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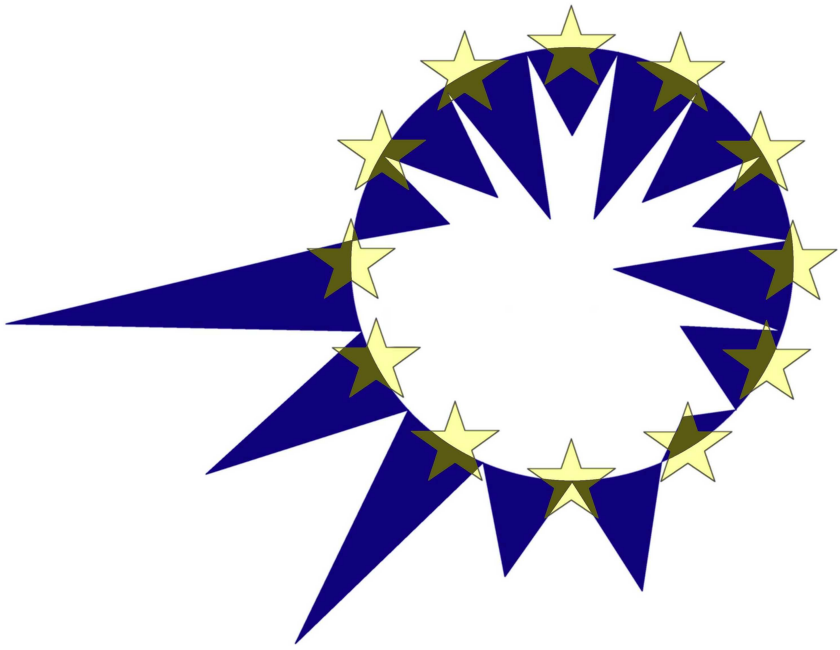

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DISCRETE CHOICE MODELLING OF LABOUR SUPPLY IN LUXEMBOURG THROUGH EUROMOD MICROSIMULATION

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DISCRETE CHOICE MODELLING OF LABOUR SUPPLY IN LUXEMBOURG THROUGH EUROMOD MICROSIMULATION[1]

Frédéric Berger, Nizamul Islam, Philippe Liégeois[2]

Abstract

In this study, the household labour supply is modelled as a discrete choice problem assuming that preference for leisure and consumption can be described by a quadratic utility function which allows for non-convexities in the budget set. We assess behavioural responses to the significant changes in the tax-benefit system during 2001-2002 in Luxembourg. Only moderate impact is found, on average, on the efficiency of the economy as measured by the labour supply effects. The impact is indeed concentrated on richer single women. These increase significantly their labour force, which more than doubles the non-behavioural effect of the tax reform on disposable income and boosts the gains in well-being for that part of population.

JEL Classification: C25, H24, H31, J22

Keywords: Labour supply, Discrete choice, Households, EUROMOD, Microsimulation, Tax reform

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[1] This paper uses EUROMOD version 31A and data from the PSELL/EU-SILC for 2004 (income 2003) made available by CEPS/INSTEAD. EUROMOD is continually being improved and updated and the results presented here represent the best available at the time of writing.

[2] The paper was written as part of the REDIS project ("*Coherence of Social Transfer Policies in Luxembourg through the use of microsimulation models*"), financed by the Luxembourg National Research Fund under Grant FNR/06/28/19. We are indebted to all past and current members of the EUROMOD consortium for the construction and development of EUROMOD. We also wish to thank Raymond Wagener from the Inspection Générale de la Sécurité Sociale in Luxembourg for continuous support. However, any remaining errors, results produced, interpretations or views presented in the paper are the authors' responsibility. In particular, the paper does not represent the views of the institutions to which the authors are affiliated.

1. INTRODUCTION

In all countries, the influence of governmental programs on individual's decisions about how much time to spend working is a decisive consideration in the design of policies. Therefore, understanding labour supply behaviour is crucial in formulating proposals that invoke work incentives.

However, in Luxembourg, most analyses relating to the effects of socio-economic reforms have relied until now on frameworks keeping the number of hours worked invariant. We would like to know more about second-round effects resulting from individual behavioural changes regarding the labour supply.

This motivates the present study.

To allow for the Lucas critique (Lucas 1976), we ground our analysis on a structural framework, the neoclassical consumer demand theory. Therefore, individuals are supposed to make decisions over their hours worked (hence the time devoted to leisure) and consumption by maximizing their well-being index (the utility function) subject to a specific budget constraint and their total time endowment.

The traditional way to model labour supply assumes that the number of hours worked is chosen on a continuous line, for example, as in Burtles and Hausman (1978). Furthermore, the budget line is usually supposed to be piece-wise linear and the budget set is expected to be convex. The main pitfall of this approach is imposing usual coherency conditions (monotonicity and quasi-concavity) to the utility function *a priori*. Experience has proven that, even in the simplest case, it is almost impossible to write down the true likelihood function of the empirical model, given standard assumptions about unobserved characteristics. Moreover, considerable expertise and computer time are required to estimate this type of model (Bloemen and Kapteyn, 2008).

As an alternative to the continuous framework, van Soest (1995), Keane and Moffit (1998), Blundell *et al*. (2000), and many others suggest adopting a discrete choice approach : the choice set for labour supply is approximated by a finite subset of its points (see Van Soest and Das 2001 for more details). The main advantage of the discrete framework is that an optimum is easily derived for the well-being index: a finite set of values, each one corresponding to a specific level for the hours worked, are to be computed and compared. Moreover, the convexity of the budget set and the piece-wise linearity of the budget line are not required. Finally, the coherency conditions need not to be imposed *a priori* but can be checked *ex post*.

Consequently, we choose the discrete choice approach. As far as we know, such a model has never been developed in Luxembourg. Our estimates are based on a maximum log-likelihood estimation controlling for unobserved heterogeneity by latent class approach. To evaluate the budget set at different levels for the hours worked, the EUROMOD tax-benefit static microsimulation model is used. We predict hourly wage rates for non-workers and refer to observed wage rates for workers.

As an illustration, we analyze both behavioural (through labour supply) and non-behavioural effects of the 2001-2002 tax reform in Luxembourg. This reform involved a reduction of the number of the tax brackets and a significant fall of the maximal marginal tax rate (from 46% in 2000 to 42% in 2001 and to 38% in 2002). The reform resulted, for the resident population of 2003, in a rise of individual equivalised income by 6% on average, the gain increasing with the income decile from 1% to 10% (see Liégeois *et al*. 2009, labour supply invariant). Such a reform is then expected to have a noticeable impact on the individual labour supply.

The paper is organized as follows. We firstly introduce the dataset used for the model estimation and explain how the population sample is set up (*Section 2*). Next, the theoretical and empirical frameworks chosen for the labour supply model are described (*Section 3*). We are then equipped for presenting and interpreting the structural estimates and deriving the predicted values for the individual labour supply (*Section 4*). Finally, the effects of the 2001-2002 tax reform are analyzed and decomposed (*Section 5*), before concluding (*Section 6*).

2. THE DATA AND CHARACTERISTICS OF THE TAX REFORM

Our main objective in the present exercise is to analyze the labour supply and its determinants in Luxembourg. We also aim at applying results to the evaluation of the effects of a tax reform on individual labour supply.

We emphasize the economic situation as it was just after full implementation, in two steps, of the 2001-2002 tax reform in Luxembourg[1]. Consequently, the estimation of the model and the

[1] We could have chosen a more recent picture for the economy, for example the years 2008 or 2009 which are also contemporaneous to a reform of the tax-benefit system. However, the latter is of limited size, compared to the 2001-2002 reform. Moreover, input data are missing and an ageing process driving from the most recent dataset made available (2007, income for 2006) to the year of interest (2008 or 2009) would imply a mismatch between different types of data of main interest in the present analysis: labour supply (that cannot be changed) and income (which is to be adapted through the aging process). We could also have grounded the developments on administrative data, but those available at date are silent regarding the education level of the individuals.

socio-economic analysis require input data properly describing the households' characteristics in 2003 (including the education level of members) on the one side, and well-adapted to microsimulation on the other side. This is why we choose to work mainly with the PSELL3/EU-SILC survey data collected during the year 2004, which include information on income for 2003. However, the analysis is targeting residence households with the simplest structure and then concentrates on a sub-sample only.

In the present section, we firstly create an input dataset, adapted to the discrete choice modelling framework and designed for EUROMOD microsimulation, from raw survey data *(Section 2.1)*. Next, the so-called "workers" are identified and their individual labour supply and wage rate are determined *(Section 2.2)*. After that, we build up households from workers and focus the analysis on specific configurations *(Section 2.3)*. Then, we examine relevant variables, including the labour supply, and adjust our selection *(Section 2.4)*. Finally, the main characteristics of the 2001-2002 tax reform are presented *(Section 2.5*).

