The economics of labor supply in the short and long run
Ian Walker

Report by Aico P. van Vuuren *

1 Introduction

The labor economics/econometrics lectures at the Rotterdam workshop were given by Ian Walker, professor in Economics at Keele University (The United Kingdom). In the past decade, he published a lot of his research on labor supply together with Richard Blundell (University College London), who was originally scheduled for the econometrics lectures of the workshop. The lectures were only related with the traditional approach of labor supply theory. Hence, the theory of job search was not included within these lectures (see for example Flinn & Heckman (1982), Mortensen (1986), Lancaster (1990) and Devine & Kiefer (1991)).

The lectures were subdivided into short- and long-run labor supply models. In the next two sections, short-run labor supply models are discussed. Section 2 discusses the basic framework and the estimation of these models is summarized in section 3. Although the lecture also contained a policy analysis part, it did not obtain much attention. Walker gave one example of a policy analysis paper, namely Preston & Walker (1999). Finally, labor supply in the long-run is discussed in section 4.

*Department of Economics, Free University and Tinbergen Institute. Address: Vakgroep Algemene Economie, Room 2E-68, De Boelelaan 1105, NL-1081 HV Amsterdam, The Netherlands. Email: vuuren@tinbinst.nl; Fax: +31-(0)20-444-6030; Ph: +31-(0)20-444-6120

2 Short-run labor supply theory

2.1 The static model

This subsection is a short introduction to the literature. We start with the introduction of the decision process for a worker facing the choice between consumption and leisure, as described in elementary textbooks in microeconomics (Laidler & Estrin (1989)):

$$\begin{array}{lll} \max_{c,l} & U(c,l;\mathbf{x}) & \\ \text{s.t.} & c+wl & =\mu+wT \end{array} \tag{1}$$

$$\begin{aligned} \Leftrightarrow \quad c &= \mu+(T-l)w \\ &= \mu+wh \end{aligned}$$

Where the symbols c, l, w, μ, T and h represent consumption, leisure time, the wage rate, unearned income, total available time (for leisure and work) and working time (labor supply). The vector $\mathbf{x}$ represents personal characteristics, such as gender, household composition, age, educational level, etc. The first order conditions of utility maximization are:

$$\begin{aligned} U_c(c,l;\mathbf{x}) &= \lambda \\ U_l(c,l;\mathbf{x}) &= \lambda w \end{aligned}$$

Provided that $l \leq T$. If $U_l(c,l;\mathbf{x}) \geq \lambda w$ for all $l \in [0,T]$, then $l=T$ and hence $h=0$. An example of the utility function is the Stone-Geary utility function, defined by:

$$U(c,l;\mathbf{x}) = \beta(\mathbf{x})\log(c-\gamma_c(\mathbf{x})) + (1-\beta(\mathbf{x}))\log(l-\gamma_l(\mathbf{x}))$$

By solving the system, it is possible to find that the optimal time of leisure is equal to $l^* = \gamma_l(\mathbf{x})\beta(\mathbf{x}) + \frac{1-\beta(\mathbf{x})}{w}(\mu+Tw-\gamma_c(\mathbf{x}))$. Other specifications of the utility function in relationship with the labor supply function are given by Stern (1986).

2.2 Family labor supply

Since the labor supply decision is usually made within the household, it seems better to modify the model of the previous section. An originally very popular framework is the unitary model, which assumes that family members maximize a unique, well behaved household utility function (Fortin & Lacroix (1997)). The maximization problem of equation

(1) is then rewritten as follows (Ashenfelter & Heckman (1974)):

$$\begin{array}{ll} \max_{c,l} & U(c, l_m, l_f; \mathbf{x}) \\ \text{s.t.} & c = \mu + (T - l_m)w_m + (T - l_f)w_f \end{array}$$

Where the subscripts m and f denote male and female, respectively. From this maximization problem, the labor supply functions of the family members follow:

$$h_i = h_i(w_m, w_f, T, \mu)$$

For $i = \{m, f\}$. Additionally, the famous Slutsky decomposition helps to obtain tests for the unitary model:

$$\frac{\partial h_i}{\partial W_j} = S_{ij} + h_j \frac{\partial h_i}{\partial Y}$$

Where S_{ij} is the substitution effect. There must hold that: (1) $S_{ij} > 0$, (2) $S_{mf} = S_{fm}$ and (3) $\det(S_{ij}) > 0$.

