market time and 'leisure', N are the desired hours of work of the individual, Y is her husband's income, exogenous, and W is her gross wage rate, assumed exogenous. τ denotes the marginal tax rate, which is in Germany a function of the individual's earnings and of the other income of the household, here her husand's income. α denotes an essential household-specific multiplier for this study: its presence corresponds to taking account of a "subjective" marginal retention rate ρ^* defined by $\rho^* = (1 - \tau)^\alpha$. In the following the *perception rate* α depends on a vector of socio-economic characteristics, V, that may proxy the individual's knowledge about the tax system. Assuming linearity we have $\alpha = V\underline{v}$, where $\underline{v}$ is a parameter vector to be estimated. For $\alpha = 1$ condition (2.1) reflects the supply condition under perfect knowledge about marginal wage rates. Given $\alpha = 0$ we are in the framework where marginal tax rates are completely ignored. However, in this approach we do not restrict α to lie between 0 and 1. Thus a negative α would lead to a retention rate above one and $\alpha > 1$ would indicate an 'exaggeration' of marginal tax rates.

Our econometric treatment of observations with missing wage information, or with irregular employment or unemployment takes care of some of the problems that availability of detailed information on demand conditions might help to handle more explicitly. Actual hours, but also the desired hours available in our data, are influenced by the availability of the corresponding (hours, wage) offers. It is also apparent from a histogram of these desired hours (reproduced in Laisney et al. 1993), that most respondents give answers that are multiples of 5. We shall cope with this by considering ranges of desired hours as the observed dependent variable rather than the actual level of desired hours. This technique is used by Blundell et al. (1993) but we are in a better position to use it here, because we do not have to make their assumption that actual and desired hours fall into the same interval.

3 Data

3.1 German data: sample selection and description of variables

We use the unbalanced sample from Laisney et al. (1993). The selection is summarized in Table 3.1. In order to avoid the non-convexity of the budget set caused by means-tested benefits, we restricted the sample used in the estimation to females who would not be entitled to the means-tested benefits giving rise to a marginal tax rate of 100% at zero hours. This selection rule only depends on the "unearned income" and on the demographics of the household, and is exogenous in the framework of our assumptions.

Table 3.1: Sample Selection

	1985	1986	1987	1988	1989
all females with valid interview	5631	5378	5308	5068	4930
German nationality	4287	4090	4010	3774	3586
age 25 - 57	2434	2328	2262	2129	2038
married and living together with partner	1903	1781	1736	1633	1555
no partner change, marriage, divorce, etc.*	1846	1726	1669	1582	1510
head or wife of head of household	1842	1717	1656	1575	1499
no other adults in household	1842	1717	1656	1574	1499
not self-employed	1734	1621	1548	1477	1411
after deleting missing values**	1530	1419	1361	1266	1192
no benefits at zero hours	1328	1237	1193	1139	1068

* in last 18 months

** except hours and female income information

We refer the reader to Laisney et al. (1993) for the description of the variables used in the determination of the form of the budget set of each household, since this represents a large portion of that paper.

Gross wages for the participants have been computed as reported gross monthly earnings of the last month divided by reported average working hours (per week) of the last month multiplied by 4.3. The resulting number is multiplied by 13/12 in order to account for the additional income component corresponding to the "thirteenth month" practice. In our final sample we consider observations in the lower and the upper percentile of the wage distribution as indicating unplausible values for either the working hours or the gross monthly income. Moreover, we discard the information on wages for several particular groups of observations and treat them like the job seekers, for whom the only information we use is the fact that their desired hours are positive.

The variables used in estimation may be summarily described as follows (see Table 3.2 for some descriptive statistics). *Wages*: real gross wage = gross wage / price index. *Hours*: desired, for participants: normal weekly hours over the year; observed, including overtime, for the computation of gross wages. These are average weekly hours over the year.

Non-participants: women who report being registered as unemployed, or being out of the labour force and, in case they answered yes to the question "future participation (yes, perhaps, no)", declared that they do not look for a job that would begin immediately. *Seekers*: women who report being registered as unemployed, or being out of the labour force and, in case they answered yes to the question "future participation (yes, perhaps, no)" declared that they do look for a job that would begin immediately. *Participants*: women who report working full- or part-time, or being in vocational training, or working irregularly, or who report positive desired hours or positive observed hours. *Participants with missing wage information*: Participants with missing information on earnings or on observed hours or on desired hours, or working irregularly, or reporting to work full time but with average weekly hours below 20, or reporting to work part time but with average weekly hours above 35, or with computed gross nominal wage in the upper or lower 5% of the distribution. We thus have four categories of observations: non-participants, seekers, participants with missing information, and participants with complete information.

Age: Woman's age in years (year of wave - year of birth), divided by 10. The square of the same variable is used also. *Schooling*: Three dummies for highest grade in general

Table 3.2: Descriptive statistics: Germany

Year	1985		1986		1987		1988		1989	
Variable	mean	std	mean	std	mean	std	mean	std	mean	std
price index	1	0	0.998	0	0.999	0	1.01	0	1.039	0
non-participants	0.49		0.49		0.48		0.48		0.47	
seekers	0.03		0.04		0.04		0.02		0.04	
participants	0.48		0.46		0.47		0.49		0.50	
part., no wage information	0.13		0.13		0.11		0.11		0.13	
real hourly wage (DM 1985)*	14.9	5.41	16.0	7.67	16.1	6.3	17.0	7.05	17.0	7.00
desired weekly hours*	25.4	9.64	26.1	8.73	26.9	9.10	25.5	8.85	26.5	8.91
actual weekly hours*	30.4	11.2	32.0	11.2	30.2	11.3	29.4	11.7	29.9	10.8
age	41.1	9.01	41.5	8.99	41.5	8.90	41.5	8.91	41.4	8.94
disability	0.03	0.15	0.04	0.14	0.04	0.16	0.04	0.15	0.04	0.15
potential experience	25.8	9.32	26.5	9.15	26.7	8.78	27.1	9.00	27.3	8.06
schooling: highest degree										
Hauptschule, or no degree	0.70		0.71		0.71		0.72		0.72	
Realschule	0.22		0.21		0.21		0.21		0.21	
Fachoberschule, Abitur	0.08		0.08		0.08		0.07		0.07	
children:										
youngest child 0-2 years	0.10		0.11		0.10		0.09		0.07	
" " 3-5 "	0.12		0.11		0.12		0.13		0.14	
" " 6-11 "	0.16		0.16		0.16		0.17		0.18	
" " 12-15 "	0.15		0.14		0.12		0.10		0.09	
" " 16-25	0.25		0.26		0.28		0.28		0.30	
number of children 0-5	0.27	0.55	0.29	0.59	0.27	0.55	0.27	0.55	0.24	0.51
" " 6-11	0.30	0.56	0.31	0.58	0.33	0.62	0.35	0.63	0.36	0.64
" " 12-15	0.26	0.50	0.23	0.48	0.21	0.46	0.20	0.45	0.19	0.43
" " 16-25	0.58	0.84	0.57	0.82	0.58	0.82	0.58	0.83	0.60	0.81
regional variables										
northern states	0.19		0.19		0.19		0.18		0.19	
Nordrhein-Westfalen	0.28		0.28		0.28		0.29		0.29	
Berlin	0.03		0.03		0.03		0.03		0.02	
central states	0.16		0.17		0.16		0.16		0.17	
Bayern, Baden-Württemberg	0.33		0.34		0.34		0.34		0.33	
Urbanisation (areas)										
more than 500' inhabit.	0.44		0.44		0.44		0.43		0.43	
100' - 500'	0.15		0.16		0.16		0.16		0.16	
20' - 100'	0.11		0.11		0.11		0.11		0.11	
less than 20'	0.30		0.29		0.29		0.29		0.29	
Parameters of tax approx										
marginal tax rate at zero hours	0.15	0.07	0.15	0.07	0.15	0.07	0.16	0.07	0.16	0.07
marg. tax rate at desired hours	0.29	0.19	0.29	0.18	0.30	0.18	0.29	0.17	0.30	0.17
benefits at zero hours: dummy	0.13		0.11		0.13		0.11		0.10	

* participants with "accepted" wage rates only

education, corresponding to (years of schooling in brackets) "Hauptschule" (9) "Mittlere Reife" (10) "Abitur" or "Zulassung zur Fachhochschule" (13 and 12, respectively). *Potential experience*: (Age - Years of schooling - 6) / 10. The square is also used. *Children*: (i) Numbers of children: up to 5 years of age, between 6 and 11, between 12 and 15, older than 15 and still in education. (ii) Dummies youngest child: up to 2 years of age, between 3 and 5, between 6 and 11, between 12 and 15, older than 15 and still in education. *Urbanization grade* (Boustedt): Town, village, rural (below 20' inhabitants).