2.1 Creating a EUROMOD input dataset from survey data

The "Panel Socio-Economique Liewen zu Lëtzebuerg (PSELL)[2] data are used in Luxembourg as a basis for the "European Union Statistics on Income and Living Conditions (EU-SILC)[3]. This is our initial source of data. It targets the resident population of Luxembourg ("International civil servants" included) through a sample of 3,571 private households (9,780 persons).

Information about all kinds of gross earnings are collected through the survey, including labour income, investment and property income, social benefits in cash, private transfers, *etc*. Regarding these earnings, monthly amounts are detailed for the civil year preceding the date of interview (2003, for the PSELL3/2004). We also know the highest level of education achieved by the interviewee. Finally, if working, interviewees are additionally asked their usual weekly labour supply at time of interview.

To be able to simulate easily changes in the tax-benefit system in Luxembourg and in earnings

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[2] See http://www.ceps.lu/.

[3] EU-SILC is an instrument aiming at collecting timely and comparable cross-sectional and longitudinal multidimensional microdata on income, poverty, social exclusion and living conditions (see http://epp.eurostat.ec.europa.eu/).

for alternative labour supplies, we make use of the EUROMOD tax-benefit static microsimulation model (Sutherland, 2007). This lets us derive several monetary characteristics of households, including the disposable income[4], through a nice implementation of the tax-benefit system, the structure of the population, the distribution of workforce and earnings, for Luxembourg as well as for most European countries[5].

The PSELL3/2004 data are then transformed into a reduced set of input variables which are precisely defined and compose a nice synthetic basis for further manipulations. However, this normalization process induces a loss of 813 cases, leaving an input dataset with 8,967 persons designed for EUROMOD microsimulation.

2.2 Marking "workers" and determining the labour supply and wage rate

Within the input dataset, we are basically interested by persons likely to join the labour market during the period under interest regarding the earnings (the year 2003). We will call them "workers" from now on, whether they were actually working or deciding not to work[6].

We want to avoid as far as possible any confusion between the classical labour supply decision formation and retirement options (either ordinary or early schemes) or some noises due to an initializing career. It is then decided to exclude from the so-called workers all persons more than 60 years old, less than 20 years old or mentioned, even during a short period only, as disabled, students, pensioners, benefiting from a parental or a maternity leave, or having a baby during the year.

We also ignore groups for which behaviour as active people is lacking in flexibility or is clearly out of the general scheme. Then, civil servants (either from the Luxembourg administration or from international institutions) and the residents who have experienced self-employment during part of the year are also dropped from marked (or selected) workers

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[4] Regarding the minimum income scheme, we had indeed to change the minimum age for eligibility from 25 to 20 years to guaranty an outcome with strictly positive household disposable income for all. This concerns (and changes) a few cases only, but is a necessary condition for the labour supply model to be estimated.

[5] EUROMOD is an integrated European benefit-tax model for the (pre-2004) fifteen Member States of the European Union. See http://www.iser.essex.ac.uk/msu/emod/.

[6] Unemployment was low in Luxembourg in early 2000s (less than 4% up to 2004, as shown by EUROSTAT) and we choose not to take this phenomenon into account in the present analysis, which means that a "worker" who is actually not working is supposed to voluntarily remain out of the labour market for a while (hence inactive).

before analysis.

The next step in preparing the data is now to determine, for workers, the values of two essential variables: the labour supply[7] as observed and the wage rate. For workers actually not working in 2003, the wage rate is determined through a classical wage equation (Heckman two stage estimation methods), separately for males and females[8]. This evaluation, to be made from the initial survey data, is an indirect process indeed, hence showing some lack of precision for part of the sample. Finally, a few outliers or marginal cases are additionally dropped from the marked sample[9].

2.3 Making up households from marked workers and focusing on simple configurations

The basic unit for the analysis of labour supply is the individual. Nevertheless, the decision to participate or not, and the level of labour supply when participating, can also be seen as a joint decision between members of a given residence household.

Therefore, the estimation of the discrete choice model of labour supply requires some knowledge of the characteristics of the household as a whole, dependents (who are mainly children) included. We thus have to make up households from the marked workers, through the integration of all their dependents.

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[7] When active, interviewees are asked their usual weekly labour supply at time of interview. But the data about income are covering the preceding civil year. Fortunately, this mismatch can be partially solved thanks to the panel nature of the dataset. Going back to PSELL3/2003, we can determine from the same part of the questionnaire the usual weekly labour supply during the year of earnings of the PSELL3/2004. For persons not working in 2003, or who were not included in the sample in 2003 yet, it is assumed that the weekly labour supply in 2003 is unchanged compared to 2004. When neither the PSELL3/2003 nor the PSELL3/2004 can be used for determining the weekly labour supply, we go back to the PSELL2/2002. If no information is available, males are supposed to be full-time workers and females to supply labour in conformity with their level of earnings. Combining the weekly labour supply with the number of months mentioned as spent to work in the questionnaire, we derive the yearly labour supply (on the basis of 4.33 weeks/month, on average).

Finally, for "workers" actually working in 2003, the hourly wage is simply defined as the ratio between the yearly employment earnings (known from the survey data) and the yearly labour supply.

[8] Wage equation estimates are available on request.

[9] These relate to wages (abnormally) higher than 70 EUR/hour or lower than the minimum wage (7.8 EUR/hour), to labour supply unknown or exceeding 3,000 hours/year, or to individuals benefiting from special earnings like a reversion pension. The latter are concerned because we will have later on to evaluate the budget constraint under several hypothetical environments regarding the labour supply. Given that a reversion pension is dependent on the level of other sources of earnings, and that we cannot today, through our microsimulation model, determine such adaptations of reversion pensions due to the changes in employment earnings, we avoid bias by dropping those (few) cases.

However, we decide to concentrate on the simplest configurations for residence households. These are composed of either exactly one "single-type" household (a "head" who is a marked/selected worker, together with non-worker dependents) or one "couple" (two marked worker partners, either married or not, together with their non-worker dependents). More generally, these configurations are called throughout the paper "nuclear" households, to be distinguished both from residence households (all persons living in the same house) and from fiscal households (defined through fiscal rules which imply that unmarried partners belong to separate fiscal units). Our target population is thus involving selected residence households including only one nuclear unit, the heads of which are marked workers[10].

Table 2.1: Targeting the Population for the Discrete Choice Modelling

Number of individuals and nuclear households (unweighted)

Table 2.1 Targeting the population for Discrete Choice Modelling analysis
Number of individuals and nuclear households (unweighted)

Type of households		Number of nuclear households in the residence household						TOTAL	
		1	2	3	4	5	6		
Not "selectable" for the present analysis		4,603	1,046	280	31	1	1	5,962	
"Selectable"	SINGLE	455	227	85	13	3	6	789	3,005
	COUPLE	1,766	364	66	18	2	0	2,216	
TOTAL		6,824	1,637	431	62	6	7	8,967	
Note :		<=> "selected" for the present analysis							

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD classification

In the present analysis, we are then dropping more complex configurations (for example, a couple and an independent adult who is a marked worker and living at the same place). Following our general framework, more complex configurations would have implied either taking into account interactions between more than two persons, a rather demanding task, or over-simplifying the process through, for example, considering the different nuclear

[10] Consequently, if one partner in a couple is not marked (*e.g.*, one parent is a researcher in the private sector, the other one is a civil servant), all the members of his/her household are dropped (even if marked workers), as our analysis obviously cannot be grounded on "partial" households. This is indeed a more severe rule than strictly needed in the present analysis.

components of a given residence household as independent units, which they are clearly not[11]. These limitations drive us to a target population of 1,355 selected "workers" involving, through their dependents, 2,221 individuals on the whole (see *Table 2.1*). Among them, 455 persons belong to 289 "single" households, headed either by a female (162 households) or a male (127 households). On the other side, 1,766 persons are part of 533 "couple" households.

2.4 Characteristics of the target population and downstream implications

Figure 2.1 shows the labour supply under four nuclear household configurations: single males, single females, males in couple and females in couple, whether dependents present in the household or not. Clearly, little heterogeneity is observed for males where an overwhelming majority is working exactly full-time (2080 hours/year[12] in the present framework). A few others mainly bunch around zero work effort for single males or more than full-time for males in couple. This lack of heterogeneity on the male side is indeed compromising the feasibility of a statistical estimation through the discrete choice modelling under the latent class approach. We are then excluding single males from the present analysis and assume a purely exogenous (hence "frozen") labour supply for males in couple when examining females in couple's behaviour.

The two groups we are considering are composed of 162 "single" households headed by a female (313 persons concerned) and 533 "couple" households (1,766 persons concerned)[13] in which both partners are selected workers. *Table 2.2* gives some descriptive information about the variables that will be used in the labour supply specifications for both single females and females in couple. As expected, individual characteristics of heads of households often differ when "singles" are compared to "couples".

