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Female Labour Market Behaviour and Fertility

A Rational-Choice Approach

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MODELS OF FEMALE LABOUR SUPPLY, WITH SPECIAL REFERENCE TO THE EFFECTS OF CHILDREN[1]

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11.1. Introduction

Much of the public concern about the growing labour force participation of women centers on feared, or hoped for, effects of the market work of mothers on the well-being of their children. On the one side, there are those who fear that the children of working mothers will not receive the care they need, and that women with jobs will more readily divorce their husbands leading to the breakup of the family units on which children depend. On the other side, it is argued that the earning power of their mothers is the only protection large numbers of children have against poverty when the earnings of their fathers are basically inadequate, when fathers are unemployed or ill for long periods of time, or when fathers financially abandon their children.

Both labour economists and the public also view children as the main reason why women work less than men do. Children must be cared for, and in western society it is the mothers to whom this task has traditionally fallen. Empirical explorations of the impacts of children on female labour supply are hampered by the fact that the labour supply responses of mothers to children are not simple cause-effect reactions to the physical existence of children and their biological needs. Rather theory and observation suggest that these responses are molded by family and economic circumstances, aspirations concerning what parents want for and from their children, and societal beliefs. Also many of the responses of interest are thought to take effect over a time span of years, or even decades. Some of these effects are thought to be

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anticipatory in nature. And many involve attitudes and theoretically specified personal attributes, such as "human capital", which are inherently hard to observe.

Child status variables are almost always included in economics studies of female labour supply. In some cases, these variables are included because the research objective is to investigate child-related effects on female labour supply. In other cases, primary interest lies in investigating the labour supply effects of other sorts of factors such as wage rates and taxes. In the context of these studies, child status variable are nuisance factors which must be controlled for in order to obtain appropriate estimates of the effects of interest.

In this paper, several different types of models of female labour supply are reviewed. For each model, attention is paid to the mechanisms by which the impacts of children are allowed for. Static models permitting only contemporaneous effects of included variables are considered in the first part of section 2. Reasons for interest in, and key problems in the implementation of, life cycle models are introduced next. Then direct and indirect child status effects on female labour supply are distinguished.

Models of indirect child status effects are the topic of section 3. The first three parts of this section examine indirect child status effects transmitted via human capital investment decisions. The fourth part of section 3 focusses on the key role of hypothesized wage impacts on female labour supply in theories of indirect child status effects. Models providing alternative frameworks for the analysis of direct child status effects are the topic of section 4. These are considered under the headings of models which allow for limited fertility control, models with lifetime budget constraints, and transition models which allow for true state dependence. Conclusions are summarized in section 5.

Empirical tractability is the reason for many of the behavioural simplifications embodied in the models outlined in this paper. However, estimation issues are not dealt with in this paper. The estimation of child status effects on female labour supply is the topic of chapter 12.

11.2. Basic behavioural concepts

Most economic models of female labour supply have the same basic form: a conditional household utility function is maximized subject to time and household budget constraints. Solving this maximization problem yields a *decision rule for determining a woman's labour supply*. For many models of female labour supply, this decision rule can be described in terms of a *reservation wage function*, implied by the maximization problem and defining the minimum wage for which a woman would be willing to work under various circumstances, and an *offered wage* which is what an employer would be willing to pay for an hour (or an additional hour) of this woman's labour. Typically the decision rule has two parts: (1) a woman will work in the current period if her offered wage is greater than or equal to her reservation wage at zero hours of work; and (2) the amount she will work, if she does, is determined so as to equate her reservation wage (which is an increasing function of the amount of time spent in market work) and her offered wage. Thus factors which shift the reservation wage function upward (downward) will tend to decrease (increase) labour supply, while factors which raise (lower) the offered wage will have the opposite effect.

11.2.1. A static, one-period model

The static, one-period model provides a convenient context within which to introduce certain concepts and definitions. By *one-period* what is meant is that a woman's labour supply decisions for the current time period are viewed as the outcome of the maximization of utility for this time period subject to budget and time constraints pertaining to this same period, and without regard to subperiods. Because of the nature of available data, the current time period is often specified to be a year. By *static* what is meant is that current labour supply decisions are not a function of a woman's past (or future) labour supply. Static, one-period models have provided the analytical basis for a large body of applied research on female labour supply. (See, for example, Heckman, 1974b; Nakamura *et al*. 1979; Nakamura and Nakamura, 1981a; and the long list of studies given in Killingsworth, 1983, table 4.3, pp. 193-199.)

In formal terms, for the given time period the woman is assumed to maximize a conditional utility function of the form

$$U = U(X,\ T\text{-}H;\ Y,\ Z^*) \tag{1}$$

where X is household consumption of a composite good, T is the total number of hours in the given time period, H is the woman's hours of work, Y is household income excluding the earnings of the wife (sometimes referred to as "other income"), and Z^* is a vector of the current values for predetermined variables arising from previous choices and circumstances. Child status variables are usually included in Z^*. The utility function is maximized subject to the household budget constraint

$$pX = Y + wH \tag{2}$$

and the woman's time constraint

$$0 \leq H < T, \tag{3}$$

where p is the unit price of the composite good and w is the wife's *offered wage* rate.