3.2 French data: sample selection and description of variables

We work with the subsample of 3658 households from the INSEE survey "Budgets des Familles 1979" already used by Laisney et al. (1991) and Blundell et al. (1993). The selection was made according to the following criteria: we consider single tax units based on a married couple where the male is either working or, if presently out of work, is seeking a job. The household has no other wage earner than the husband or the wife. The latter is neither at school nor is a student or a pensioner or an 'aide familiale', she is neither self-employed nor a teacher or an artist or a member of clergy, army or police. She is between 26 and 65 years of age and reports at most 69 normal weekly hours of work. Since means-tested benefits are assessed on the taxable income of the previous year, we only take taxes in a strict sense proper into account in this first approach. We now summarily describe the variables used (age and potential experience have the same definition as for the German data). *Wages*: gross wages for the participants have been computed as reported gross yearly earnings (including bonuses) divided by reported normal weekly working hours times 52. *Hours*: reported normal weekly hours of work.

Seekers: unemployed and women who do not participate at the time of the interview but who report that they are currently looking for a job. *Participants*: only women who report positive hours. *Non-participants*: women who do not belong to either of the previous categories. We thus have only three categories of observations for the French data.

Schooling: three dummies for highest grade in general education, corresponding to end of primary school (BE), mid secondary school (BEPC), end of secondary school or above (baccalauréat). *Numbers of children*: (i) not yet in the next category, (ii) at the "école maternelle" (kindergarden), (iii) dummies for the numbers of children at primary and secondary school (1, 2, 3 or more). *Marginal tax rate*: the approach here is simpler than for the German data and makes the assumption of constancy of the marginal tax rate over the relevant range of hours. For the French data this is an acceptable approximation (see Blundell et al. 1993 for details).

Table 3.3: Descriptive statistics: France 1978/1979

Variable	mean	std	min	max
non-participants	0.52			
participants	0.43			
seekers	0.05			
gross nominal hourly wage (FF)*	17.7	7.5	2.00	56.6
normal weekly hours (actual)*	36.6	9.6	3	66
age	39.6	9.5	26	65
potential experience	23.1	9.7	3	49
regional unemployment rate	0.06	0.01	0.05	0.10
telephone (dummy)	0.63			
schooling: highest degree				
none	0.28			
end primary school (BE)	0.43			
mid secondary school (BEPC)	0.18			
end secondary school (baccalauréat) or above	0.11			
numbers of children:				
small	0.18	0.43	0	3
école maternelle	0.22	0.49	0	3
dummy one other child	0.26			
dummy two other children	0.23			
three or more other children	0.14			
suburb	0.39			
marginal tax rate	0.23	0.07	0.09	0.50

* participants only

4 Results

Due to a substantial clustering of hours in both samples we restrict our attention to a model specification where hours information is grouped according to the cut-points 22.5, 27.5, 32.5, 37.5 hours per week. The choice of these cut-points is justified in Laisney et al. (1993). For the German panel data we estimate the model for all five cross-sections by maximum likelihood and use the minimum distance estimation technique to enforce the panel structure on the cross-section estimates. In Table 4.1 we present two sets of estimates for Germany, according to whether or not we restrict the variance of the taste shifter to 1. Table 4.2 presents the corresponding maximum likelihood results for the French cross-section. Both sets of results are based on the choice of $\overline{L}$ = 10.5 hours a day.[1]

A first feature of the results is that estimates of the wage elasticity of leisure are fairly high in absolute terms compared to the results of previous studies using the same data (Laisney et al., 1993, and Hujer and Schnabel, 1992, for Germany; Dagsvik et al., 1988, and Blundell et al., 1993, for France).

In many respects the estimates for Germany seem more reliable than the results for France and we discuss these first. The parameters of the wage equation and the taste shifter are fairly standard. The (log-) wage profile is bell-shaped in terms of potential experience, with a maximum at 22 years of experience. In interpreting the coefficients in the taste shifter it must be remembered that a positive impact on the taste shifter increases the weight of leisure in the utility function. Having children in any of the defined age groups implies a reduction of hours supplied.

Most interesting for the present study are the results obtained for the coefficients appearing in the perception rate. In terms of our model, positive coefficients on the different child dummies in V indicate that women with children are likely to have a higher perception of the marginal tax rate. We offer the following tentative explanations for this finding. If families with children find it more difficult than childless couples

1 In opposition with most of the literature on this point, we find that this choice *does* matter. Ideally, one would want to allow $\overline{L}$ to vary with demographics, but this would strain identification one step further than we already do. For the German data, the value of 10.5 corresponds approximately to an estimate obtained by restraining α to be equal to 1.

to make ends meet, they may be more inclined to take into account their true marginal tax rate. Moreover, having access to special tax allowances for families with children may produce a better knowledge about the true tax rate. However, this argument is not supported by our finding that owning a house, and thus possibly receiving corresponding tax reductions, has no significant impact on the perception rate. The neoclassical assumption that individuals are perfectly aware of the implications of marginal tax rates appears more likely to hold for women with a higher educational degree than for the reference group.

The estimates for France differ to some extent from previous results. This holds for the wage equation, where we do not find a significant impact of potential experience on wages; furthermore, the coefficients on the child dummies appearing in V are not well determined and are negative in contrast to the results obtained with the German data. Education has the expected positive sign. The impact of age on the perception rate is concave with a maximum at age 48, whereas we find no such effect for Germany. The dummy variable for the ownership of a telephone was included to pick up potential differences in information. Its positive impact on wages and the perception rate might also pick up an income effect. Although the results for France appear robust with respect to inclusion of this variable, they are very fragile as far as other modifications of the specification are concerned: since the specification reported here is derived from the final specification retained for the German data, we have good reasons to suspect it to fit the French data less well. Experimenting with changes in the level of $\overline{L}$, we found that $\overline{L} = 15$ led to a lower elasticity but to even more negative values of α than implied by the estimates reported here. When changing the grouping of hours we encountered difficulties with convergence.[2] Due to this instability and to the better quality of the German data as regards the evaluation of marginal tax rates, we concentrate on the implications of the estimated model for Germany. We will come back to the French data when discussing models which take advantage of the availability of information on expenditures.

2 We also had convergence problems when trying to produce results with α constant across individuals while retaining the same specification for the preferences, as done by Rosen (1976b): the resulting model was obviously underparameterized, which again points to the identification issue discussed above.