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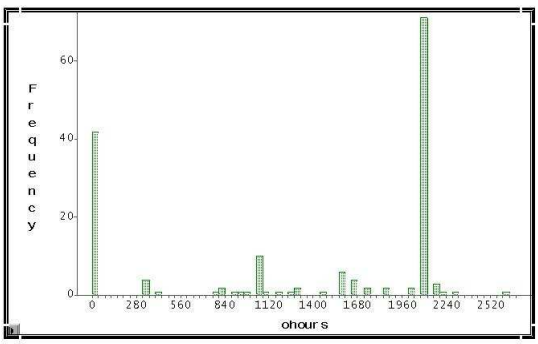
[11] Given the rules for social assistance in Luxembourg, a decision taken by any member of a residence household (for example, "not working") can have an impact on the budget of other members of the household (for example, through minimum income scheme), which matters in the present analysis. Therefore, considering "nuclear" units as isolated each others would be unrealistic.

[12] The full-time work is normalized to 2,080 hours per year (40 hours/week, 4.33 * 12 = 52 weeks/year).

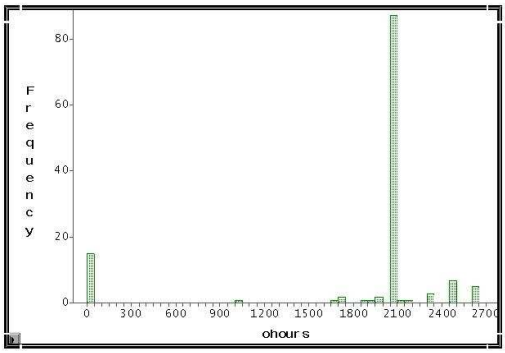
[13] The 695 selected persons marked as "workers" in our final sample represent 18% (weighted count) of the population aged between 20 and 60 in the original PSELL3/2004 sample.

Figure 2.1: **Distribution of Labour Supply**

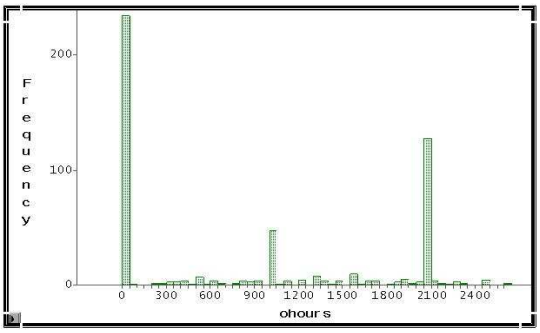
(in hours/year)



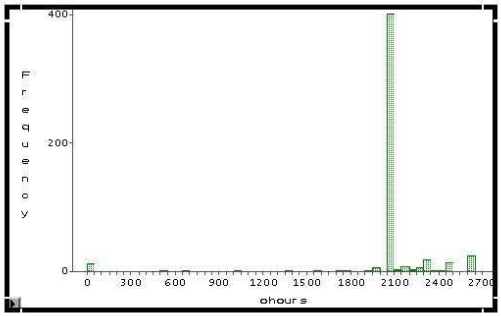
(a) Single females



(b) Single males



(c) Females in couple



(d) Males in couple

Source : PSELL2/2002 to PSELL3/2004 and CEPS/INSTEAD computations

For example, single heads are more often tertiary educated than heads of a couple and are supporting a number of dependents which is remarkably lower. Yearly disposable income per worker is higher, on average, for singles, who are also working more.

2.5 The 2001-2002 Tax Reform in Luxembourg

In Luxembourg, the tax unit is the "family" which might not include all members of a "residence/nuclear household". To belong to the same family, you must either be (an official) spouse or a dependent child. Two cohabiting but non-spouse persons are then members of separate tax units. A "child" belongs to his/her parents' tax unit if unmarried and less than 21 years old. As soon as he/she marries, a son/daughter enters his/her own tax unit. The same prevails if an individual is older than 21 years and is neither a student nor a disabled person.

Of course, the set of rules includes many other aspects, related to the questions of "earnings" of dependent children, children living part-time only with their parents, status changing during the civil year, spouses separating/being divorced, etc. These questions, although essential to the system as a whole, are not discussed here.

***Table 2.2*: Descriptive Statistics of the Variables Relevant for the Labour Supply Specifications**

Unweighted values (*)

	Single females		**Females in couple**	
Variables	Mean	*Standard deviation*	Mean	*Standard deviation*
Yearly disposable income (in EUR)	29,263	*12,830*	25,785	*10,898*
Yearly hours worked	1,319	*896*	900	*915*
Age	39.6	*9.9*	38.1	*8.8*
Education				
Primary degree	28.4%		37.1%	
High school degree	12.3%		11.8%	
University degree	38.9%		33.9%	
Higher Non-University degree	20.4%		17.1%	
Children				
Number of children	0.722	*0.954*	1.124	*1.174*
Number of children 0-5	0.167	*0.435*	0.396	*0.679*
Number of children 6-10	0.209	*0.452*	0.345	*0.685*
Number of children 11-17	0.367	*0.672*	0.383	*0.323*
Nationality				
Luxembourgish	53.1%		43.7%	
Portuguese	8.0%		23.1%	
Other EU-15	31.5%		24.0%	
Non-EU15	7.4%		9.2%	
Number of observations	162		533	

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

(*) The discrete choice modelling framework chosen in the present exploratory exercise does not take into account sample weighting. Therefore, all the results in the paper (including the present table) are shown unweighted.

The main outlines of the 2001-2002 reform in Luxembourg are described below:

- the first tax bracket is enlarged, which means that the minimum income before tax is increased, from 6,693 EUR in 2000 up to 9,750 EUR in 2002;
- the number of tax brackets is reduced, from 18 down to 17 in 2002 and band widths are made uniform to 1,650 EUR in 2002; and
- the maximum tax rate significantly decreases, from 46% to 38% in 2002.

The following methodological framework has been chosen for assessing the effects of such a tax reform (see Liégeois *et al.*, 2009).

We would like to strictly avoid changes not directly resulting from the tax reform or from a modified labour supply. This is the reason why we choose to concentrate on a given year, as far as the economy and the social field are concerned, with a simple treatment of the tax-benefit environment. The year 2003 is chosen as a basis for analysis. In the benchmark, the 2003 tax system is designed conforming to the brief description earlier, which means in its post-reform state. The alternative is then simply to set up (in 2003) the tax system as it was before the 2001-2002 reform. On the benefit side, no change is to be mentioned between the benchmark and the alternative. Altogether, these options raise the following question: What would have happened for the population in 2003, had the 2000 tax system either been frozen on the one side, or be replaced by the new 2003 tax system on the other side?

3. THEORETICAL AND EXMPIRICAL FRAMEWORKS FOR THE LABOUR SUPPLY ANALYSIS

The model underlying the formation of labour supply is based on the neoclassical consumer demand theory in which individuals make decisions about their hours worked (hence the time devoted to leisure) and consumption by maximizing their utility subject to a specific budget constraint and the total time endowment.

We describe the model (*Section 3.1*), specify its empirical implementation (*Section 3.2*) and derive the likelihood function to be maximized (*Section 3.3*). Finally, the process is adjusted in order to conform to economic rationality (*Section 3.4*).

3.1 Theoretical framework

The worker's program can be written as:

$$\text{Max } U(y_i, h_i, z_i)$$

subject to (1)

$$y_i \leq w_i * h_i + W_i + A_i - t(w_i * h_i, W_i, A_i)$$

where:

U(.) : well-being index (utility function)

i : household's index (*i* = 1, …, N)

y_i : net disposable income of the household (= "consumption", given our static framework)

h_i : labour supply by the head of household (either single female, or female in a couple)
= total time endowment (*T*) – chosen level of leisure

z_i : (a vector of) characteristics of the household

W_i : non-labour income (all sources)

A_i : all kinds of allowances (positive transfers)

$t(w_i * h_i, W_i, A_i)$: (all kinds of) taxes on labour income, non-labour income, allowances