Recently, there is some critique on the unitary labor supply model. The major problem is that it does not take account of the decision making of individuals within the household. Moreover, it is not able to explain changes within the household composition (Fortin & Lacroix (1997)).

2.3 Labor supply and expenditure patterns

The previous sections were implicitly based on the common assumption of separability. This assumption states that the pattern of consumption is independent of the pattern of labor supply. Hence, there are no consumption goods that are either substitutes or complements to leisure. Blundell & Walker (1982) are able to test this separability assumption by using a model determining the household labor supply and commodity demands. They use the following demand system for commodity i:

$$p_i q_i = p_i \gamma_i m_i + \delta_{mi} w_m d_m + \delta_{fi} w_f d_f + \psi(w_m, w_f, d_m, d_f)$$

Where p_i, q_i and m_i represent the price for commodity i, the quantity purchased of commodity i and the number of equivalent adults in each household, respectively. The parameters d_m and d_f are defined from the costs function that is used (see Blundell & Walker (1982)). The function ψ contains the residual terms and the other parameters are reduced form parameters. Separability requires that the δ's are equal to 0. In the empirical analysis of the paper, Blundell & Walker find that this restriction is strongly rejected.

2.4 Life cycle labor supply

The static models assume that the utility level of one period gets the same weight as the utility level of all other periods. In other words, these models use the assumption of intertemporal separability. More general models look at the maximization problem related to the dynamic labor supply decision:

$$\begin{array}{lll} \max_{c_s,l_s;s\in\mathbb{N},s\geq t} & U_t & = U(c_s, l_s; s \in \mathbb{N}, s \geq t) \\ \text{s.t.} & A_{s+1} & = (1+r_s)(A_s + w_s h_s - c_s) \quad s \in \mathbb{N}, s \geq t \end{array}$$

Where the subscripts s and t denote the time periods and the symbols r and A_s represent the market rate of return and the asset levels at time period s, respectively. This problem is intractable for empirical applications. Therefore it is better to reduce the problem by making the assumption of additive separability. Then, the maximization problem reduces to:

$$\begin{array}{llll} max_{c_t,l_t;t\in\mathbb{N}} & U_t & = \sum_{i=0}^{T} \frac{U(c_{t+i},l_{t+i})}{(1+\rho)^i} & \\ \text{s.t.} & \sum_{i=0}^{T} & \frac{c_{t+i}}{(1+r_{t+i})^i} = \sum_{i=0}^{T} \frac{w_{t+i}h_{t+i}}{(1+r_{t+i})^i} + A_0 & \end{array} \quad (2)$$

Where ρ is the subjective discount rate. There are two methods to determine the relative amounts of l and c in each period. These are: (1) two stage budgeting (Blundell & Walker (1986)) and (2) the λ-constant approach, which assumes constant marginal utility of money (Heckman & Macurdy (1980), Deaton & Muellbauer (1981) and Browning, Deaton & Irish (1985)).

2.4.1 Two stage budgeting

This method is for example described in Blundell & Walker (1986). The two stages are described as follows:

1. The household allocates full life-cycle wealth across the life-time so as to equalize the marginal utility of money in all periods of the life-cycle.

2. The current period's allocation of full income out of life-cycle wealth is distributed between consumption and leisure depending on the level of the current real wages.

If full income in period t is defined as:

$$y_t = w_{ft}T_f + w_{mt}T_m + \mu_t$$

With:

$$\mu_t = r_t A_{t-1} - \nabla_t A_t$$

Then the problem in the first stage is how to allocate the y_t's among the life-cycle, conditional on current and future prices and the market discount rate. In the second stage, the demands for commodities are determined, given these y_t's and current prices (Blundell & Walker (1986)).