Table 4.1: Germany: Minimum Distance Estimation, Unbalanced Panel, Results with and without Restriction on Variance of Taste Shifter (*: std. err)

	Restriction (Yes/No)	No		Yes	
		coef.	t-value	coef.	t-value
β		0.715	11.6	-0.029	-0.5
Wage equation	constant 1985	2.495	34.0	2.279	26.2
	constant 1986	2.560	34.9	2.372	27.2
	constant 1987	2.600	34.4	2.384	27.4
	constant 1988	2.624	33.8	2.410	27.0
	constant 1989	2.647	33.8	2.433	27.3
	potential experience /10	0.171	3.1	0.299	4.6
	pot. experience squared /1000	-0.515	-4.9	-0.691	-5.5
	less than 20' inhabitants	0.011	0.6	-0.044	-1.8
	Realschule	0.154	6.0	0.238	9.3
	Fachoberschule, Abitur	0.281	6.0	0.501	12.8
Taste shifter	constant 1985	4.654	9.9	10.216	23.7
	constant 1986	4.729	10.0	10.346	24.0
	constant 1987	4.775	10.2	10.347	24.2
	constant 1988	4.782	10.2	10.327	24.0
	constant 1989	4.842	10.3	10.399	23.9
	number of children 0-5	0.246	6.0	0.593	11.4
	" " 6-11	0.135	5.1	0.318	8.0
	" " 12-15	0.080	2.7	0.200	4.0
	" " 16-25	0.049	2.4	0.189	6.2
Variables in *V*	constant 1985	0.043	0.6	0.082	0.6
	constant 1986	0.002	0.0	-0.043	-0.3
	constant 1987	-0.095	-1.3	-0.196	-1.7
	constant 1988	-0.010	-0.1	0.096	0.7
	constant 1989	-0.170	-1.6	-0.159	-1.2
	youngest child 0-2 years	0.184	1.9	0.576	3.7
	" " 3-5 "	-0.008	-0.1	0.010	0.1
	" " 6-11 "	0.131	1.9	0.346	3.0
	" " 12-15 "	0.074	1.0	0.291	2.2
	Realschule	0.225	4.4	0.374	4.4
	Fachoberschule, Abitur	0.352	4.1	0.575	4.0
Covariance	σ_1 1985	0.430	0.052*	1	-
structure	σ_1 1986	0.456	0.045	1	-
	σ_1 1987	0.416	0.057	1	-
	σ_1 1988	0.415	0.055	1	-
	σ_1 1989	0.351	0.059	1	-
	ρ 1985	0.737	0.066	0.327	0.074*
	ρ 1986	0.828	0.051	0.498	0.061
	ρ 1987	0.798	0.060	0.478	0.065
	ρ 1988	0.817	0.060	0.483	0.068
	ρ 1989	0.777	0.065	0.489	0.067
	σ_2 1985	0.341	0.013	0.328	0.013
	σ_2 1986	0.375	0.019	0.368	0.019
	σ_2 1987	0.366	0.015	0.359	0.014
	σ_2 1988	0.380	0.016	0.377	0.015
	σ_2 1989	0.368	0.016	0.356	0.016

Table 4.2: France: Maximum Likelihood Estimation, Cross-section, Results with and without Restriction on Variance of Taste Shifter (*: std. err.)

	Restriction (Yes/No)	No		Yes	
		coef.	t-value	coef.	t-value
β		0.723	9.4	0.747	49.3
Wage equation	constant	2.722	34.8	2.723	35.4
	potential experience /10	0.052	0.9	0.053	0.9
	pot. exp. squared /100	-0.007	-0.6	-0.008	-0.6
	suburb	0.093	5.0	0.091	5.2
	regional unemployment	-3.343	-4.8	-3.340	-4.9
	telephone	0.172	8.3	0.173	8.6
	BEPC	0.211	7.0	0.205	9.2
	baccalauréat or above	0.413	12.1	0.411	12.2
Taste shifter	constant	11.532	4.0	10.727	8.3
	age /10	-3.095	-2.7	-2.809	-4.4
	age squared /100	0.378	2.8	0.343	4.6
	numbers of children:				
	small	0.507	2.7	0.464	3.6
	école maternelle	0.393	3.0	0.359	5.0
	dummy 1 other child	0.382	2.9	0.348	4.7
	dummy 2 other children	0.802	3.4	0.732	8.2
	3 or more other children	1.082	3.5	0.988	9.7
	BEPC or below	-0.607	-2.8	-0.551	-4.3
	baccalauréat or above	-1.221	-2.4	-1.076	-4.6
Variables in *V*	constant	30.080	-3.1	-27.414	-6.1
	age /10	11.414	2.9	10.389	4.8
	age squared /100	-1.189	-2.8	-1.083	-4.4
	youngest child small	-0.147	-0.2	-0.135	-0.2
	" " éc. mat.	-0.498	-1.1	-0.447	-1.1
	" " other	-0.634	-1.8	-0.575	-2.1
	BEPC or below	1.665	2.4	1.522	3.1
	baccalauréat or above	5.129	3.1	4.660	6.5
	telephone	1.336	5.3	1.284	6.9
Covariance structure	σ_1	1.076	0.236*	1	-
	ρ	0.516	0.093	0.541	0.059*
	σ_2	0.406	0.013	0.406	0.013

Based on the estimates with no restriction, the perception rate was computed for every year and individual for the German data. Table 4.3 gives descriptive statistics on the predicted individual perception rates. The mean of 0.23 is far from Rosen's (1976b) estimate for a constant α close to unity. For 70% of the individuals in the sample the predicted α lies between 0 and 1 with a median value of 0.15.

Table 4.3: Descriptive statistics of pooled estimated perception rates and t-statistics for Germany, 1985-1989

Quantiles	1%	25%	50%	75%	99%	Mean
$\alpha_i = \nu V_i$	-0.20	-0.04	0.15	0.44	1.11	0.23
$H_0{:}\alpha_i = 0$ (disregard)	-1.67	-0.34	1.10	2.97	5.51	1.38
$H_0{:}\alpha_i = 1$ (rationality)	-10.16	-7.37	-5.87	-3.78	0.50	-5.60

The table also presents t-statistics which allow various one-sided and two-sided tests. Thus α is significantly negative for only about 1% of the sample. In terms of our model these are people who overstate redistribution in their favour. For more than half the sample we cannot reject the assumption of total disregard of the marginal tax rate at the 5% level ($\alpha = 0$ againts $\alpha \neq 0$), whereas it is only for a little more than 10 per cent of the individuals that we are unable to reject the hypothesis of perfect rationality ($\alpha = 1$ against $\alpha \neq 1$). For no individual is α significantly above 1. This means that, contrary to what Wahlund (1987) reports for Sweden, we do not find in our German sample any marked tendency to exaggerate the marginal tax rate.

The plots of the perception rate α against the marginal tax rate according to labour market status, given in Figures 2a and 2b indicate on the whole an increasing relationship (the irregularities around marginal tax rates of 0.3 to 0.4 or in excess of 0.65 are caused by very few individuals, as documented in Figure 3b).[3] Individuals with a marginal tax rate around 0.35 and individuals with extremely high marginal tax rates are most likely to take their tax rates into account when they make their labour supply decisions. However, even for these two small groups α is far from being unity.

3 The plots show kernel regressions of α on τ with confidence bands constructed with $\pm$ twice the standard deviation (of the conditional mean).

Comparing across groups, we find that the perception of part-time workers seems more accurate than that of full-time workers, which is consistent with the higher education, on average, of part-time workers, and that seekers have a flatter profile than non participants.

For individuals with zero marginal tax rate, whatever their labour market position, the question of misperception of the marginal tax rate is without any importance for the labour supply decision since at a tax rate of zero the impact of the misperception on hours supplied is nil, at least in our model.

Therefore it is interesting to look at the relationship between the actual marginal tax rate τ and the perceived marginal tax rate τ^*, where the latter is defined by the relation $(1-\tau)^\alpha = 1-\tau^*$, and represents the tax rate that would produce the same behaviour if exactly perceived. This relationship is depicted in Figures 3a and 3b, where on top of the kernel plots we have also represented each individual point (τ, τ^*). The clustering of values of τ around some of the lower values correspond to tax allowances and to an allowance for the payment of social contributions (see Laisney et al., 1993, for details). The solid straight line shows equality between τ and τ^*, or perfect perception.