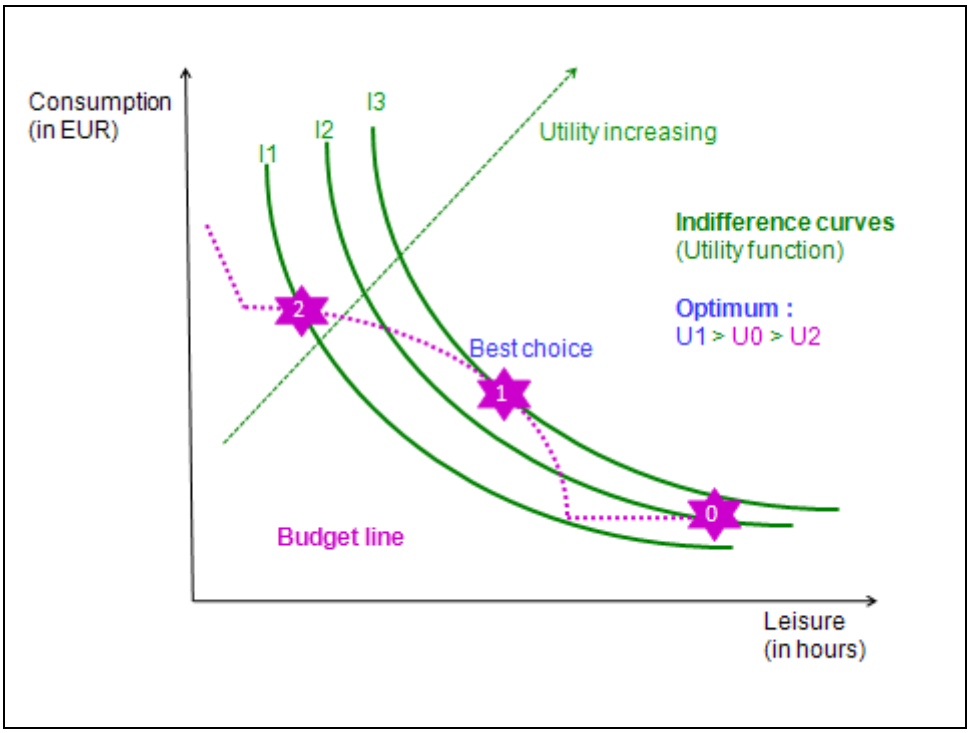
As explained earlier (*cf. Section 1*), we adopt the discrete choice approach regarding the number of hours worked. These are to be chosen by the worker in finite set of distinct values.

Compared to the traditional (continuous) model, the main advantage of the discrete approach is that a finite set of values only are to be computed for the well-being index and compared. Then, an optimum is easily derived (see *Figure 3.1*). Moreover, the convexity of the budget set and the piece-wise linearity of the budget line are not required. Finally, the coherency conditions (monotonicity and quasi-concavity of the utility function) are not to be imposed *a*

priori but can be checked *ex post*[14].

***Figure 3.1*: The Worker's Program: Looking for an Optimum**

(the indifference curves and the budget line are purely illustrative)



Remark : The well-being index *U(.)* including in the present analysis random components (see *infra*), the "predicted" optimum for labour supply is indeed based on the combination (consumption, leisure) showing the highest *probability* (*cf. Section 4.2*).

3.2 Empirical Specification of the Utility Function

We assume a quadratic utility function (household's index is omitted for simplicity):

$$U(y,h,z) \triangleq \beta_y y + \beta_h (T-h) + \beta_{yy} y^2 + \beta_{hh} (T-h)^2 + \beta_{yh} y(T-h) + \varepsilon_j \qquad (2)$$

where :

β_y, β_h, β_{yy}, β_{hh}, β_{yh} are coefficients

j is denoting (indexing) the choice of labour supply : $j = 1, \ldots, J$

$h = h_1, h_2, \ldots, h_J$ is the choice of labour supply, in a finite set of possibilities

[14] For more details see MaCurdy *et al.* (1990) and Moffit (1990).

ε_j is a random disturbance (*e.g.* error made in evaluating alternative *j*) : $\varepsilon_j \sim EV(I)$;

$EV(I)$ stands for "Type I extreme value distribution", with cumulative density $Pr[\varepsilon_j < \varepsilon] = \exp(-\exp(-\varepsilon)), \varepsilon \in \mathrm{R}$.

The utility *U(.)* is classically assumed to be increasing with consumption *y*, and decreasing with respect to hours worked *h*, even if those properties are not to be imposed *a priori* but can be checked *ex post*. The total time endowment *T* is set to 4,000 hours per year.

Regarding the budget constraint in (1), the specification of the model allows for non-convexities in the budget set and complex shapes for the budget line. These are unavoidable, especially due to fixed costs and intricated rules for benefits and taxes: tax allowances depending on whether the partner works or not, thresholds in social security premiums, *etc*. Moreover, the budget constraint is to be evaluated for a finite set of hours-steps only (h_1, h_2, … , h_J).

The appropriate number of hours-steps is evaluated by looking at the mode value of the histograms of hours worked for females (see *Figures 2.1.a* and *2.1.c*). We consider three choices for females: 0 (0 hour/year), 1040 (0+ up to 1500 hours/year), and 2080 (1500+ hours/year). The labour supply by males in a couple is exogenous and unchanged compared to the level observed in the source data (*cf. Section 2.3*).

Furthermore, to account for preference variations across households, we need to specify the nature of heterogeneity. For this, we assume that the preference parameters depend on the person's and household's observed and unobserved characteristics. These characteristics are likely to influence the preference for leisure. Hence the leisure coefficient β_h is written as:

$$\beta_h = \sum_{c=1}^{C} \beta_{h,c} z_c + \theta \qquad (3)$$

where the first part of the right member is relating to observed characteristics (in total there are $C = 4$ different characteristics : age, education, nationality and the number of the children) and the second part θ refers to unobserved (latent) characteristics[15].

[15] Heterogeneity is then enriching the well-being index and considering, beyond consumption and leisure as such, several complementary individual and family dimensions, *e.g.*, the number of children.

We follow Flood *et al.* (2004), which assumes that the unobserved heterogeneity capture the effect of unobserved fixed costs of work as well as unobserved preferences for leisure. It is worth mentioning that we do not have any explicit information on fixed costs in the data. This is the reason why fixed costs variables are latent, unobserved variables in the model. They comprise the costs of child care, commuting costs, *etc*. But they may also capture other disincentives for paid work, such as search effort. It is indeed difficult to distinguish between the various sources of fixed costs (van Soest *et al.* 2001) [16].

As unobserved heterogeneity (characteristics) θ is not observed, we specify a distribution for it. We choose the latent class approach proposed by Heckman and Signer (1984)[17] and assume that there exists *S* different mass points for θ , each observed with probability π_s satisfying $0 <= \pi_s <= 1 \quad \forall \quad s = 1, ..., S$ and $\sum_{s=1}^{S} \pi_s = 1$. The major advantage of this approach is the greater flexibility allowed in the labour supply modelling. The interpretation of this unobserved heterogeneity parameter (mass points θ) is straightforward : the higher the value. the stronger the preference for leisure.

3.3 Likelihood Function

Given the specification introduced in *Section 3.2*, it can be shown that for any household *i* and given a mass point *s* (*i* = 1, …, *N* ; *s* = 1, …, *S*) :

$$P_{i,j}|\theta_s \triangleq Pr[U_{i,j} > U_{i,k}, \forall k \neq j, j = 1, \ldots, J \mid \theta_s] = \frac{\exp(U_{i,j} \mid \theta_s)}{\sum_{k=1}^{J} \exp(U_{i,k} \mid \theta_s)} \qquad (4)$$

where $U_{i,j}$ is the *value* of the utility function for household *i*, given his choice *j* for labour supply.

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[16] Fixed cost was also included in the utility function with a dummy variable so that it captures the effect of the cost only if the person is working. But the coefficient was not significant and didn't improve the model with respect to likelihood ratio.

[17] This approach has been applied in many other literatures, for example, in duration data (Ham and Lalonde, 1996), in count data (Deb and Trivedi, 1997) and in labour supply (Hoynes, 1996). Heckman and Singer (1984) also showed that estimation resulting from this approach might provide a good discrete approximation even if the underlying distribution is continuous.

It follows that the contribution l_i of household *i* to the likelihood function is given by :

$$l_i \triangleq \sum_{s=1}^{S} \pi_s \left\{ \sum_{j=1}^{J} \left(P_{i,j} | \theta_s \right) \right\} \delta_j \qquad (5)$$

where δ_j is an indicator (1 or 0) that the state (labour supply) is the one observed for the household under consideration.

Practically, the analytical expression for $P_{i,j}|\theta_s$ is derived from the $U_{i,k} \mid \theta_s$ (k = 1, …, J) which in turn result from (2). For each hypothetical level of labour supply ($h = h_1, \ldots, h_J$), the net income *y* in (2) is determined through EUROMOD microsimulation.

Finally, the likelihood function L can be written as:

$$L\left(\beta_y, \beta_{h,c}, \beta_{yy}, \beta_{hh}, \beta_{yh}, \pi_1, \pi_2, \theta_1, \theta_2 \; ; c = 1, \ldots, C\right) = \prod_{i=1}^{N} l_i \qquad (6)$$

Maximizing equation (6) yields estimates for the unknown coefficients of utility function which, under general regularity assumptions, are consistent and asymptotically normal.

3.4 Adjusting the process to conform to economic rationality

Scientific literature often claims about discrete choice models that quasi-concavity of the utility function is not obligatory, due to the fact that the utility is maximized over a finite set, not requiring a tangency condition.