2.4.2 The constant λ approach

This is the original approach of life cycle labor supply models. The maximization of lifetime utility, as defined in equation (2) leads to (cf. Blundell & Walker (1986)):

$$\lambda_t = \frac{1 + r_t}{1 + \rho} \lambda_{t+1}$$

Where the λ_t's represent the Lagrange multipliers. Taking logs of this equation leads to:

$$\log \lambda_t = d_t + \log \lambda_{t+1}$$

Where $d_t = (1 + r_t)/(1 + \rho)$. Repeated substitution gives $\log \lambda_t = \sum d_t + \sum \log \lambda_0$ and hence λ_0 is an individual fixed effect.

2.5 New developments

Important new developments are related with (1) unions and hours, (2) interdependent utility, (3) intra household decision making (Chiappori (1988), Chiappori (1992) and Browning & Chiappori (1998)), (4) household production, (5) learning by doing (Eckstein & Wolpin (1989)), (6) human capital markets and (7) fertility (Hotz & Miller (1988)). We do not discuss these issues in detail and refer to the cited articles.

3 Estimating labor supply models

There are four approaches in the literature: (1) questionnaire evidence, (2) social experiments (Ashenfelter (1983) and Heckman, Ichimura & Smith (1998)), (3) natural experiments (Blundell, Duncan & Meghir (1998)) and (4) cross-section econometrics. The most important drawbacks of these approaches are given in table 1. In the next subsections, some research fields and one of these approaches are described.

Method:	Questionnaire Evidence
Drawbacks:	Difficult to asses compensated ability
Method:	Social Experiment
Drawbacks:	Difficult to value intertemporal effects Drop outs are non-random
Method:	Natural Experiment
Drawbacks:	Ashenfelter "dip" May be difficult to generalize
Method:	Cross-section econometrics
Drawbacks:	Wage endogeneity

Table 1: Drawbacks of the different approaches for estimation

3.1 The econometrics of piecewise-linear constraints

Individuals face a non-standard budget constraint in their labor supply decision. Hence, ordinary estimation techniques are not valid any more. For example, when there is one tax rate with a basic tax allowance, then the budget constraint of an individual worker is as illustrated in Figure 1. The problem is that ordinary least squares is not consistent in the presence of these piecewise-linear budget constraints (Moffit (1986)) and one has to develop more sophisticated techniques which do take account of the possible correlation between both observed and unobserved heterogeneity and measurement error. Moffit (1986) develops a maximum likelihood technique for this problem. We refer to Hausman & Ruud (1984), MaCurdy, Green & Paarsch (1990) and Blundell, Duncan & Meghir (1992) for applications.

An individual worker, who faces the budget constraint of Figure 1 might prefer to work either (1) at zero hours, h_0, (2) in the interval (h_0,h_1), (3) at the kink point h_1, (4) in the interval (h_1, T) or (5) at the maximum number of hours, T. In this situation of a convex budget set, it is possible to show that individuals are quite likely to choose their labor supply at the kink point.

If we introduce the function f_v to be the distribution function of the (unobserved) personal characteristics v, then it is possible to calculate the probability of observing an