One way to look at the pictures is to ask what the perceived marginal tax rate is on average for a given marginal tax rate of, say 0.45. That value is 0.18 for non participants, 0.14 for seekers, 0.08 for part-timers and 0.06 for full-timers. It is small, but the relative magnitudes are in intuitive accordance with the observed labour market status. However, it is worth noting also that a possible explanation for this ranking could lie in the fact that our model takes no account of the "investment in human capital" aspect of market work.

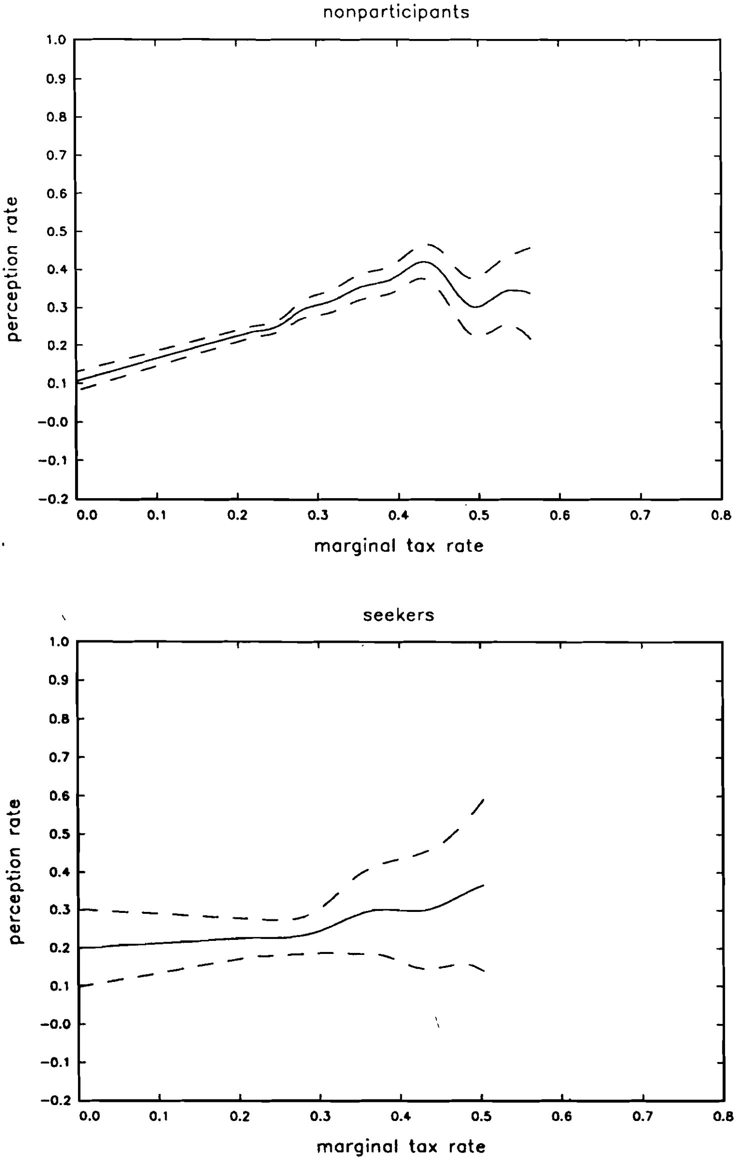


Figure 2a: Perception rate: non-participants (top) and seekers (bottom)

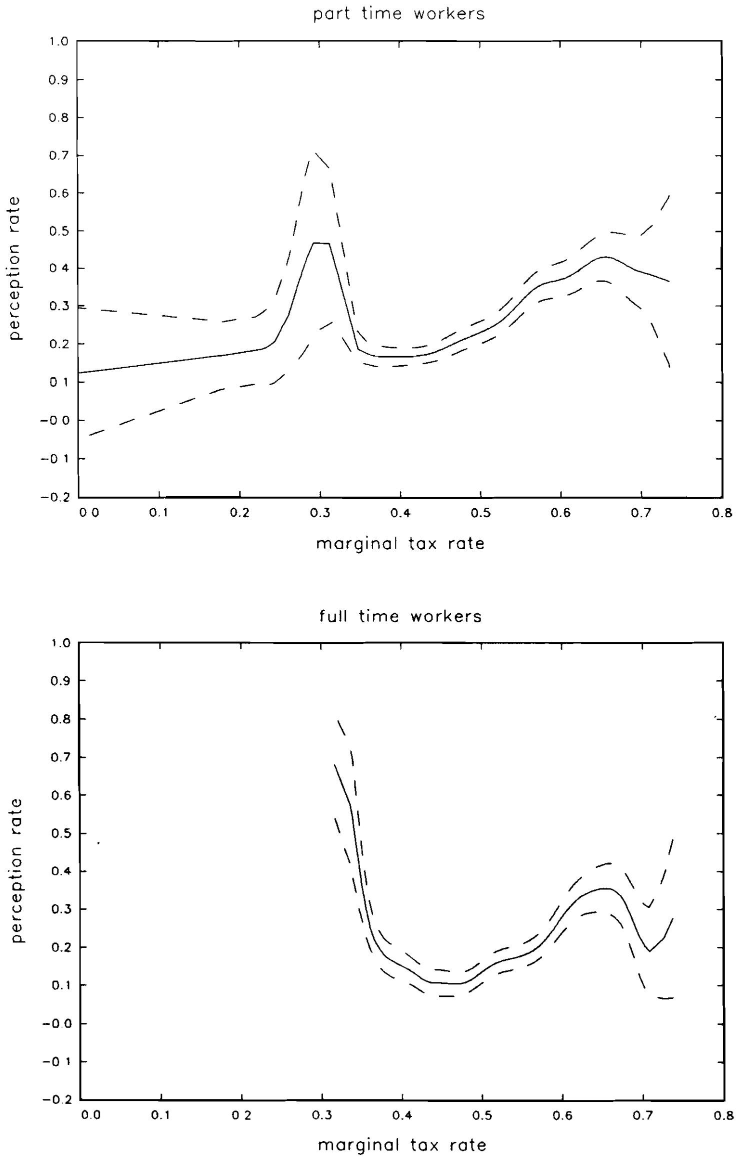
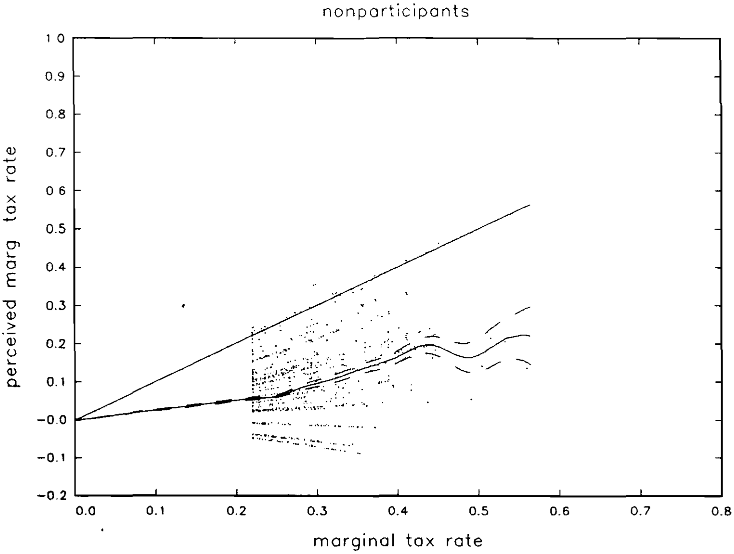