The Lagrangean for this decision problem is

$$G = U(X,\ T\text{-}H;\ Z^*) + \lambda_Y(Y + wH - pX) + \lambda_T H, \tag{4}$$

where λ_Y and λ_T are, respectively, an unconstrained and a nonnegative Lagrange multiplier. These Lagrange multipliers can be interpreted as the utility gains associated with relaxing the budget and time constraints, (2) and (3), by one unit each. Hence λ_Y will sometimes be referred to as the marginal utility of other income. The first-order optimality conditions are:

$$U_X - \lambda_Y p = 0, \tag{5}$$

$$-U_L + \lambda_Y w + \lambda_T = 0, \tag{6}$$

$$Y + wH - pX = 0, \tag{7}$$

$$\lambda_T H = 0, \tag{8}$$

where U_X and U_L are the partial derivatives of the utility function with respect to X and L, and where L = T-H is the number of hours of nonmarket work (often referred to in the labour economics literature as "leisure").

From (6) it follows that

$$w = (U_L/\lambda_Y) - (\lambda_T/\lambda_Y) = w^*(H) - (\lambda_T/\lambda_Y), \tag{9}$$

where $w^*(H) = (U_L/\lambda_Y)$ is the *reservation wage*, or the shadow price of a woman's time, at H hours of work.

It follows from the optimality conditions that *a woman will work when her market wage exceeds her reservation wage evaluated at zero hours of work*; that is, when

$$w > w^*(0), \tag{10}$$

or equivalently when

$$\ln w > \ln w^*(0). \tag{11}$$

Moreover the model implies that *a woman who works will choose her hours of work so that her reservation wage evaluated at her actual hours of work equals her offered wage*; that is, a woman will choose her hours of work so

$$w = w^*(H) \text{ when } H > 0. \tag{12}$$

From the definition of the reservation wage it can be seen that w^* depends on H, wH, p, Y and Z^* when H is positive; and on p, Y and Z^* when H is zero.

In empirical applications, it is common to use linear approximations for $\ln w^*(H)$ such as:

$$\ln w^*(H) = \begin{cases} \beta_0 + Z^*\beta_1 + \beta_2 Y + \beta_3 \ln w + \beta_4 H + u^* & \text{if } H > 0 \\ \beta_0 + Z^*\beta_1 + \beta_2 Y \quad + u^* & \text{if } H = 0, \end{cases} \tag{13}$$

where u* is a disturbance term and the β's are parameters to be estimated. It is also common in empirical applications to assume that a woman's offered wage can be expressed as a function of a vector Z of personal characteristics (such

as years of schooling) and of variables characterizing labour market conditions (such as the unemployment rate). A typical specification is

$$\ln w = \alpha_0 + Z\alpha_1 + u, \tag{14}$$

where u is a disturbance term and the α's are parameters to be estimated.

Offered wage rates are not usually observed for women who did not work in the given time period. Hence relationships containing the offered wage, such as equation (14), are usually estimated using data for women who worked. For this same reason, a model of the *decision to work* is usually respecified so that the equation to be estimated does not explicitly involve the offered wage. This can be accomplished in the present case by substituting into condition (11) the right-hand side of the expression for ln w given in (14) and the right-hand side of the expression for ln $w^*(0)$ given in (13). As a result of these substitutions, a woman's probability of work can be represented as

$$P(H > 0) = P[\ln w > \ln w^*(0)] = F(\phi) \tag{15}$$

where F denotes the cumulative density function for $(u^* - u)$ and

$$\phi = (1/\sigma)[(\alpha_0 - \beta_0) + Z\alpha_1 - Z^*\beta_1 - \beta_2 Y], \tag{16}$$

with σ denoting the standard deviation of $(u^* - u)$.

An equation for a woman's *hours of work* is obtained by equating with ln w the right-hand side of the expression given in (13) for ln $w^*(H)$ when H is positive, in accordance with condition (12); and then solving for H. The resulting equation is:

$$H = (1/\beta_4)[(1-\beta_3)\ln w - \beta_0 - Z^*\beta_1 - \beta_2 Y - u^*]. \tag{17}$$

11.2.2. Life cycle models

In real life, women often plan for both careers and children, with these plans stretching over many years. The one-period model cannot incorporate or allow for planning over multiple time periods within a longer time horizon. Mincer was one of the first to draw attention to this shortcoming. Mincer states:

> "... the *timing* of market activities during the working life may differ from one individual to another. The life cycle induces changes in demands for and marginal costs of home work and leisure ... There are life cycle variations in family incomes and assets which may affect the timing of labor force participation ..." (Mincer, 1962, p. 68).