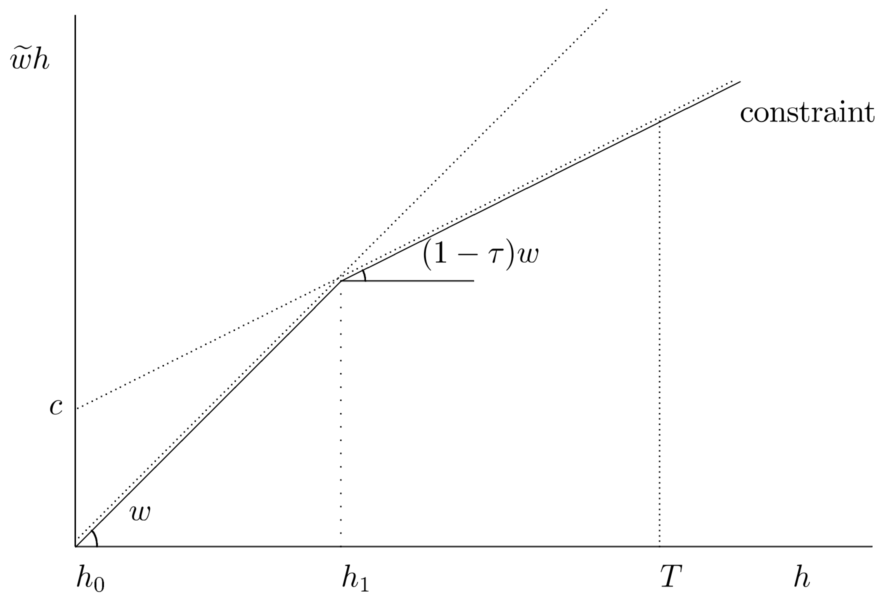

Figure 1: Illustration of the piecewise-linear budget constraint in the presence of a progressive tax rate

individual in either of the five regimes. Using this simple approach, the probabilities of observing individuals at the kink points are very high, which is somewhat counterfactual. Therefore, in most empirical studies an additional stochastic variable is introduced, which is interpreted as measurement error. For example, MaCurdy et al. (1990) use the following specification:

$$H = h + \varepsilon$$

Where H is observed labor supply and ε is the measurement error term which is assumed to be normally distributed. An important additional problem in the empirical applications of this method is that the boundary values between the different regimes are determined by the observed wage levels. This brings in some additional selection bias since wages are only observed for those who are in the regimes (2)-(6). MaCurdy et al. (1990) develop a method to take account of these unobserved wages.

Another estimation method is obtained by the construction of differentiable constraints, which eliminates a lot of the problems described above (MaCurdy et al. (1990)). This estimation method is based on an approximation of the actual non continuous tax schedule.

3.2 Program participation

A puzzling phenomenon among economists is the non participation of individuals in welfare programs. Usually, this phenomenon is explained by the existence of welfare stigma. This means that individuals do not participate because of the disutility arising from these welfare programs (Moffit (1983)). It is possible to distinguish two types of stigma: (1) a flat amount arising from participation, say ϕ, or (2) an amount that varies with the size of the benefit. Additionally, it is important that the participation decision is related with the labor supply decision.

The easiest way to illustrate a stigma is by representation of a utility function $U(h, y)$, where y is income. The maximization problem faced by an individual who is eligible for a certain welfare program is now given by:

$$\begin{array}{ll} \max_{h,P} & U(h, y + \gamma P B(w, h)) - \phi P \\ \text{s.t.} & y = wh + \mu \end{array}$$

Where the symbols $P \in \{0, 1\}$ and μ represent a dummy variable whether the individual participates or not and the unearned income, respectively. B is the amount obtained by program participation and the parameter γ represents the variable stigma. The existence of flat and variable stigma is tested by the hypotheses $\phi > 0$ and $0 \leq \gamma < 1$.

The above representation shows that there are actually two simultaneous limited dependent variables in the model, namely h and P. The first variable is estimated by a Tobit model, while the second is estimated by a Probit model. Moffit (1983) finds that the flat welfare stigma seems to be important in the participation of the AFDC (Aid to Families with Dependent Children) program in the United States. However, the variable stigma seems to be not important at all [1].

3.3 Random utility models

A lot of empirical research in the economics of labor supply uses random utility models (Bingley & Walker (1997) and Keane & Moffit (1996). A general framework is given in Greene (1993)). These models assume that there is a discrete set of possible working hours. The wide use of these models is driven by two motivations. First, it serves as a simplification for the models with piecewise-linear budget constraints (Keane & Moffit (1996)). Second, one could argue that the choice between discrete hours is in fact an empirical regularity (Bingley & Walker (1997)).