Figure 2b: Perception rate: part-time workers (top) and full-time workers (bottom)



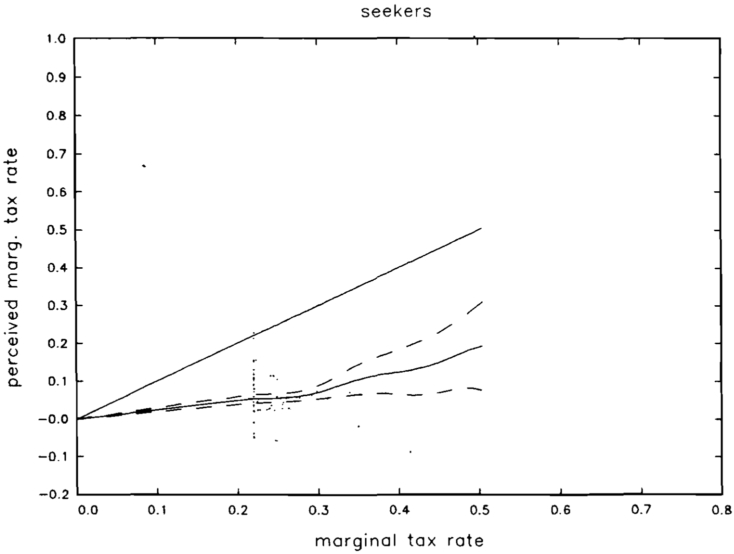


Figure 3a: Perceived marg. tax rate: non-participants (top) and seekers (bottom)

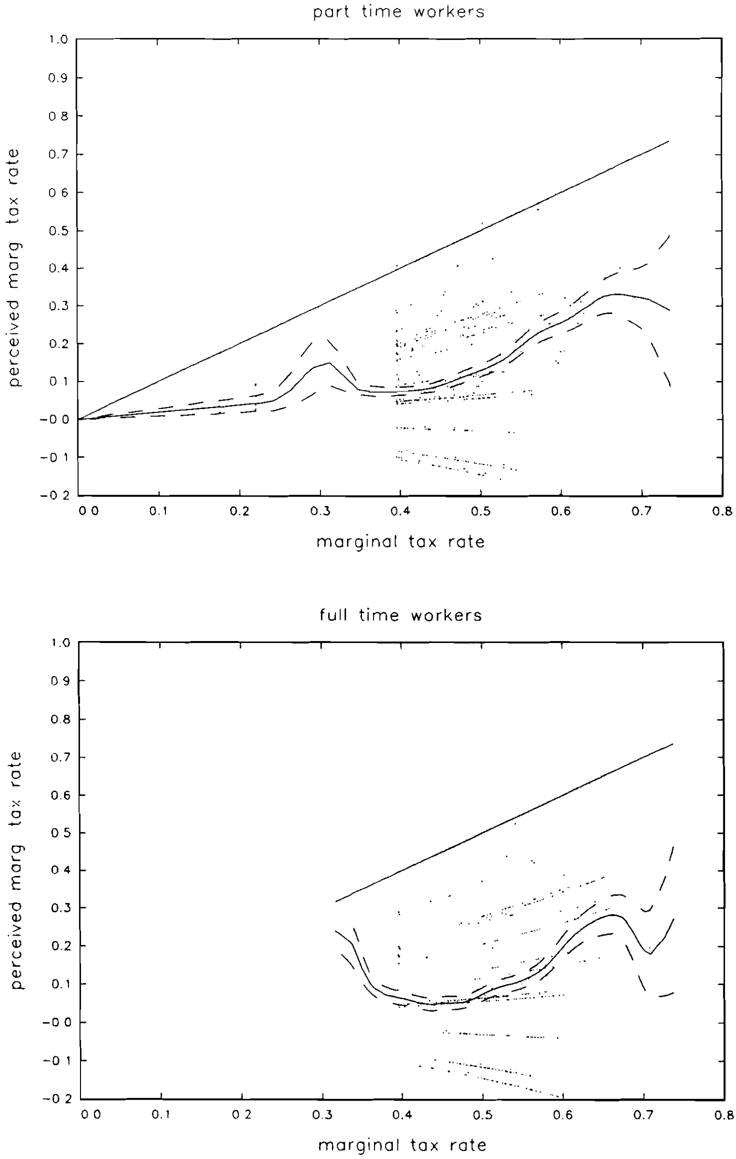


Figure 3b: Perceived marg. tax rate: part-time workers (top) and full-time workers (bot.)

5 Alternative Approaches

5.1 Theoretical Model and Previous Results

We start with no taxes and with the standard problem of one individual with intertemporally separable preferences who maximizes expected discounted utility

$$\underset{t}{\mathrm{E}} \sum_{k=t}^{T} \beta_k U(c_k, h_k) \tag{5.1}$$

over the life cycle, subject to

$$A_k = (1+r_k)A_{k-1} + y_k + w_k h_k - p_k c_k, \qquad k = t, \ldots, T-1 \tag{5.2}$$

$$A_T = 0 \qquad \text{(no bequest)}$$

in self-explaining notation, and with uncertainty limited to the (gross) wage and interest rate profiles. Using the Bellman principle, we define

$$V_{t+1} = \max \underset{t+1}{\mathrm{E}} \sum_{k=t+1}^{T} \beta_k U(c_k, h_k) \quad \text{s.t. (2) for } k = t+1, \ldots, T. \tag{5.3}$$

The only choice variable entering V_{t+1} is A_t, and

$$V_t = \max_{c_t, h_t} U(c_t, h_t) + \beta_{t+1} \underset{t}{\mathrm{E}} V_{t+1} \tag{5.4}$$

subject to

$$A_t = (1+r_t)A_{t-1} + y_t + w_t h_t - p_t c_t \,. \tag{5.5}$$

Thus, conditioning on A_t, the current period decision variables c_t and h_t are solutions of

$$\max_{c_t, h_t} U(c_t, h_t) \quad \text{s.t.} \quad p_t c_t - w_t h_t = (1+r_t)A_{t-1} - A_t + y_t =: \mu_t \tag{5.6}$$

and the form of the constraint in (5.6) stresses the relevance of "dissaving" μ_t as conditioning variable. This will allow us to omit the time period subscript t in the sequel. In a model with taxes, the constraints (5.2) are replaced by

$$A_k = (1 + r_k)A_{k-1} + y_k + w_k h_k - p_k c_k - I(h_k, y_k, r_k, A_{k-1}, A_k) \quad (5.7)$$

with $I(.)$ a general tax function. An approximation (exactly valid over some range of hours for a piecewise linear budget restriction) is obtained by linearizing the budget constraint, using the "net" counterparts of y_t, r_t, and w_t:

$$A_k = (1 + r_k^*)A_{k-1} + y_k^* + w_k^* h_k - p_k c_k. \quad (5.8)$$

Hence the definition of the "net" dissaving variable

$$\mu_t^* := (1 + r_t^*)A_{t-1} - A_t + y_t^* = p_t c_t - w_t^* h_t. \quad (5.9)$$

Thus for given (pc, h) and w (or w^*), μ (or μ^*) is obtained from the relevant (linearized) budget constraint.[4]

Finally, going over to the households we shall be interested in subsequently, namely households based on a married couple, the analysis goes through under the assumption that male leisure is both separable from female leisure and consumption and constrained. The only change necessary is a redefinition of the unearned income variable y so as to include the male's earnings.

The preference specification we use here is described in detail in Blundell et al. (1993). Here it will suffice to say that it leads to the following labour supply equation:

$$h = (1 - \beta)\gamma + \beta(d - \mu)/w, \quad (5.10)$$

with a normal stochastic component appearing additively in γ. This interpretation of the stochastic component in terms of random preferences only will simplify the exposition without introducing significant restrictions. Since the labour supply function (5.10) includes the "net" dissaving variable μ we are only able to estimate the model for the French data which include information on expenditures.