Nevertheless, the economic interpretation of the model is reasonably expecting a utility function increasing with income[18]. This comes from the assumption that everyone prefers consuming more, *ceteris paribus*, hence choosing a point on the frontier of the budget set. In our results based on program (1)-(6), this condition is not fully satisfied. For example, around 17% of sample observations for females in couple do not satisfy the monotonicity condition. Similar shortcoming is found in many other papers (see, for example, Lebeaga *et al.*, 2008, Van Soest and Das, 2001, and Vlasblom 1998).

To overcome this drawback, Van Soest and Das (2001) impose *ad hoc* parametric restrictions *a priori* (hence reducing *de facto* the dimension of the parameter set), which are sufficient to guarantee that marginal utility is positive *ex post*. Vlasblom (1998) avoids this by using a CES utility function. However, those restrictions might sometimes appear to be unnecessarily too severe. Alternatively, we complete the program (1)-(6) with necessary conditions (one per household) imposing positive marginal utilities at optimum. We follow Islam and Liégeois (2009) in which it has been shown that such a high-dimensional program can be equivalently replaced by a one-dimensional one[19]. In the end, no observation shows negative marginal utility at optimum.

4. STRUCTURAL ESTIMATES AND ANALYSIS OF THE LABOUR SUPPLY

We launch the analysis of the labour supply in Luxembourg regarding single females and females in couple. The objective is to illustrate the link between individual characteristics or wages and the choice of hours worked. We also examine how far the model properly fits observed values for the labour supply in Luxembourg.

Structural estimates and the socio-economic properties of the well-being index are firstly analyzed (*Section 4.1*). Then, predictions for the labour supply are formed from the model and compared to the observed levels (*Section 4.2*). Finally, we examine the impact of an increase in gross wages on labour supply and derive wage elasticities (*Section 4.3*).

4.1 Structural estimates and utility

We conduct similar analyses for single females and females in couple. The results are based on equation (2) where the parameters are replaced by their estimated values shown in *Tables A1* and *A2* in the *Appendix*.

It is well known that in a structural discrete choice specification, the estimated coefficients are very difficult to interpret because they are not directly tied to the marginal effects of characteristics on leisure and consumption. However, they give a hint about preferences.

Figure 4.1 represents the utility surface (a three-dimensional view from top) for a single

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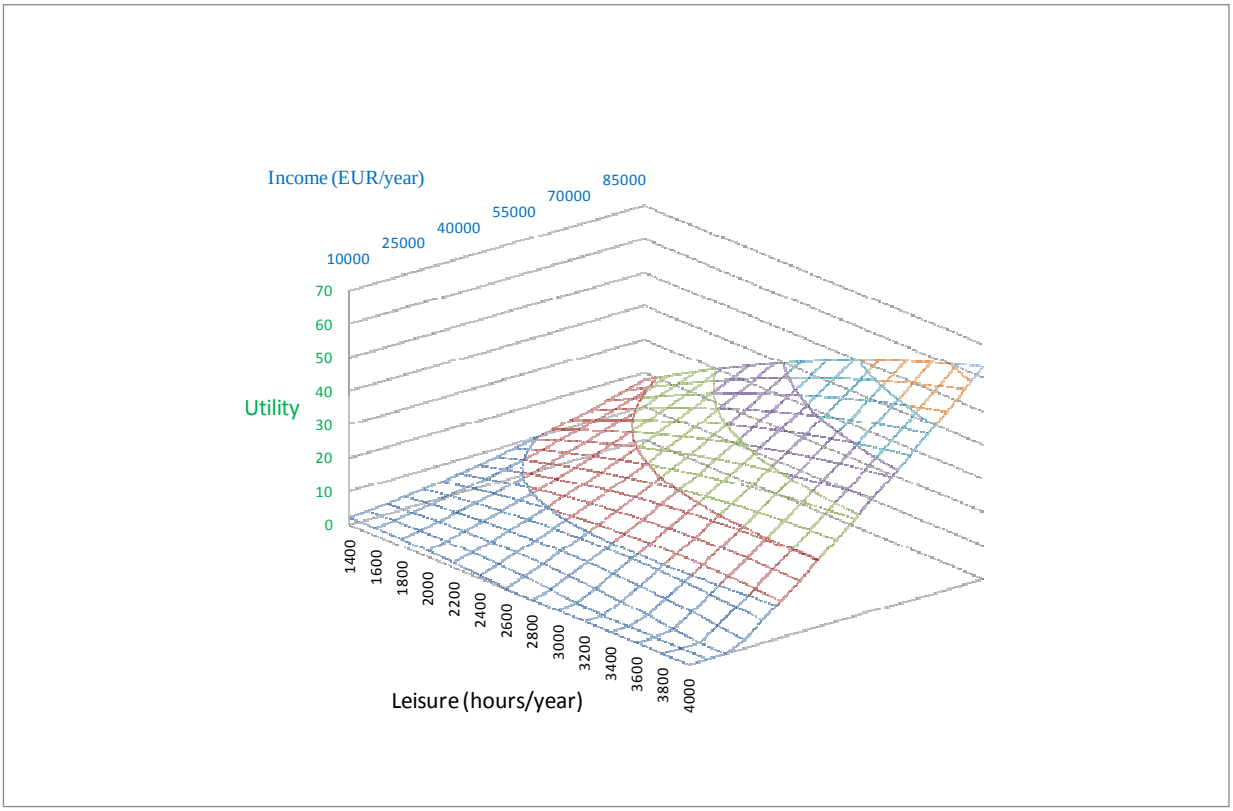
[18] Taking first derivative of equation (2), marginal utility of income follows : $U_y = \beta_y + 2\beta_{yy}(y) + \beta_{yh}(T-h)$

Luxembourgish female aged 37 with one child and a higher non-university degree, an example arbitrarily chosen in the sample. The computation is based on the estimated results[20] presented in *Table A1*. It can be seen that utility is increasing with income everywhere, which is expected given the constraint imposed on the utility function (*cf. Section 3.3*). However, the unconstrained marginal utility of leisure happens to be negative, especially for low income.

***Figure 4.1*: Utility Surfaces (Three-dimensional View from Top)**

Single Luxembourgish female aged 37 with one young child and higher non-university degree



Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Going further, it is very likely that females with young children have a stronger "preference" for leisure. This is firstly illustrated through *Figure 4.2*, which represents indifference curves for the same female as before. Solid lines refer to the "with one young child" case and dashed lines refer to "no child".

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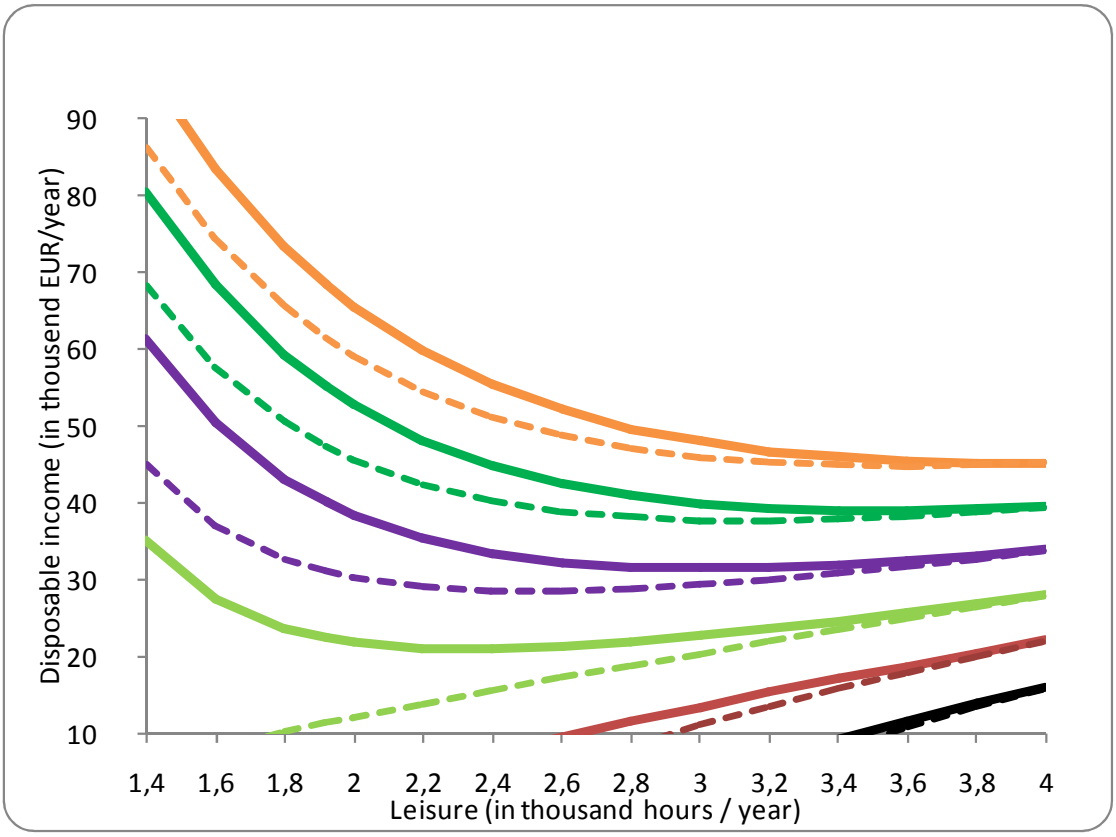
[19] The likelihood function (6) is then maximized under a single constraint, and corresponding Kuhn-Tucker conditions derived and solved.