In his survey of the literature on the labour supply behaviour of men, Pencavel provides a cogent summing up of the key problems faced in implementing life cycle labour supply models:

> "The empirical implementation of the life-cycle model would appear to require a great volume of data: to understand an individual's labor supply today, the economist needs information on prices and wages throughout the individual's life ! In fact, the empirical work on life-cycle labor supply has proceeded by placing sufficient restrictions on the form of the lifetime utility function that the parameters governing the dynamic allocation of consumption and hours can be estimated with relatively little data. To date, there exist two general approaches to this dynamic allocation problem. One derives from the literature on habit persistence and stock adjustment and specifies the individual's utility function in period t as conditional on the individual's consumption and hours of work in the previous period. The notion that the standards by which individuals gauge their welfare are molded by their prior experiences is, of course, an old one. ... Whereas in this specification the lifetime utility function is intertemporally not (strongly) separable, the opposite hypothesis is maintained in the second approach to the individual's life-cycle labor supply problem." (Pencavel, 1986, p. 46).

Thus Pencavel differentiates two classes of life cycle models depending, in formal terms, on whether the utility function is intertemporally (strongly) separable. Gorman captures in words the empirical importance and, indeed, necessity of explicit and implicit *separability assumptions*, and the key role economic theory plays in both motivating and justifying these assumptions. Gorman writes:

> "Separability is about the structure we are to impose on our model: what to investigate in detail, what can be sketched in with broad strokes without violence to the facts. Perfect competition and the absence of external economies, which allow us to examine the behaviour of individual firms in isolation; constant returns, permitting us to discuss the structure of a firm's production plans without knowing its size; Samuelson's independence axiom which says that how we use our resources when it shines is independent of how we would have had it rained; and Bergson's Social Welfare Function, based on

> the sovereignty of self-regarding households; all embodying separability assumptions, whose function is to allow us to examine one aspect of a problem in at least relative isolation from the others, given that we have posed it in terms of appropriate independent variables." (Gorman, 1987, p. 305)

In real life, people's plans for education and training, work, family formation, and expenditure and savings extend over long time periods, though these plans may be revised; and these different sorts of plans are surely interrelated. Yet all tractable life cycle models of female labour supply behaviour explicitly allow for only certain interactions with other types of behaviour, and for only certain types of influences across time periods.

11.2.3. Modelling the impacts of children on female labour supply

Alternative models of female work behaviour can be grouped according to the sorts of child status effects that can be explicitly represented. Hypothesized child status effects can be grouped into two main categories: direct and indirect. The *direct effects* of the time, effort and other resources devoted to having and caring for children are usually modelled as affecting the labour supply of a woman via her reservation wage, which by definition reflects the competing household needs for her time versus the income she could earn.

It is also hypothesized that children affect the amounts and types of human capital that women accumulate, and furthermore that human capital accumulation affects women's offered wage rates which in turn affect their labour supply. These theorized *indirect effects* of children on female labour supply are the subject of the following section. Section 4 is devoted to theories and models allowing for direct, reservation wage-related effects of children.

11.3. Indirect effects of children on female labour supply

All of the theories concerning indirect, human capital-related effects of children on female labour supply begin with the presumption that most women plan to and do have children. Moreover it is assumed that most women plan to and do supply less market labour during their active child bearing and rearing years. The theories differ in terms of whether effects on the amount or the

type of human capital investment are emphasized, and depending on who is viewed as choosing whether or not to make (and pay for) these investments.

11.3.1. Human capital investment decisions of women and their families

If wives devote less time to market work than their husbands while bearing and rearing children, they will accumulate less job experience than their husbands. Job experience is usually thought to contribute to an individual's stock of job-related human capital.

Also training in job-related skills is usually obtained in the hope of enhancing one's job-related human capital. Mincer and Polachek (1974, p. 401) argue that "since job-related investment in human capital commands a return which is received at work, the shorter the ... actual [or expected] duration of work experience, the weaker the incentives [of individuals] to augment job skills over the life cycle." Following this line of argument, the investment decisions of couples with children should tend to increase the wage rates of the husbands relative to the wives. In turn, the generally higher offered wage rates of the husbands should lead them to specialize more in market work and wives to specialize more in household work even when the child bearing and rearing years are over. An implication of these theories is that the cumulative investment effects of the child-related roles of women should cause the offered wage gap between wives and husbands to widen over the course of the life cycle.

Arguments concerning linkages among children, labour supply and human capital investment have been expanded to encompass anticipatory behaviour prior to marriage and even parental choices concerning the education and training of children. According to Mincer and Polachek:

> "Prospective discontinuity may well influence many young women during their prematernal employment ... to acquire less job training than men with comparable education ..." (Mincer and Polachek, 1974, p. 404).