4 A more detailed analysis of the case of a nonlinear tax function and a justification of the procedure followed here are given by Blomquist (1985).

Since the study of Blundell et al. gives some grounds to distrust the hours information available in the data used, we shall concentrate on the participation rather than on the full labour supply decision. In doing so we lose information which may help identifying the preference parameters, but on the other hand we discard one potential source of misspecification. Other potential sources of misspecification are errors in variables, simultaneity bias, and fixed costs of participation. Errors in variables and endogeneity in both wages and dissaving are, to some extent, taken care of by the use of instrumental variables. Fixed costs of work may be more problematic since these are included in the consumption of participants but are unobserved for non-participants.

Table 5.1 shows probit estimates for the participation condition derived from (5.10). The first pair of columns relates to the assumption that every woman in the sample considers the complete tax system, including benefits and social security contributions, while the second sets the marginal tax rate to zero and corresponds to a linear budget constraint. Assuming that everyone disregards her marginal tax rate leads to much stronger wage effects. Another striking difference is the reversal on the impact of education on participation, and the very different estimates for the minimum expenditures, which are identified from a probit model (three last lines of the table). See Blundell et al. for more details.

The diagnostics reported in Table 5.2 show a trade-off between the specification of the marginal tax rate and non-linearity in the preferences: linearity is passed easily for the model with complete treatment of the tax system only. The deterioration of the heteroscedasticity diagnostic for the inverse of the marginal wage reinforces this finding, which is no surprise since that diagnostic picks up a special type of non-linearity.

Table 5.1 Probit estimates with identical perception of the tax system for all households.

Model	marginal wage rate		gross wage rate	
Variable	coeff.	t-val.	coeff.	t-val.
intercept	0.8246	3.3162	2.7082	10.8132
(age-40)/10	-0.3812	-11.5598	-0.3601	-10.5605
same, squared	-0.1310	-4.3122	-0.1237	-4.0230
primary school	0.2909	5.1043	0.1941	3.2905
lower secondary	0.4548	5.3075	-0.0412	-0.4470
end secondary	0.3623	3.0921	-0.3322	-2.6525
higher education	0.2863	2.0110	-0.3482	-2.3681
small children	-0.6878	-10.4453	-0.5634	-8.2270
école maternelle	-0.4793	-9.3007	-0.3599	-6.6668
one other child	-0.2481	-3.9844	-0.1018	-1.6071
two other children	-0.6666	-9.0512	-0.3657	-4.7561
> 2 other children	-0.9137	-10.1181	-0.3510	-3.5295
suburb dummy	0.1610	3.3477	0.0008	0.0172
1/marg. wage [1/w]	2.3854	0.9246	-16.7075	-5.3414
owner/w	-0.9884	-1.0722	0.2224	0.1826
buyer/w	2.1465	3.4361	2.8566	3.4540
m/w	-1.5684	-8.4054	-4.0566	-14.0549
-2*Log Lik.	4397		4182	

Table 5.2 Diagnostics: empirical significance levels (%).

Model		marginal wage rate	gross wage rate
QLM - Test	d.o.f.		
linearity	3	35.965	0.000
m^2	1	36.322	0.000
w^2	1	15.829	0.000
$\ln w$	1	20.083	0.000
homoscedasticity	16	0.012	0.012
(age-40)/10	1	1.275	39.852
end secondary	1	0.011	0.003
1/marginal wage [1/w]	1	0.464	0.051
normality	2	20.645	6.997
skewness	1	8.283	10.900
kurtosis	1	80.828	3.936

5.2 Two Alternative Statistical Models

5.2.1 Switching Regressions

In this approach we consider that each individual has some probability π to take her true marginal tax rate into account and probability $1-\pi$ to disregard it fully. Given that (5.9) is written with different versions of w and μ in each case, but with the same error term, the model will have the following structure:

$$y_1^* = X_1 b - u \tag{5.11}$$

$$y_2^* = X_2 b - u$$

$$z^* = Zc - v \, ,$$

where u and v are jointly normal with variances set equal to 1 and correlation ρ. The normalisation of the variances corresponds to the usual lack of identification in dichotomous models. The latent variable y^* coincides with y_1^* in regime 1, that is, if $z^* \geq 0$, and with y_2^* otherwise. The observed dichotomous variable y is defined as $y = \mathbf{1}[y^* \geq 0]$. Thus the participation probability is given by

$$\begin{aligned} p = \mathrm{P}[y=1] &= \mathrm{P}[y_1^* \geq 0 \quad \wedge \quad z^* \geq 0] \quad + \quad \mathrm{P}[y_2^* \geq 0 \quad \wedge \quad z^* < 0] \\ &= \mathrm{P}[u \leq X_1 b \quad \wedge \quad v \leq Zc] \quad + \quad \mathrm{P}[u \leq X_2 b \quad \wedge \quad v > Zc] \\ &= \Phi^{(2)}(X_1 b, Zc, \rho) \quad + \quad \Phi(X_2 b) \quad - \quad \Phi^{(2)}(X_2 b, Zc, \rho) \, , \end{aligned} \tag{5.12}$$

where $\Phi^{(2)}$ denotes the cumulative of the bivariate normal. If $\rho = 0$ this simplifies to:

$$p = \Phi(Zc)\Phi(X_1 b) + [1 - \Phi(Zc)]\Phi(X_2 b). \tag{5.13}$$

In any case the log-likelihood function for an i.i.d. n-sample takes the form

$$\ln L(y \mid X, b, c, \rho) = \sum_{i=1}^{n} [y_i \ln p_i + (1 - y_i) \ln(1 - p_i)] \tag{5.14}$$

with score vector given by

$$\frac{\partial \ln L}{\partial p_i} = \frac{y_i - p_i}{p_i(1-p_i)} \tag{5.15}$$

and

$$\frac{\partial p}{\partial b} = \phi(X_1 b)\Phi(Zc - \rho X_1 b)X_1' + \phi(X_2 b)\,[1 - \Phi(Zc - \rho X_2 b)]X_2' \tag{5.16}$$

$$\frac{\partial p}{\partial c} = \phi(Zc)\,[\Phi(X_1 b - \rho Zc) - \Phi(X_2 b - \rho Zc)]Z'$$

$$\frac{\partial p}{\partial \rho} = \phi^{(2)}(X_1 b, Zc, \rho) - \phi^{(2)}(X_2 b, Z_c, \rho),$$

the latter relationship being given in Hausman and Wise (1978, fn.17). There does not appear to be any theoretical identification problem in either case, except in some pathological cases. For instance, if $X_1 = X_2$, γ is not identified. It is however clear that the model puts great strain on the data (see Kiefer, 1979). The Appendix reports on limited experimentation with simulated data using this model. This yields the following conclusions, which would need to be checked with a thorough Monte-Carlo study. 1 Convergence is obtained easily using numerical gradients but is often difficult with analytical gradients. The explanation seems to lie in insufficient precision in the computation of the univariate and bivariate cumulative probability functions for the normal. 2 Wrongly assuming that $\rho = 0$ causes little bias in the estimation of b as long as ρ is not too large. 3 The number of observations necessary for precise estimation of the parameters c of the switching process is much larger than that giving precise estimation for the preference parameters b. Precise estimation of ρ requires even more observations.