[20] We consider the expected value for unobserved characteristic θ.

***Figure 4.2*: Indifference Curves for a Female with a Young Child (Solid Lines) or Without a Child (dashed lines)**

Single Luxembourgish female aged 37 with higher non-university degree



Source: EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Clearly, the marginal rate of substitution between leisure and income (slope of the indifference curve) is higher for the mother, showing that a loss of leisure is to be compensated by more additional consumption for the well-being keeping unchanged. For lower income levels, the positive slopes of indifference curves result from utility decreasing with leisure.

Complementarily, we can calculate the elasticity of substitution (linked to the curvature of the indifference curve) for the same person at optimum when income is 62,114 EUR/year and leisure is 1,920 hours/year (full-time worker). The elasticity of substitution is 0.77 for the single female with one child and would be 0.71 without a child at the same point, which shows up a higher "sensitivity" to relative changes in wages for the mother.

Aside from parenthood, other variables can play a role (see *Tables A.1* and *A.2*). For example,

females with higher non-university degrees have significantly weaker preference for leisure, compared to females with lower education and controlling for other characteristics. This result is consistent whether they are single females or females in a couple.

Structural differences in labour supply behaviour may also depend on nationality. We find, for example, that the non-EU15 single females have a stronger preference for leisure, compared to Luxembourgish ones, contrarily to Portuguese and other EU-15s. Regarding couples again, females show a preference for leisure depending negatively on their partner's labour supply and education when the partner has a university degree.

Hitherto, we have discussed how far females' preferences are influenced by their observable characteristics. But preferences may also vary with unobservable characteristics.

To evaluate such an impact, we have estimated the distribution of the unobservable characteristics by latent class approach (*cf. Section 3.2*). Under such a framework, the model appears to be well fitted[21] with two types[22] of unobserved heterogeneity (factors) determining female's preferences, each observed with an associated probability π .

The results are presented in *Tables A.1* and *A.2*. For example, for single females, the estimated values $\theta_1 = -5.175$ and $\theta_2 = 0.065$ represent two types of unobservable factors with corresponding estimated probabilities $\pi_1 = 0.41$ and $\pi_2 = 0.59$. A possible interpretation is that 59% of single females belong to a group showing a relatively stronger preference for leisure (as $\theta_2 = 0.065 > \theta_1 = -5.175$). Similarly, it appears that 20% of females in couple have a stronger preference for work.

4.2 Prediction

The fit of the model can be judged according to its ability to properly predict the hours worked.

We can, for example, compare the distribution of predicted hours given by the model to the

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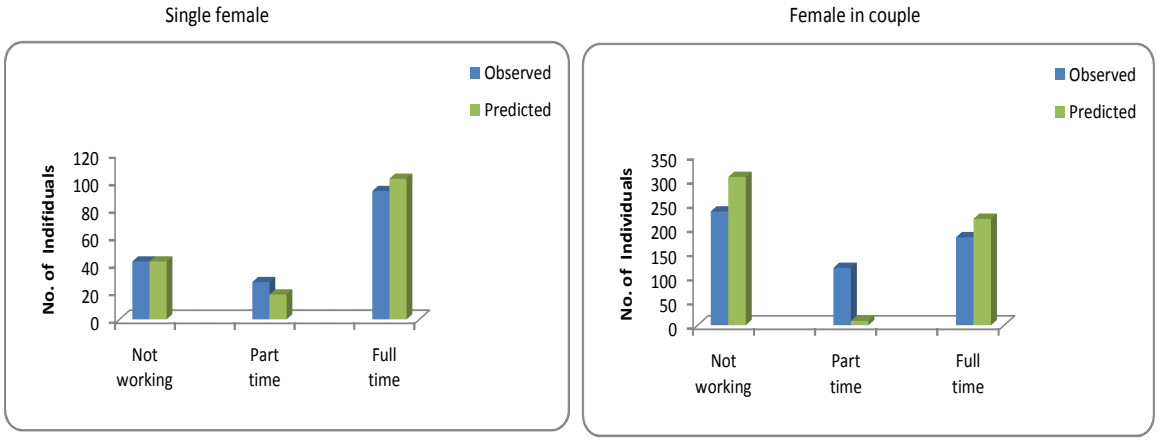
[21] We compare the estimated results with and without unobserved characteristics for both single and females in couple and find that preferences for leisure effectively depend on these unobserved factors.

[22] S = 2, *cf. Section 3.2*. We have also tried to identify the model considering more than two types of unobserved factors, but the procedure could not converge. This is the limitation of latent class approach (there is a huge literature on this issue such as Hansen and Lofstrom 2001, Cameron and Heckman 2001, Stevens 1999, Ham and Lalonde 1996, Eberwein *et al.* 1997, Heckman and Singer 1984).

observed distribution[23]. Regarding the predicted outcome, the fitted probability values $P_{i,j}$ in (4) are firstly computed using the parameter estimates in *Tables A.1* and *A.2* for single females and females in couple respectively. Then, the labour supply prediction is here chosen based on the highest probability. The distributions of observed hours worked, together with distributions resulting from the prediction, are presented in *Figures 4.3*.

***Figure 4.3*: Observed and Predicted Labour Supply for Females in Luxembourg**



Source: EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Notes: (a) Not working = 0 hour/year; Part-time = 0+ up to 1500 hours/year; Full-time = 1500+ hours/year.

(b) Labour supply decision of females in couple has been considered as a single decision, with partner's earnings included in the female's non-labour income.

The fit seems rather good, especially for single females, in the sense that predicted participation rates and predicted average hours worked are very close to the corresponding observed values.

However, the model does not succeed in reproducing the distribution completely, especially for females in couple. In particular, the model has a tendency to under-predict those cells with small representations and over-predict others. This is a common difficulty with discrete choice labour supply models (see, for details, Euwals and van Soest, 1999).

[23] Of course, the observed distribution not only depends on the workers' labour supply decisions, but also on the demand of labour by firms : constraints or additional specificities on the demand side of the labour market, which are not taken into account here, do play a role as well.

4.3 Elasticity

As mentioned before, the estimated coefficients give very little information regarding the effects of individual characteristics on preferences. An alternative to illustrate the results is to compute the elasticity of labour supply with respect to the price of leisure, which is the wage rate.

Table 4.1 summarizes the uncompensated wage elasticities of labour supply for single females and females in couple and various quartile groups. The gross wage rate is increased by 10% and the resulting disposable income of the households determined through EUROMOD microsimulation[24]. Then, the "new" predicted labour supply is computed and compared to the initial one (without the wage change) on an individual basis. Finally, elasticities are derived from changes in the total labour supply by income group.

***Table 4.1*: The Wage Elasticity of Labour Supply, Overall and by Quartile of Income**
(Through a 10% wage increase)

	Single females	**Females in Couple**
Full sample	*0.32*	*-0.28*
1st quartile	1.25	-0.19
2nd quartile	0.57	-0.39
3rd quartile	0.14	-0.24
4th quartile	0.00	-0.26

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Notes : a) The ranking on income is based on household total disposable income before the wage change (singles and couples separately);

b) Labour supply decision of females in couple has been considered as a single decision, with partner's earnings included in the female's non-labour income.

The results show that overall wage elasticities are rather small: a 10% wage increase raises labour supply by about 3.2% (of hours worked) for single females and drops it by about 2.8% for females in couple, on average.

Moreover, for single females only, a negative link between the wage elasticity and disposable

[24] Of course, we consider here that no additional constraint happens due to the demand of labour by firms (see previous footnote).

income is observed. But it must be remembered that if the relative gain in gross wage is 10% for all here, the higher the quartile of income, the weaker the transposition in terms of net disposable income, due to the progressivity of the tax system, *ceteris paribus*. Thus, disparities in *Table 4.1* result from both the socio-economic inter-quartile heterogeneity and uneven transmission from gross to net along the income line.

The economic literature indeed confirms that the sign of the wage elasticity is ambiguous, depending on the model specification and the data source (see, *e.g.*, Kornstad and Thoresen, 2007). Moreover, a worker may have different wage elasticities, both in sign and magnitude, depending on his position on the labour supply curve. The general picture in *Table 4.1* is therefore expected. This kind of diversified outcome is also visible in the next section, in which tax reform induces changes in the labour supply that are not always qualitatively purely in line with elasticities.