And Becker argues:

> "Since specialized investments begin while boys and girls are very young ..., they are made prior to full knowledge of the biological orientation of children, which is often not revealed until the teens or even later. If only a small fraction of girls are biologically oriented to market rather than household activities, and if only a small fraction of boys are biologically oriented to household

> activities, then in the face of no initial information to the contrary, the optimal strategy would be to invest mainly household capital in all girls and mainly market capital in all boys until any deviation from this norm is established." (Becker, 1981, p. 24).

That is, Becker argues that rational parents, and others in society as well, will invest less in the job-related education of girls than of boys. If behaviour of this sort is widespread, then, even before marriage and children, young women will tend to be at a disadvantage versus young men in terms of their accumulated stock of job-related human capital.

11.3.2. Atrophy and wage appreciation theories of occupational choice

Another sort of anticipatory theory focusing more on the type of job-related human capital investment is developed in Polachek's papers (1976, 1979, 1981). He specifies a model of occupational choice in which it is assumed that by choosing the kinds as well as the amounts of human capital investments, individuals choose occupations with characteristics that will maximize their expected lifetime earnings. In the formal derivation of his model, Polachek (1981, p. 16) represents lifetime earnings as the product of years of work, the rental rate per unit of human capital of a given type, and the amount of human capital of the given type. It is assumed that an individual's stock of human capital "atrophies" during years of home time at a rate determined uniquely by the kind of human capital that the individual has accumulated. Thus for any given number of years of home time, the loss of human capital will be greater in those occupations characterized by higher atrophy rates.

Polachek concludes that women will tend to choose different occupations than men because most women anticipate that their labour force participation will be more intermittent. In particular, most women are expected to prefer occupations with lower atrophy rates. Moreover, among women, those who anticipate more intermittency in their labour force participation are expected to be more interested in choosing occupations with lower atrophy rates.

A related theory of female occupational choice is suggested by H. Zellner (1975). She notes that jobs with steep earnings-experience profiles are thought to have low starting wages because employees pay some portion of the specific training costs associated with these jobs through foregone earnings. She argues that women who anticipate dropping out of the work force to raise children will not select jobs of this sort because, when these jobs are held for only short

periods, the realized appreciation in earnings will not provide adequate compensation for the lower starting wages. According to Zellner's theory, therefore, women will tend to be found in occupations characterized by relatively high starting wage rates, but low rates of wage appreciation with increased work experience.

11.3.3. Human capital investment practices of employers

If women work intermittently, they will accumulate fewer hours of job experience than most men. Both human capital and more institutionally based screening and seniority arguments suggest that rational employers will pay relatively lower wage rates to workers with less actual experience, and also that employers will be less inclined to make training investments in workers who are expected to supply relatively less labour in future time periods. Becker explains:

> "If a firm had paid for the specific training of a worker who quit ..., its capital expenditure would be partly wasted, for no further return could be collected. ... The willingness of ... firms to pay for specific training should, therefore, closely depend on the likelihood of labor turnover." (Becker, 1975, p. 29).

The theory of statistical discrimination suggests that even women who do not, and may never, have children may still be passed over by employers with no personal biases against working women when it comes to opportunities for employer-subsidized training. (See Aigner and Cain, 1977; and the classic paper of Phelps, 1972). Bielby and Baron provide a verbal description of the concept (in their words, the model) of statistical discrimination with respect to the employment of women:

> "The model assumes employers perceive that on average the marginal productivity of men and women differ for a given line of work. For example, within a specific occupation, women may be more likely to quit their jobs. If an employer incurs significant turnover costs due to the expense of finding and training new employees, the expected net contribution of the average female job applicant is less than that of an otherwise comparable male applicant. The model also assumes that it is unduly costly to ascertain these differences among individual male and female job applicants. For example, employers may be unable to devise any procedure for screening individual applicants with respect to quit propensity or work commitment. ... Group differences may in fact be small relative to variation within groups; there may be many female applicants with lower quit propensities and

> greater work commitment than the average male applicant. But if employers are unable to obtain this information for individual applicants, expected profits are maximized by segregating workers by sex. Females will be allocated to jobs with low turnover costs. ... Moreover, statistical discrimination produces inequities between men and women in wages and other career outcomes." (Bielby and Baron, 1986, pp. 761-766).

11.3.4. Wage effects on labour supply

The indirect effects of children have been defined as child-related effects on labour supply transmitted via the offered wage. So far we have reviewed a number of child-related, human capital investment factors that are presumed to lower the wage rates of women. If this is the case, then the indirect effects of children on female labour supply will be negative if there is a positive relationship between women's offered wage rates and their labour supply, and will be positive otherwise.

As explained in section 2, economic models of female labour supply typically imply that a woman will work in a given time period if her offered wage exceeds her reservation wage evaluated at zero hours of work. Clearly then, these models also imply that factors which decrease (increase) a woman's offered wage will decrease (increase) the probability that she will engage in market work in the given time period.