5.2.2 Convex Combination Approach: Nonlinear Probit

The basic idea of the following convex combination approach is to treat wages and nonwage income perceived by the individual as a convex combination of the two extreme cases: The rational perception of the budget constraint's curvature and the complete disregard of marginal wage rates. Assuming that the individual's perception of the budget constraint is given by:

$$pc - w^p h = \mu^p, \tag{5.17}$$

where the superscript p denotes the individual's perception of the corresponding variable. This perception is expressed as weighted average of the two extreme cases. For the perceived wage rate this is given as the weighted average of the marginal wage, w^*, and the gross wage, w. More precisely, if ψ denotes the relative weight given to "rational" tax behaviour, w^p is defined as:

$$w^p = \psi w^* + (1-\psi)w \; , 0 \le \psi \le 1, \tag{5.18}$$

The perceived nonlabour income is defined correspondingly. Hence for $\psi = 1$ equation (5.18) reduces to the linearized budget constraint of the conventional neoclassical labour supply model with taxes, and results in the linear budget constraint of an individual ignoring taxes for $\psi = 0$. In a second step the perception weight is endogenized by expressing ψ as a function of observable socio-economic characteristics. For our econometric approach we assume a logistic functional form for ψ in order to restrict the weights to the interval [0, 1] while keeping the computational burden low:

$$\psi = (1 + \exp(-z'\gamma))^{-1}, \tag{5.19}$$

where z is a $k \times 1$ −vector of explanatory variables and γ is the corresponding parameter vector to be estimated. For the quasi-homothetic preferences corresponding to (5.10) the labour supply specification will be:

$$h = \gamma(1-\beta) + \beta \frac{d}{w^p} - \beta \frac{\mu^p}{w^p}, \tag{5.20}$$

Since we use only binary information on hours, the convex combination approach results in a probit model which is both parameters and variables. In comparison to the switching probit model this model is stochastically simpler, but this does not reduce the computational burden, because of the high degree of non-linearity implied by equations (5.18-5.20).

The convex combination approach is not only justified as an approach that nests the two extreme cases while being parametrically considerably richer, it also has some theoretical justification since it can be derived from utility maximizing behaviour under uncertainty with respect to the income taxes. This, however, requires the strong assumption that expected wages are based on a binary outcome as given by (5.18). Since it is more likely that individuals have some partial knowledge about their tax rates we would prefer to refer to w^p as perceived marginal wage rate rather than expected marginal wage rate.

5.3 Estimation Results

5.3.1 Switching Regressions Model

In our first attempts at estimating the switching regressions model we did not impose equality of all the preference parameters between regimes and assumed a constant probability of disregard across households. This led to almost exactly the results obtained for the gross wage rate in Table 5.1, and a probability of disregard almost equal to 1. In a second type of attempts, we moved to the other extreme in order to obtain some deviation from complete disregard: we retained only a constant, the inverse of the wage and the ratio μ/w in each regime, without restrictions, while all other variables appeared in the switching process. The results are not reproduced because the corresponding hessian is not invertible: it has three null eigenvalues associated with the preference parameters for the "tax" regime. Besides, the probability of participation for the tax regime amounts to zero for almost every observation. Finally, we did impose the restriction of identical preference parameters across regimes: a surprising consequence is that the hessian now has 8 null eigenvalues, all of them being related to switch parameters.

5.3.2 Estimation Results of the Convex Combination Approach

Estimating the convex combination model turns out to be computationally burdensome and sensitive to the optimization algorithm chosen. We first estimated the model assuming all demographic variables to enter only the weighting function (5.19). The results are presented in Table 5.3.

Several of the weighting function parameter estimates are only mildly significant, but are, apart from the sign (the convention is different) and a factor of proportionality, broadly in accordance with the (non-converged) parameters obtained for the switching regressions (see subsection 5.3.1). Women with higher education or end secondary education are more likely to take marginal tax rates into account when deciding upon work force participation. The same holds for older women. More surprisingly perhaps, but still in accordance with the intuition presented in the introduction, the variables small children and école maternelle reveal a significant impact on the probability of a rational perception of the marginal tax rate. The average estimate of the weight given to full perception (average ψ) is 0.19 with some 15% of the individuals giving a weight above 1/2 to complete perception of the budget constraint. The fact that most individuals in the sample are more likely to ignore their marginal taxes is also reflected in the estimates of the preference parameters which come close to the estimates under the no tax assumption. In terms of the number of correct predictions this estimated model lies between those for the participation decision under the two polar cases regarding tax perception. The squared age variable and the suburb dummy used in Table 5.1 had to be deleted here due to problems of convergence of the various optimization routines applied.

In a second step we estimated a richer specification using the set of demographic variables belonging to the utility function as well as to the weighting function (see columns 3 and 4 of Table 5.3). For several choices of the starting values used, convergence was achieved for parameter values of γ that appear at first sight as blown-up versions of the estimates of the restricted model. Yet there are striking differences beyond scale. Firstly, none of the coefficients of the weighting function turns out to be significant. Secondly, the average estimate of ψ is now much smaller. Accordingly, the preference parameters are more similar in size and significance to those from the simple participation model based on the gross wage rate (see columns 3 and 4 of Table 5.1 for comparison).

Finally, we used the estimated parameters of the restricted model to calculate the perceived wage rate according to equation (5.18) and estimated the borderline models with the estimated perceived wage rate instead. The number of correct predictions (0.691%) is close to the figure obtained when taxes are completely ignored (0.697%) and exceeds the figure for the full tax borderline case by roughly 2%.

Table 5.3 Estimates of the convex combination model

Model	restricted pref.		unrestr. pref.		2-stage estimation	
Variable	coeff.	t-val.	coeff.	t-val.	coeff.	t-val.
preference parameters						
intercept	2.5696	14.20	2.7363	11.52	2.1853	9.30
(age-40)/10			-0.3176	-9.24	-0.2521	-7.35
same, squared			-0.0968	-2.94	-0.0647	-2.04
primary school			0.1829	3.18	0.1810	3.11
lower secondary			-0.0594	-0.66	0.1091	1.22
end secondary			0.1163	-0.97	0.1247	1.08
higher education			-0.2652	-1.73	0.1703	1.17
small children			-0.5460	-8.16	-0.4390	-6.16
école maternelle			-0.3430	-6.25	-0.3053	-5.59
one other child			-0.0837	-1.29	-0.1292	-2.06
two other children			-0.3488	-4.54	-0.3752	-4.87
> 2 other children			-0.2698	-2.62	-0.3888	-3.81
suburb dummy			-0.0043	-0.09	0.0347	0.71
1/marg. wage [1/w]	-18.0392	-6.89	-17.9048	-5.92	-13.017	-4.30
owner/w	-0.8166	-0.73	-0.0624	-0.05	-0.4611	-0.40
buyer/w	2.8760	3.70	2.8596	3.52	2.6029	3.28
m/w	-4.1054	-18.19	-4.0026	-15.27	-3.2987	-12.13
parameters of ψ						
intercept	-5.4347	-3.38	-1124.5	-0.11		
(age-40)/10	3.3674	4.47	555.2	0.10		
primary school	-0.8991	-1.15	-83.8	-0.04		
lower secondary	0.6877	0.61	27.7	0.02		
end secondary	3.7416	4.29	1029.7	0.10		
higher education	4.6546	3.74	388.6	0.11		
small children	4.9568	2.54	490.6	0.02		
école maternelle	2.8853	3.22	249.1	0.09		
one other child	0.0415	0.04	24.0	0.01		
two other children	1.4464	1.39	-104.0	-0.05		
> 2 other children	2.6174	2.04	639.0	0.11		
-2*Log Lik.	4317		4134		4220	