[1] It is even found that γ is significantly greater than one, which suggests that there might be something wrong with the model

Suppose that the utility function is given by $U^*(y, h, \mathbf{x}, \varepsilon)$, where $\mathbf{x}$ is a vector of observed characteristics and ε is a stochastic variable of unobserved characteristics. Individual i chooses j over k whenever the utility level derived from j, U^*_{ij} exceeds the utility level derived from k, U^*_{ik}. Hence, the probability of observing individual i in state j is given by:

$$P_{ij} = \mathbb{P}(U^*_{ij} > U^*_{ik}) \quad \forall j \neq k$$

When the error terms are jointly normally distributed, then we obtain a multinomial Probit random utility model. It is found that the estimation of these models is numerically quite burdensome and therefore simulation techniques are used in applications (Keane & Moffit (1996) and Stern (1997)).

3.4 The natural experiment approach

The natural experiment approach is based on the comparison of two groups, one that is affected (*treatment* group) and one that is unaffected (*control* group) by a reform. Such comparisons provide the foundation of much of the empirical work in labor economics, such as: (1) including exogenous variables to adjust for differences between observations, using instrumental variable estimators, (2) select observations to generate "*matched*" pairs according to observable variables, (3) before and after comparisons and (4) *difference of differences estimators.*

The first use of natural experiments that is described here is the fixed effects estimator. Suppose that there is a sample of individuals, $i = 1, \ldots N$. Let δ_{it} be a dummy variable which indicates whether the individual i is affected by a policy change. We assume that affected people react by an amount γ. Then, the fixed effects model is defined by the following equation:

$$y_{it} = \gamma \delta_{it} + \eta_i + m_t + \varepsilon_{it}$$

Where η_i is the individual fixed effect and m_t is the time period fixed effect. The variable ε_{it} is a stochastic variable and represents an error term. If η_i and m_t are also random, then generalized least squares is consistent and efficient (Hsiao (1986)). A version of this *within* estimator uses first differences:

$$\nabla_t y_{it} = \gamma \nabla_t \delta_{it} + \nabla_t m_t + \nabla_t \varepsilon_{it} \tag{3}$$

Where $\nabla_t x_{it} = x_{it} - x_{i,t-1}$. This is the *difference of differences estimator* (Eissa & Liebman (1996) and Blundell et al. (1998)). It is important to note that, apart from the rank conditions of the covariance structure, the difference of differences estimator is based on two important assumptions. These are (1) common time effects and (2) the composition of the treatment and control groups is exogenous. Both assumptions are hard to justify. For example, tax reforms may lead to changes in labor market participation (cf. Blundell et al. (1998)).

A related item is the grouping estimator. Suppose that the data is grouped according to some variable g_{it} that allocates individuals into different groups (say age, educational level, etc.). Suppose that the grouping satisfies the following assumption:

$$\nabla_t y_{it} = \gamma \nabla_t \delta_{it} + \theta_{gt} + \nabla_t m_t + \nabla_t \varepsilon_{it}$$

This equation is an extension of equation (3) and it generalizes the ordinary difference of differences estimator by not assuming common time effects. An important extension of the difference of differences estimator is developed by Blundell et al. (1998). These authors use their framework for an application of labor supply. Their model is described by the following labor supply equation:

$$h_{it} = a + b \log w_{it} + u_{it}$$

With:

$$\mathbb{E}(u_{it}|P_{it}, g, t) = a_g + m_t + \delta \lambda_{gt}$$

Where the symbols P and g represent labor market participation and the group of the observed individual (control or treatment), respectively. Taking expectations, we obtain:

$$\mathbb{E}(h_{it}|P_{it}, g, t) = b\mathbb{E}(w_{it}|P_{it}, g, t) + a_g + m_t + \delta \lambda_{gt}$$

Econometric techniques to estimate this equation follow from this (Blundell et al. (1998), page 836).

4 Labor supply in the long-run: Human capital accumulation

The final lecture was addressed to the estimation of the rates of return to schooling. Standard human capital theory states that schooling is an investment decision and increases the wage level of an individual. Hence, given the level of hours worked, the income level is a function of education, say $w = f(S)$, where S is the number of years of schooling.