The implied nature of the effect of a wage change on the hours of work of a working woman is more complex. Mincer explains:

> "On the assumption that leisure time is a normal good, the standard analysis of work-leisure choices implies a positive substitution effect and a negative income effect on the response of hours of work supplied to variations in the wage rate. An increase in the real wage rate makes leisure time more expensive and tends to elicit an increase in hours of work. However, for a given amount of hours worked, an increase in the wage rate constitutes an increase in income, which leads to an increase in purchases of various goods, including leisure time. Thus, on account of the income effect, hours of work tend to decrease. In which direction hours of work change on balance, given a change in the wage rate, ... depends on the relative strengths of the income and substitution effects in the relevant range." (Mincer, 1962, p. 65).

Two lines of argument have been presented suggesting that, for married women, the negative income effects on labour supply associated with a wage change may

be weak in comparison with the positive substitution effects. The first of these lines of argument is due to Mincer (1962).

According to Mincer, married women divide their time among work at home, work in the market, and leisure. He assumes that income has a positive effect on the demand for leisure, and hence a negative effect on the total amount of (home and market) work. But in some cases, income earned through market work can be used to purchase substitutes (such as child care and restaurant meals) for work in the home. Mincer concludes that "the lesser the substitutability the weaker the negative income effect on hours of work at home, and the stronger the income effect on hours of work in the market" (p. 65). Nevertheless so long as some substitution is possible between the wife's time and market-produced goods or what Mincer terms "other (mechanical, or human) factors of production at home", it is argued that the income effect associated with a given wage change should be weaker for a married woman than for an otherwise similar married man who is presumed to divide his time only between work in the market and leisure. That is, the income effect associated with a given wage change is assumed to be stronger for husbands because they must give up leisure in order to work longer hours, while wives can increase their market work without necessarily sacrificing their leisure.

The second line of argument concerning the strength of the income effect for working wives is much simpler. Holding hours of work constant, the dollar value of the change in earned income associated with any given wage change will be smaller (larger) the shorter (longer) the hours of work are. Following this line of reasoning, when wives work less than full-time or full-year because of child care and household responsibilities, the income effects associated with any given wage change should be weaker for them than for their husbands who predominantly work longer hours.

If the negative income effects associated with a wage change are weaker for married women who work than for married men (and presumably for unmarried women and unmarried men as well) and if the positive substitution effects are similar for married women and married men, then the relationship between changes in hours of work and wage rates should be more positive for married women than for married men (or for unmarried women or unmarried men). Some have argued on these grounds that the net effect of a wage change on the hours of work of working wives will almost surely be positive, and may possibly be large in magnitude.

11.4. Direct effects of children on female labour supply

As already noted, in order for models of female labour supply to be analytically and empirically tractable it is necessary to limit the types of effects that are explicitly allowed for. Hence models of female labour supply allowing for indirect, human capital-related effects of children usually ignore factors directly affecting labour supply decisions through women's utility functions or the household budget constraint. On the other hand, the types of models that offer the most promise as frameworks for investigating the direct effects of children on female labour supply usually ignore human capital accumulation behaviour.

11.4.1. Models which allow for limited fertility control

Hotz and Miller (1988, p. 92) note that most empirical studies of female labour supply treat children as exogenously imposed constraints. They state that their analysis "departs from this latter approach by recognizing that such constraints are chosen by parents indirectly via the contraceptive strategies they follow over their lifetimes." Parents' contraceptive decisions are characterized by an index function which involves the husband's income, the woman's time costs for rearing her existing children, monetary expenditures due to existing children, the woman's birth history (described by dummy variables indicating the birth years for her children), and an age variable included "to account for the fact that women at different ages have different market wage prospects given the age trend in their market wage opportunities" (p. 96). Hotz and Miller also note that parental desires for children may differ depending on expectations about the amount of time remaining before the wife reaches menopause. On a modelling level, therefore, certain aspects of the technology of child bearing and rearing are explicitly treated in the Hotz-Miller study. Empirical implementation of this aspect of the model is hampered because the data utilized by Hotz and Miller contain no information about contraceptive usage or the monetary costs of caring for existing children, and limited information about child-related time costs. Nevertheless, a number of interesting results emerge concerning child-related effects on female labour supply.

An earlier study by Rosenzweig and Schultz (1985) more fully develops the concept that fertility is determined by the dynamic interaction between

the biological capacity to bear children that is stochastic and mostly unaffected by choice behaviour (the supply of births) and the financial resources devoted to birth control (reflecting the demand for births). Placing their study in a historical context, Rosenzweig and Schultz note:

> "Economists have recognized the joint relevance of biological and behavioral factors in determining fertility under a regime of costly fertility control ... , but this perspection has not been suitably incorporated into the empirical study of fertility. In particular, this insight has not been employed in estimating the effectiveness of contraceptive methods, or in estimating the effects of fertility variation on labor supply behavior ..." (Rosenzweig and Schultz, 1985, p. 993).