Table 5.4 Disregard Probabilities and Participation Wage Elasticities

Statistics \ Quantiles		1%	10%	25%	50%	75%	90%	99%	mean
Disregard probabilities[5]									
all women	(a)	0.005	0.276	0.753	0.961	0.996	0.999	1	0.811
	(b)	0	1						0.939
non-participants	(a)	0.002	0.123	0.586	0.916	0.989	0.998	1	0.747
	(b)	0	1						0.901
seekers	(a)	0.009	0.478	0.842	0.987	0.997	1	1	0.856
	(b)	0	1						0.980
Participation wage elasticities[6]									
all women	(1)	0.177	0.565	0.941	1.597	2.551	3.720	7.773	1.975
	(2)	0.642	1.498	2.301	3.601	5.295	7.829	15.716	4.308
	(3)	0.178	0.582	0.980	1.703	2.838	4.575	10.018	2.271
non-participants	(1)	0.369	0.944	1.405	2.140	3.156	4.654	8.728	2.546
	(2)	0.909	1.995	2.974	4.379	6.368	9.033	18.266	5.169
	(3)	0.426	0.992	1.492	2.385	.3.682	5.934	12.828	3.039
seekers	(1)	0.211	0.486	0.822	1.315	2.236	3.181	6.866	1.687
	(2)	0.645	1.028	1.928	2.986	4.358	6.031	15.947	3.524
	(3)	0.211	0.486	0.829	1.402	2.312	3.499	6.866	1.792
Models of Table 5.1: non-participants									
gross wage rate		0.494	1.114	1.701	2.608	3.852	5.665	10.414	3.086
marginal wage rate		0.033	0.172	0.315	0.536	0.885	1.357	2.790	0.688

5 We refer to the lower panel of Table 5.3:
(a) column 1,
(b) column 2.

6 We report elasticities computed with the parameter estimates of the second column in the first panel of Table 5.3:
(1) Gross wage and virtual dissaving,
(2) Net wage and virtual dissaving,
(3) "Expected" elasticity.

5.3.3 Estimated Disregard Probabilities and Participation Elasticities

Table 5.4 gives quantiles and means for the magnitudes of interest, first for all women in the sample (3658 observations), then for the true non-participants (1902 observations), and finally for those who do not work but report that they are looking for a job (200 observations). True non-participants have higher disregard probability than seekers, but a lower one than the participants, which is in accordance with the intuition. Looking into some more detail than reported in the table we found that a large number of children and a high education were associated with the lowest disregard probabilities.

All participation elasticities reported are very high, except those of the last line of the table, which correspond to the parameters of the first column of Table 5.1 and thus to disregard probabilities of zero for everyone. Although this is not supported by the evidence presented here, this is still the model we would prefer to use for policy simulations ... until we have a better one.

6 Conclusions

This paper addresses the issue whether married women perceive their true marginal tax rate when making their labour supply decision and to what extend the perception differs among various socio-economic groups. A simple framework of analysis is presented and three alternative suitable statistical models discussed.

While the computational burden of the first approach is comparable to the computational burden involved with the estimation of more conventional labour supply models the two latter approaches seem to require larger sample sizes than the one considered in the empirical part of this study. Due to the computational problems involved in the estimation of the two latter approaches, the different definition of the dependent variable and a slightly different set of explanatory variables, a final conclusion on the basis of the comparison of the functional forms is premature. Therefore, the results for these two approaches have mainly illustrative character.

All three approaches deviate from standard neoclassical labour supply approaches by functional form, i.e. the deviation from rational acting behaviour is only identified by assuming a specific form for the underlying labour supply functions. Hence the eventual statistical significance of the parameters that reflect this departure might be the result of a misspecification of the labour supply function rather than evidence against rationality. This made a comparison of various functional forms and a comparison across countries particularly meaningful. Since the estimates of models with different underlying preference structure point into the same direction with respect to the perception parameters, this is some evidence that the additional parameters do pick up what they are intended to.

All estimates have one thing in common regardless of which model is applied or which data set is used: the estimates are more in accordance with the extreme disregard assumption. Contrary to the findings by Rosen (1976 b) who does not find a significant departure from a correct perception of marginal taxes, none of the approaches presented here gives support to the neoclassical view of complete rationality.

In general the models lead to the same conclusions: 1 The probability of disregard of the marginal tax rate by married women is a decreasing function of age, of education, and of the number of children they have. 2 Previous estimates obtained under the assumption of complete disregard of the marginal tax rate for everyone suggested a negative impact of education on participation. This counterintuitive result disappears when the impact of education on the perception of the marginal tax rate is taken into account.

This encouraging aspect of the results should not mask their fragility. In particular it would be important to develop a theoretical model that jointly explains labour supply and learning behaviour about taxes. Our approach of modelling the individuals tax perception is fairly traditional in the sense that perception is explained by standard variables used in labour supply specifications. Another path of future research should incorporate insights from economic psychology. If tax perception is regarded as the mediation between tax stimulus and labour supply response to the tax stimulus one should incorporate 'soft' variables such as the beliefs about the disincentive effects of taxation or perceptions of the purpose of taxation and preferences about the redistribution of wealth (see for instance Lewis, 1982).

Finally, in order to assess the overall impact of taxes on labour supply a closer look should be taken at the qualitative dimensions of labour supply (motivation, job satisfaction etc...) rather than at the participation hours decision alone.

Appendix: Simulation Results for the Switching Regressions Model

Table A1 shows the bias in the estimates of the preference parameter b and of the switching parameter c for various values of the correlation ρ when the presence of the latter is ignored. The corresponding pseudo-true values are obtained by minimization of the Kullback-Leibler information criterion. The conditional expectation of y given the exogenous variables and the parameters is the corresponding conditional probability of $[y = 1]$ and the expectation with respect to the distribution of the exogenous variables is estimated by the sample mean over a simulated sample. In the 1000 simulated independent observations, X_1 is the constant 1, X_2 is standard normal, and Z is uniform in $[-0.5, 0.5]$ and independent of X_2.

Table A1 Pseudo-true values for b and c when ρ is ignored.

	$\rho =$ 0 (true)	0.10	0.25	0.50	0.75	0.90
b	1	0.998	0.994	0.985	0.962	0.927
c	1	1.001	1.015	1.079	1.231	1.406

It appears that the bias in both coefficients is quite small up to $\rho = 0.5$ and remains fairly small beyond that for b, but becomes important for c.

Table A2 shows estimation results for independent samples with different sizes, using the same design (but not the same realization) as above for the exogenous variables and with (u, v) bivariate normal with variances 1 and correlation $\rho = 0.28$. The true values of b and c are as above and this yields odds of about (2/3, 1/3) for y.

Table A2 (Estimated) Precision with Different Sample Sizes.

Sample size	500		1000		5000	
	$\rho = 0$	ρ estimated	$\rho = 0$	ρ estimated	$\rho = 0$	ρ estimated
b	0.781	0.775	1.036	1.044	1.001	1.007
	(0.105)	(0.104)	(0.083)	(0.085)	(0.036)	(0.037)
c	0.887	0.690	1.631	1.615	0.970	0.955
	(0.520)	(0.447)	(0.359)	(0.354)	(0.143)	(0.142)
ρ	-	0.700	-	0.190	-	0.217
	-	(0.263)	-	(0.126)	-	(0.123)
r_{bc}	-0.125	0.014	-0.325	-0.324	-0.176	-0.174
$r_{b\rho}$	-	-0.282	-	0.026	-	0.017
$r_{c\rho}$	-	-0.351	-	-0.046	-	-0.095
mean log-lik.	-0.6194	-0.6164	-0.5639	-0.5636	-0.5799	-0.5796

These results indicate that b is estimated more precisely than c which is in turn estimated more precisely than ρ. A sample size of 1000 seems necessary in this example to estimate b satisfactorily, whereas 5000 is barely enough for c and clearly insufficient for ρ. For the large sample size, the estimations with and without the restriction $\rho = 0$ yield very similar results, and it seems to be the case that the restricted estimator converges more quickly to the pseudo-true values than the restricted estimator to the true values. All this should be confirmed by a Monte-Carlo study, but at this stage it suffices to motivate our choice of the restricted estimator.

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