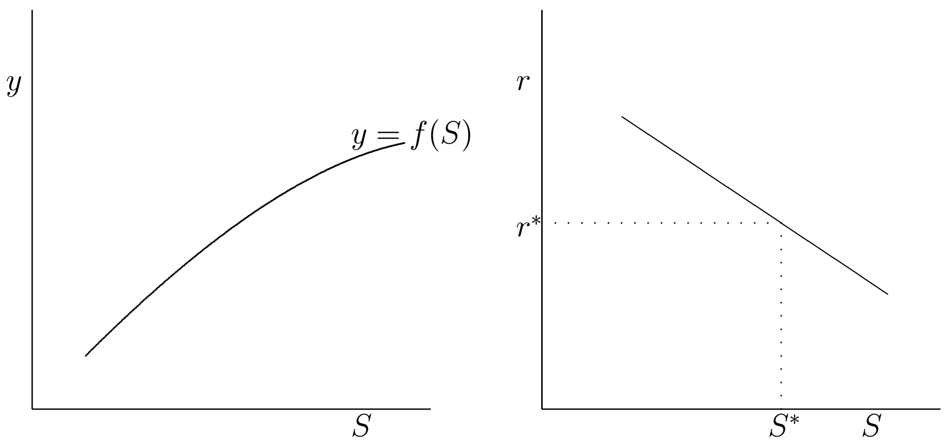

Figure 2: Illustration of the basics of human capital theory

This is illustrated in Figure 2. In the right half of this figure, there is an illustration of the decision process. As long as the rate of return to schooling is higher than the market rate of return, it is optimal to take another year of schooling. Human capital theory is usually represented in the following way:

$$\log w = \alpha + \gamma S + g(\mathbf{x}) \tag{4}$$

Where γ is the private rate of return and $\mathbf{x}$ is again a vector of personal characteristics, such as experience. There are several problems with the estimation of equation (4) which are related with the endogeneity of the variable schooling. First, there is the ability bias. It might be the case that more able individuals obtain higher schooling. Second, there is the problem of measurement error. Finally, there is the correlation of schooling with other (unobserved) variables, such as the discount rate, motivation and contacts. These problems make ordinary least squares biased and inconsistent.

There are four solutions to this problem (see also Harmon & Walker (1995)). First, one might use instrumental variable estimators, that correct for the ability bias (Card (1995)). An example is the use of IQ tests. Second, it is possible to use a natural experiment, for example by looking at the season of birth. A third procedure is to treat ability as a fixed effect and to use panel data. The final approach uses data obtained from twins, siblings and farther/son pairs (Ashenfelter & Krueger (1994) and Ashenfelter & Rouse (1998)).

We explain the latter method somewhat further, since it recently obtained a lot of attention (see for example, Card (1998)). We assume that the relationship between schooling and income is given by:

$$\xi_{ij} = \alpha \mathbf{x}_j + \gamma S_{ij} + \mu_j + \varepsilon_{ij}$$

Where the subscript $i = 1, 2$ denotes the index number of the twin and j denotes the twin pair in the sample. The symbols ξ_{ij}, μ_j and ε_{ij} represent $\log w_{ij}$, the family (fixed) effect and an error term. Note that we assume that the individual characteristics are the same for both twins. This is of course a rather restrictive assumption, but it fits for illustration. We refer to Ashenfelter & Krueger (1994) for a more general model. Using equation (4), we find that the difference between the income levels of the twins is equal to:

$$\xi_{1j} - \xi_{2j} = \gamma(S^*_{1j} - S^*_{2j}) + \varepsilon_{1j} - \varepsilon_{2j}$$

Where S^*, is the reported education level of the twin. It is possible to estimate this by using fixed effects. A problem however is that it even increases the impact of measurement errors. Ashenfelter & Krueger (1994) solve this by using an instrument for the difference between schooling levels. The instrument is obtained from the reported values of the twins about the schooling level of the other twin.

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