The Rosenzweig and Schultz study explicitly models contraceptive usage by type. Moreover the data used in this study contain detailed information on the fertility control practices of couples. Differences in the use of fertility control are related to differences among households in fecundity. However, no attention is paid to the time or monetary costs of caring for children, as in the Hotz-Miller study.

As in the Hotz-Miller study, there is no provision for inter-period borrowing or saving. Thus possible effects of a woman's wage offers in other time periods are ignored. Also human capital accumulation decisions are ignored.

11.4.2. Models with lifetime budget constraints

In one-period models, there is no intertemporal borrowing or saving and the household budget constraint must be satisfied in each time period. Hence one-period models cannot provide a framework, for example, for incorporating variations in the timing of children in response to a woman's future expectations about her offered wage rate. Models with lifetime budget constraints could be extended, however, to encompass intertemporal choices of this sort.

Heckman and MaCurdy (1980, 1982) present such a model, which is based on earlier work by Heckman (1974a, 1974b, 1976b) and MaCurdy (1977, 1978). This model is perhaps the most important example so far of the second of the two approaches to implementing life cycle concepts delineated by Pencavel (see subsection 2.2).

A woman is assumed to maximize a lifetime, additively-separable utility function which can be written in a discrete-time form as

$$U = \sum_{t=1}^{N} (1 + s)^{-t} U[X(t), T\text{-}H(t)], \tag{18}$$

subject to the lifetime budget constraint

$$S(0) + \sum_{t=1}^{N} (1 + r)^{-t} [w(t)H(t) - p(t)X(t)] = 0 \tag{19}$$

and the time constraint in each period that

$$0 \leq H(t) < T. \tag{20}$$

In accordance with the notation used in section 2, for period t, X(t) is household consumption of a composite good with unit price p(t), H(t) is the woman's hours of work, and w(t) is the woman's offered wage rate. T is the total number of hours in a given time period which is presumed the same in all time periods, and (N+1) is the total number of time periods in the person's adult lifetime. Also s, which is the woman's subjective rate of time preference; r, which is the market rate of interest; and U[·], which is a strictly concave single-period utility function, are all assumed to be the same in all time periods. Finally, S(0) is the woman's initial savings and asset holdings (that is, her net worth at the start of period t=0). In this simplest specification of the model, income from other family members (including the husband's earnings) is ignored.

The Lagrangean for this decision problem for periods t = 0, ..., N is:

$$G = \sum_{t=1}^{N} (1 + s)^{-t} \{U[X(t), T - H(t)] + \lambda_T(t)H(t)\} + \\ + \lambda_S(0) \{S(0) + \sum_{t=1}^{N} (1 + r)^{-t} [w(t)H(t) - p(t)X(t)]\}, \tag{21}$$

where $\lambda_S(0)$ is the Lagrange multiplier associated with the lifetime budget constraint (19), and $\lambda_T(t)$ (which must be nonnegative) are the Lagrange multipliers associated with the time constraints (20). Following Killingsworth and Heckman (1986, p. 151), for convenience we define

$$\lambda_S(t) = [(1 + r)/(1 + s)]^{-t} \lambda_S(0). \tag{22}$$

Then for t = 0, ..., N, the first-order optimality conditions for this decision problem are:

$$U_x(t) - \lambda_S(t)\, p(t) = 0, \tag{23}$$

$$-U_L(t) + \lambda_S(t)\, w(t) + \lambda_T(t) = 0, \tag{24}$$

$$S(0) + \sum_{t=1}^{L} (1 + r)^{-t} [s(t)\, H(t) - p(t)\, X(t)] = 0, \tag{25}$$

$$\lambda_T(t)\, H(t) = 0, \tag{26}$$

where now L(t) = T-H(t) so that $U_L(t)$ is the partial deviative of the utility function for period t with respect to nonmarket time.

From (24) it follows that

$$w(t) = [U_L/\lambda_S(t)] - [\lambda_T(t)/\lambda_S(t)] = w^*[H(t)] - [\lambda_T(t)/\lambda_S(t)], \tag{27}$$

where $w^*[H(t)] = [U_L/\lambda_S(t)]$ is the *reservation wage*, or shadow price of a woman's time, at H hours of work in period t. From (22) and (23), it can be seen that $\lambda_S(t)$ is positive. Hence from the nonnegativity of $\lambda_T(t)$ and condition (26) it follows that

$$w(t) \leq w^*[H(t)] \qquad \text{for } H(t) = 0, \tag{28}$$

$$w(t) = w^*[H(t)] \qquad \text{for } H(t) > 0. \tag{29}$$

Note that in this model $\lambda_S(0)$, which may be interpreted as the marginal utility of the woman's initial net worth, is endogenous just like X(t) and L(t) (and hence also hours of work given by H(t) = T - L(t)). The value of $\lambda_S(0)$ is simultaneously determined along with the values of X(t) and L(t) for t = 1, ..., N, given the values of the exogenous variables (which include S(0) and also w(t) and p(t) for t = 0, ..., N). If the values of $\lambda_S(0)$ are fixed over time for individuals, then the resulting demand functions for X(t) and L(t) are sometimes called "marginal utility of wealth-constant" demand functions; or "Frisch" demand functions following Browning (1982) and Browning *et al.* (1985), and in recognition of Frisch's extensive use of additive utility