5. EFFECTS OF A TAX REFORM IN LUXEMBOURG

As an illustration, we analyze the effects of the significant 2001-2002 tax reform in Luxembourg (*cf. Section 2.5*). The gain in income resulting from the reform is expected to have a noticeable influence on the individual's choice of hours worked.

The impact is firstly measured in terms of changes in the labour supply. Individual transitions from one class of hours worked to another are examined and the overall impact is shown, by quartile of disposable income and globally (*Section 5.1*). Then, the effects on disposable income and well-being are presented, for the population as a whole and by quartile again. Finally, the gain in disposable income is decomposed into behavioural effects (due to the change in labour supply) and non-behavioural effect (due to the reform of the fiscal rules alone) (*Section 5.2*).

5.1 Efficiency of the tax reform in terms of changes in the labour supply

At the individual level, the effects of the tax reform are summarized in a transition matrix where rows *i* relate to the discrete distribution of hours worked with the reform and columns *j* refer to what would be the discrete distribution of hours without the reform. Both distributions are based on predicted values (*cf. Section 4.2*).

***Table 5.1*: The Transition Matrix of Labour Supply Due to Tax Reform for Single Females**

		Without the reform			
		Not working	Part-time	Full-time	*Total*
With the reform	Not working	41	1	0	*42*
	Part-time	0	18	0	*18*
	Full-time	0	8	94	*102*
	Total	*41*	*27*	*94*	*162*

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Note : Not working = 0 hour/year ; part-time = 0+ up to 1500 hours/year ; full-time = 1500+ hours/year

***Table 5.2*: The Transition Matrix of Labour Supply Due to Tax Reform for Females in Couple**

		Without the reform			
		Not working	Part-time	Full-time	*Total*
With the reform	Not working	305	0	0	*305*
	Part-time	1	8	0	*9*
	Full-time	1	0	218	*219*
	Total	*307*	*8*	*218*	*533*

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Notes : (a) Labour supply decision of females in couple has been considered as a single decision, with partner's earnings included in the female's non-labour income.

(b) Not working = 0 hour/year ; Part-time = 0+ up to 1500 hours/year ; Full-time = 1500+ hours/year

Each cell a_{ij} of the matrix (for $i \neq j$) shows the number of individual (households) moving from one discrete hours point to another one. The values to the right of the diagonal reflect individuals who reduce their labour supply due to reform and *vice versa*. The diagonal elements refer to those individuals (households) that do not change their labour supply after the reform.

It can be seen from the transition matrix in *Table 5.1* that only nine single females, working part-time without the reform, change their labour supply due to reform, eight of them towards a full-time job, the last one deciding to leave the labour market.

All other individuals remain on the diagonal, implying that the reform has limited impact on the labour supply for single females[25].

Regarding the females in couple, *Table 5.2* shows that only two non-working females change their position on the labour market. They join it, due to the reform.

The overall outcome for females in couple is clear: almost all of them stay on the diagonal of the transition matrix, implying that the efficiency of the tax reform in terms of changes in the labour supply is negligible.

The results are confirmed at the macro level in *Table 5.3* (Columns 1 and 2), with an increase of the labour supply by 3.3% for single females, on average, and by 0.6% for females in couple. Moreover, the participation rates are quasi-stable for both groups[26] (Columns 3 and 4).

Nevertheless, in each reform, there are winners and losers. This is emphasized by the distribution of the effects, which is not uniform over the quartiles of household disposable income.

Table 5.3 shows that single females who belong to the second and third quartiles change neither their labour supply nor their participation rate due to reform. By contrast, members of the upper quartile increase their labour supply by 12.7% with the reform (despite a participation rate to the labour market that remains unchanged), denoting a dominant price effect for that class, whereas the poorest single females are deciding to work 3.9% less. For females in couple, the reform leads to very little impact on the second and third quartiles (+0.9% and +1.5% respectively).

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[25] This is qualitatively in line with results about the (low and positive) wage elasticity of labour supply (*cf. Section 4.3*). Of course, the relation is weak given the complex nature of the tax reform, involving more than a simple homogenous increase in gross wages.

[26] 121 single females choose to work without the reform (out of 162 = 74.1%), while only 120 choose to work with the reform. For females in couple, there is a little increase from 226 to 228, out of 533.

***Table 5.3*: The Effects on the Labour Supply, on Average and by Quartile of Disposable Income**

(separately for single females and females in couple)

	Working hours		**Participation rate**	
	(1)	(2)	(3)	(4)
	Without the tax reform	With the tax reform	Without the tax reform	With the tax reform
Single females				
Full sample	*1,380*	*1,425*	*74.7%*	*74.1%*
1st quartile	634	609	41.5%	39.0%
2nd quartile	1,378	1,378	75.0%	75.0%
3rd quartile	1,877	1,877	92.7%	92.7%
4th quartile	1,638	1,846	90.0%	90.0%
Females in couple				
Full sample	*867*	*872*	*42.4%*	*42.8%*
1st quartile	388	388	18.7%	18.7%
2nd quartile	891	899	42.9%	43.6%
3rd quartile	1,009	1,024	49.6%	50.4%
4th quartile	1,181	1,181	58.7%	58.7%

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Notes : a) The ranking on income is based on household total disposable income when predicted labour supply and with the reform (singles and couples separately);

b) Labour supply decision of females in couple has been considered as a single decision when partner's earnings included in the female's non-labour income.

5.2 Effects of the tax reform in terms of disposable income and well-being

It can be shown that everyone is benefiting from the tax reform, what results in positive impacts on the disposable income, for all quartiles, in *Table 5.4* (columns 1 to 3). However, the reform seems to favour rich households compared to poor ones. Females belonging to the fourth quartile experience the highest relative gains, when considering single females or females living in a couple.

But one of the motives for implementing the tax reform was to improve the individual's economic well-being.

Table 5.4: **The Effects on the Household Disposable Income, on Average, by Quartile of Disposable Income and by Origin**

(separately for single females and females in couple)

	Disposable income			**Equivalent variation** (EV, in EUR/year)	**Decomposition** (in % of gain of disposable income)		
	Without a tax reform (in EUR/year)	With the tax reform (in EUR/year)	Gain due to the reform (in %)		*Behavioural effect* (due to labour supply)	*Non-behavioural effect* (due to the reform of the fiscal rules)	
	(based on Predicted values, *cf. Section 4.2*)						(Observed)
	(1)	(2)	(3) = (2) / (1) - 1 = (5) + (6)	(4)	(5)	(6)	(7)
Single females							
Full sample	*28,011*	*30,222*	*7.9%*	*1,326*	*3%*	*4.9%*	*5.0%*
1st quartile	15,162	15,488	2.2%	393	-0.4%	2.5%	5.1%
2nd quartile	23,596	24,100	2.1%	504	0.0%	2.1%	2.6%
3rd quartile	30,793	32,656	6.1%	1,863	0.0%	6.1%	5.2%
4th quartile	42,746	48,951	14.5%	2,620	8.1%	6.5%	6.0%
Females in couple							
Full sample	*24,351*	*25,609*	*5.2%*	*1,222*	*0.2%*	*5.0%*	*5.1%*
1st quartile	14,553	14,848	2.0%	295	0.0%	2.0%	2.8%
2nd quartile	19,978	20,623	3.2%	592	0.3%	3.0%	3.3%
3rd quartile	25,734	27,085	5.2%	1,258	0.4%	4.9%	5.2%
4th quartile	37,211	39,960	7.4%	2,749	0.0%	7.4%	6.9%

Source : EUROMOD input dataset (from PSELL2/2002 to PSELL3/2004) and CEPS/INSTEAD computations (through EUROMOD microsimulation for disposable income)

Notes : a) The ranking on income is based on household total disposable income when predicted labour supply and "with the reform" results (singles and couples separately);

b) Labour supply decision of females in couple has been considered as a single decision when partner's earnings are included in the female's non-labour income. The disposable income mentioned for the females in couple is half of the total household disposable income.

Clearly, we cannot measure the well-being (utility) through the disposable income (hence consumption) only. The labour supply plays a role as well. It may be that a higher disposable

income somewhat due to an increase in the hours worked is partially compensated, in terms of well-being for the persons, by a reduced level of leisure. Then the disposable income is inadequate if the effects on leisure and consumption are taken into account altogether.

However, the ordinal nature of the utility function prevents us from using it directly as a basis for comparisons. We must first transform the variation of utility in measurable terms. We choose the equivalent variation (EV) as our money metrics of a welfare change. EV is defined as the amount of money to be added or subtracted from the households' disposable income under the "without tax reform" fiscal rules to make the household indifferent (in terms of utility) between the two tax systems[27].

The equivalent variation due to the tax reform is 1,326 EUR/year for single females (*Table 5.4*, column 4). This is less than the 2,211 EUR yearly gain in disposable income. The difference is explained by the increased labour supply, which under common economic properties leads to a loss in welfare. As an illustrative complementary example, we can consider females in couple belonging to the first income quartile who do not change their supply of labour (see *Table 5.3*). These households experience a gain in equivalent variation which is identical to the change in disposable income (295 EUR/year, see *Table 5.4*, column 4).

Once again, the higher the quartile, the higher the equivalent variation is when considering single females or females living in a couple. In all cases, the gain is positive[28] and even considerable for the highest quartile (6.1% for single females, in terms of disposable income without the reform, 7.4% for females in couple).

We can go further with the decomposition of the income gain and consider both the behavioural and non-behavioural effects of the tax reform.

The column 5 in *Table 5.4* refers to the average change in disposable income a female would

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[27] Indeed, for reasons of simplicity and following common practice, we fix the labour supply at initial state (without tax reform) and change only the income, to reach the same indifference curve as under the reformed tax system.

[28] This is an expected outcome. All workers have the opportunity, with the tax reform, to leave their labour supply unchanged compared to the initial state. If so, they would benefit from a higher consumption level, hence an improved welfare (given economic rationality, *cf. Section 3.4*). This is due to the nature of the present tax reform that leaves everybody better off (if the labour supply is unchanged) in terms of disposable income. On the whole, the feasibility of a gain in well-being is assured for all workers.

experience, with fiscal rules[29] unchanged, hence due to the variation in her labour supply only (columns 1 and 2, *Table 5.3*). This is the "pure" behavioural effect, which is nil, for example, for single females belonging to the intermediate quartiles who do not adjust their labour supply. However, the fiscal rules are reformed indeed, and a complementary non-behavioural effect[30] is generated (column 6 in *Table 5.4*).

Clearly, the behavioural effects appear to be negligible for most females, except for a single female belonging to the upper quartile. For all others, the gain in disposable income largely results from the change of the fiscal rules.

Most results in the *Table 5.4* are derived from predicted values for the labour supply, for comparability reasons. The last column only is based on "observed" levels for the labour supply, directly copied from the input dataset. We can see from columns 7 and 6 that non-behavioural effects computed from these alternative data[31] are generally not too far, on average, from outcome resulting from predicted values. Only the first quartile of single females shows a clear divergence. This is an indication that we can be moderately confident in the model, as far as such an analysis is concerned.

6. CONCLUSIONS

In this paper, we analyze the formation of labour supply decisions in Luxembourg.

We present a structural model in which the labour supply is treated as a discrete choice problem and assume that these choices follow a simple conditional logit rule. The static microsimulation model EUROMOD is used to evaluate consumption bundles corresponding to different levels of hours worked (hence earnings). In addition, we allow for unobserved individual-specific effects drawn from a discrete distribution. A coherency condition on the marginal utility of consumption is imposed *a priori*, to allow for economic rationality, and is taken into account during the estimation process. Under this framework, we analyze the impact of an important tax reform that has been implemented in Luxembourg in 2001 and

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[29] Relating to the "with tax reform" case.

[30] Fixing the labour supply at its "without tax reform" level.

[31] Column 7 in *Table 5.4* corresponds, for example, to the usual outcome of a EUROMOD microsimulation, in which the labour supply is constant and exogenous, directly and implicitly derived from input data, through the gross employment income variable.

2002.

Given the very limited heterogeneity of labour supply for males in the PSELL3/EU-SILC data, we concentrate on females' decisions only. Additionally, the nature of the model induces a focus on residence households composed of one nuclear household only, either of single-type or a couple.

Even if difficult to interpret, the estimated coefficients of the utility function show that the marginal utility of leisure may be negative for lower disposable income households. We can also observe, *e.g.*, that females with young children have a stronger preference for leisure, *ceteris paribus*. The same kind of preference prevails for about half of single females, regarding their distribution of unobserved characteristics.

The fit of the model is rather good, especially for single females, in the sense that predicted participation rates and predicted average hours worked are very close to the corresponding observed values. However, the model does not succeed in reproducing the distribution completely, especially for females in couple. In particular, there is a tendency to under-predict those cells with small representations and over-predict others.

In terms of "reactivity", the results show that overall wage elasticities are rather small: a 10% wage increase raises labour supply by about 3.2% (of hours worked) for single females (decreasing with the household disposable income quartile) and drops it by about 2.8% for females in couple.

The 2001-2002 tax reform in Luxembourg, despite a significant change in the fiscal rules, shows limited impact both in terms of transitions between one class of hours worked to another and in terms of hours worked. Due to the reform, the labour supply increases by 3.3% for single females, on average, and by 0.6% for females in couple. Nevertheless, the effects may differ with income. For example, single females belonging to the upper quartile increase their labour supply by 12.7% with the reform.

One of the motives for implementing the tax reform was to improve the individual's economic well-being and not the disposable income as such. It may be that a higher disposable income due to an increase in the hours worked is partially compensated, in terms of well-being for the person, by a reduced level of leisure. We compute the "equivalent variations" due to the reform, a money metrics of the welfare change, and show, for example, that it is 1,326

EUR/year for single females. This is less than the 2,211 EUR yearly gains in disposable income. The difference is explained by the observed increase in the labour supply.

Finally, we decompose the gain in disposable income into pure behavioural effect (due to adjustments in labour supply only) and non-behavioural effect (labour supply unchanged). We show that the former is negligible, compared to the latter, except for single females in the upper income quartile.

More generally, the paper initiates an analysis of labour supply which is, as far as we know, the first of its kind for Luxembourg. The message might be two-fold. First, the well-being index obviously tells us more about actual welfare gains, which can differ a lot from changes in the disposable income. Second, it appears that the behavioural component may be negligible, but with noticeable exceptions like single females in the upper quartile (at least as far as the 2001-2002 tax reform and our target population are concerned). This can be seen as an encouragement to introduce such a component in static microsimulation models, as a complementary module and certainly not as a unique and compulsory track.

Of course, we could go further and involve a larger sample of the resident population. We could also test other policy reforms, but this is out of the scope of the present paper.

APPENDIX

Table A1: Estimated Parameters for Single Females

Variable	Coefficien	Estimate	S.E
	Preference for leisure		
Observed heterogeneity			
No. Of Children in the household	**βh1**	-0.194	0.151
No of children age <6 in the household	**βh2**	2.929	0.966
Household head with Age/10	**βh3**	1.403	0.454
Household head with Highschool dgree	**βh4**	-0.895	0.719
Household head with University degree	**βh5**	-1.099	0.572
Household head with Higher non-University degree	**βh6**	-1.679	0.635
Household head Portugease National	**βh7**	-2.129	0.876
Household head European	**βh8**	-1.519	0.522
Household head Non European	**βh9**	1.567	0.717
Unobserved Heterogeneity error:			
Type 1	**θh1**	-5.175	1.344
Type 2	**θh2**	0.065	0.054
Probability of Unobserved Heterogeneity error:			
Type 1	**π1**	0.41	
Type 2	**π2**	0.59	
	Other utility parameters		
Income	**βy**	-2.869	0.588
Income square	**βyy**	0.468	0.092
Leisure square	**βhh**	-0.797	0.258
Income* leisure	**βyh**	0.771	0.196
Log likelihood function	**L**	124.448	
No of observations	**N**	162	

Notes : *a) We keep only those available variables which are significant or which do not generate convergence problems (e.g., university degree).*

b) The variables have been rescaled in the following way: Income = (Disposable income in euros)/10,000;

Hours worked = (Yearly hours worked)/1000; Age = (Age between 20-60)/10.

***Table A2*: Estimated Parameters for Females in Couple**

Variable	Coefficient	Estimate	S.E
		Preference for leisure	
Observed heterogeneity			
No. Of Children in the household	**βh1**	0.262	0.067
No of children age 0<6 in the household	**βh2**	0.744	0.157
Household head with Age/10	**βh3**	0.571	0.111
Household head with University degree	**βh4**	-0.359	0.102
Household head with Higher non-University degree	**βh5**	-0.505	0.174
Household head Portugease National	**βh6**	-0.994	0.202
Household head European	**βh7**	-0.691	0.188
Husband labor supply	**βh8**	-0.216	0.092
Husband university education	**βh9**	-0.071	0.026
Unobserved Heterogeneity error:			
Type 1	**θh1**	-3.408	0.463
Type 2	**θh2**	-5.562	0.578
Probability of Unobserved Heterogeneity error:			
Type 1	**π1**	0.80	
Type 2	**π2**	0.20	
	Other utility parameters		
Income	**βy**	-1.291	0.390
Income square	**βyy**	0.167	0.039
Leisure square	**βhh**	0.268	0.077
Income* leisure	**βyh**	0.485	0.090
Log likelihood function	**L**	487.607	
No of observations	**N**	533	

Notes : *a) We keep only those available variables which are significant.*

b) The variables have been rescaled in the following way: Income = (Disposable income in euros)/10,000;

Hours worked = (Yearly hours worked)/1000; Age = (Age between 20-60)/10.

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