functions. An important feature of this class of demand functions is that they relate decisions in any given period t to variables for other time periods solely through the Lagrange multiplier associated with the lifetime budget constraint, denoted here by $\lambda_S(0)$. One implication of this sort of a life cycle model is that a woman's reservation wage in any given time period depends, through $\lambda_S(0)$, on her market wage rates in all time periods.

11.4.3. Transition models which allow for true state dependence

The basic assumption underlying the Heckman-MaCurdy model as presented in their 1980 paper is that the impacts of all past and expected future decisions and experiences of women that affect their current labour supply decisions can be captured in a single, unchanging, individual-specific parameter ($\lambda_s(0)$ as the model is presented in the previous subsection). Heckman and MaCurdy (1980, p. 56) note that, "Using panel data, one can eliminate the fixed effect, and hence purge the analysis of unobservable variables that are bound to be correlated with the included variables...."

But suppose that in addition to, or instead of, intertemporal interactions that can be captured in individual-specific, fixed effects terms, there are interactions that develop over time in an evolutionary fashion. That is, suppose there is true state dependence (as contrasted with the spurious state dependence, sometimes termed *heterogeneity*, that can result from the presence of individual-specific fixed effects). *True state dependence* means that the change(s) from one period to the next in the dependent variable(s) of a model depend in a direct causal sense on the previous value(s) of the dependent variable(s). (See Heckman, 1981). The final form in which Heckman and MaCurdy (1980) present their model and the estimation approach they suggest cannot easily accommodate true state dependence. Yet casual empiricism would suggest that processes such as learning how to blend work outside the home and parenting are intrinsically evolutionary in nature, with outcomes that are revealed through doing and which are often less than perfectly foreseen.

The approach adopted in Nakamura and Nakamura (1985a) can be modified to allow for true state dependence as well as for individual-specific fixed effects. The approach is based on reformulating the labour supply model in a first difference form. First difference formulations of models embodying inequality decision rules are conceptually more difficult to specify than is the case for intrinsically linear models.

We begin by adopting the customary specification of the *reservation wage for those who work* as an increasing function of the reservation wage at zero hours of work and of ln w and H (see 13)):

$$\ln w^*(H) = \ln w^*(0) + \beta_3 \ln w + \beta_4 H \text{ if } H > 0. \tag{30}$$

But now the *reservation wage evaluated at zero hours of work* is specified as being given by

$$\ln w^*(0) = \gamma^* \ln w^*(0)_{-1} + \Delta Z^* \beta_1 + \beta_2 \Delta Y + e^*, \tag{31}$$

where a sub minus one indicates that the variable is for the previous time period and a Δ denotes a current-previous period difference. Suppose the parameter γ^* in (31) equals one. In this case, (31) can be obtained directly from the static, one-period specification for ln $w^*(0)$ given in (13) with e^* redefined as first differences for the original error term. The meaning, in this case, is simply that the reservation wage evaluated at zero hours of work will be the same this period as it was last unless there are random changes, changes in Y, or changes in the values of variables in Z^*. If γ^* is greater than one, then women's reservation wage rates at zero hours of work will tend to rise over time even in the absence of other changes in observable or unobservable factors.

Suppose that the static, one period formulation for the *offered wage* equation given in (14) is also modified as follows to allow for true state dependence:

$$\ln w = \gamma \ln w_{-1} + \Delta Z \alpha_1 + e. \tag{32}$$

The interpretation of (32) is analogous to the interpretation of (31).

Recall that in the static, one-period model the *condition for work* in the current period (given in (11)) is

$$\ln w > \ln w^*(0).$$

Notice that this condition is *not* equivalent to

$$\ln w - \ln w_{-1} > \ln w^*(0) - \ln w^*(0)_{-1}.$$

However, an equivalent *difference version of the condition to work* is given by the following inequality statement:

$$\ln w - \ln w_{-1} > \ln w^*(0) - \ln w_{-1}. \tag{33}$$

From (32) we see that the expression on the left-hand side of (32) can be written as

$$\ln w - \ln w_{-1} = (\gamma-1) \ln w_{-1} + \Delta Z\alpha + e. \tag{34}$$

As for the right-hand side of (33), it can be seen from (31) that

$$\ln w^*(0) - \ln w_{-1} = \gamma^* \ln w^*(0)_{-1} + \Delta Z^*\beta_1 + \beta_2\Delta Y - \ln w_{-1} + e^*. \tag{35}$$

For those who worked in t-1, we see from (30) that

$$\ln w^*(0)_{-1} = \ln w^*(H)_{-1} - \beta_3 \ln w_{-1} - \beta_4 H_{-1}. \tag{36}$$

Also for those who worked in period t-1 we have the condition that hours of work will be chosen so that

$$\ln w^*(H)_{-1} = \ln w_{-1}. \tag{37}$$

This means that (35) can be rewritten as

$$\ln w^*(0) - \ln w_{-1} =$$

$$= \Delta Z^*\beta_1 + \beta_2\Delta Y + [\gamma^*(1-\beta_3) - 1] \ln w_{-1} - \gamma^*\beta_4 H_{-1} + e^*. \tag{38}$$

Thus from (34) and (38) it follows that for those who worked in t-1, the *condition for work in period t* given in (33) can be rewritten as

$$[\Delta Z\alpha - \Delta Z^*\beta_1 - \beta_2\Delta Y + (\gamma-\gamma^*(1-\beta_3)) \ln w_{-1} + \gamma^*\beta_4 H_{-1}] > (e^* - e). \tag{39}$$

This means that for women who worked in the previous period, the *probability of work in the current period* is given by

$$P(H > 0) = F(\phi^D) \tag{40}$$

where F denotes the cumulative standard normal density function if the error terms e^* and e are jointly normally distributed with zero means and constant variances, and where

$$\phi^D = (1/\sigma^D)[\Delta Z\alpha - \Delta Z^*\beta_1 - \beta_2\Delta Y + (\gamma-\gamma^*(1-\beta_3))\ln w_{-1} + \gamma^*\beta_4 H_{-1}] \tag{41}$$

with σ^D denoting the standard deviation of (e^*-e).

The optimal hours of work for those who work and who also worked in t-1 can be found by substituting the right-hand side of (36) into (31), substituting the right-hand side of the resulting expression for $\ln w^*(0)$ into (30), applying the condition for both periods t and t-1 that for those who work the hours of work will be chosen so as to equate the reservation wage with the offered wage (hence $\ln w^*(H) = \ln w$ and $\ln w^*(H)_{-1} = \ln w_{-1}$), and solving for H. The resulting expression for the optimal hours of work is:

$$H = (1/\beta_4)[(1-\beta_3)\ln w - \Delta Z^*\beta_1 - \beta_2\Delta Y - \gamma^*(1-\beta_3)\ln w_{-1} + \gamma^*\beta_4 H_{-1} - e^*]. \tag{42}$$

For those with a work history but who did not work in the previous time period, condition (32) for work might be rewritten as

$$\ln w - \ln w_L > \ln w^*(0) - \ln w_L, \tag{43}$$

where w_L denotes the (real) offered wage for the last job the woman held. This will result in a formulation identical to the one developed in expressions (33) - (41) for women who worked in the previous year, with a sub L substituted throughout for a sub one, and with all differences (denoted by Δ) defined as between current period values and the values in period L, where L is the individual-specific time period when each woman last worked. For women who never worked before, there is no alternative except to estimate the model in levels rather than difference form, ignoring possible fixed effects and true state dependence.

11.5. Conclusions

A sequence of models of female labour supply have been reviewed with attention to mechanisms by which child status effects are, or potentially could be, incorporated. The effects on female labour supply of the time, expenditure and effort needed to bear and raise children are termed *direct child status* effects. The labour supply effects of children due to effects on human capital accumulation transmitted via the wage offers women receive are termed *indirect child status* effects.

There are many reasons for trying to gain a better understanding of the *effects of children on women's offered wage rates*. However, the extent to which it is also important to gain a better understanding of *indirect child status effects on female labour supply, transmitted via women's wage offers*, depends on the extent to which female labour supply is responsive to current period or intertemporal offered wage rates. It is argued in a companion paper (see chapter 12) that the evidence concerning offered wage effects on female labour supply is far from conclusive.

Current period, direct child status effects can be represented in a static, one-period model of female labour supply. Certain types of *intertemporal direct effects* can potentially be allowed for in fixed-effects, life cycle models of female labour supply of the sort presented by Heckman and MaCurdy (1980). Finally, it is argued that an empirically tractable model which can accommodate both *true state dependence and heterogeneity* can be developed along the lines of the first difference model given in Nakamura and Nakamura (1985a). (See also Nakamura and Nakamura, 1985b.) Certain empirical aspects of this sort of a modelling approach are explored more fully in chapter 12.

In much of the earlier literature on female labour supply, it was acknowledged that children do have important effects on female labour supply. However, in most of those studies the child-related effects were treated as nuisance factors which had to be controlled for in order to obtain efficient and consistent estimates of the income and substitution effects of primary interest. Recently there has been more interest in child status effects in their own right. We would hope that this interest will accelerate progress toward developing theoretical models which incorporate increasingly explicit and realistic representations of hypothesized effects of children on the labour supply behaviour of women.

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