Intransigencies in the Labour Supply Choice

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Abstract

There have been significant recent advances in the estimation of labour supply models. Here the hours continuum is split into a number of discrete options and the preferred choice obtained as the solution to a constrained utility maximisation problem. However, the underlying probabilities of an individual being in a particular hours state, are assumed to be those given by standard Logit-type ones. As is well known, such a specification embodies the underlying Independence of Irrelevant Alternatives (IIA) property, which is likely to be violated in a model of labour supply choices. Moreover, if such models are used in microsimulation, they implicitly assume that individuals are able to change their observed hours state at the margin following a policy reform. This paper suggests an alternative general (non-IIA) specification for these probabilities, which can additionally incorporate the fact that: individuals may be captive to certain choices (for example, due to institutional reasons). Moreover, this model has the benefit that when used for microsimulation, the reform has to work harder to coax individuals out of the captive hours states. The results suggest that, for sole parents, the Logit model is misspecified and there is a significant amount of captivity, most notably to full-time employment hours. The effect of such captivity on microsimulation is illustrated by considering a range of actual and hypothetical policy reform.

Keywords: Labour Supply, Discrete Choice, Institutional Effects, Simulated Policy Response

JEL classification number: H25

1 Introduction and Background

Traditionally the modelling of labour supply has treated the choice of hours as a continuous and unconstrained (see, amongst others, Hausman and Ruud 1984, Hausman 1985, Moffitt 1986, Blundell, Duncan, and Meghir 1998). Recent advances by Van Soest (1995), Keane and Moffitt (1997) and Duncan and Giles (1998b) have broken this mold and now more realistically treat the choice problem faced by the individual as a choice among a number of finite outcomes. This will be the case for both institutional and psychological reasons and at the extreme, can be represented by a choice between no work and part- or full-time work. Indeed, such an approach has been advocated as by far the most preferable method of estimating labour supply models, especially with regard to microsimulation (Creedy and Duncan 1999b).

Although these advances permit much flexibility in estimation (for example being able to distinguish amongst the non-waged, to incorporate fixed costs and random preference heterogeneity and so on), their essence is that once the choice set has been discretised, the underlying probabilities of being in any particular state are given by standard Logit-type ones.[1] This is potentially problematic on two fronts. Firstly, it is well known in the literature though, that this particular functional form for multinomial probabilities is very restrictive and embodies the Independence of Irrelevant Alternatives (IIA) property. This implies, amongst other things, that the probability an individual chooses no-work relative to the probability that she works full-time, is independent of the possibility of part-time work. This appears to be

[1] In the literature is common to refer to a logit model where the coefficients are the same across the states, as is the case here, as a "Conditional" Logit.

an untenable assumption.

Secondly, a major use of such labour supply modeling is in microsimulation. Use of Logit-type probabilistic models implicitly assumes that individuals are able to change their observed hours state at the margin following a policy reform. Obviously this will not always be the case. For example, even if the policy reform is such that an individual's maximum utility is changed from working 40 hours to, say, 30, it is likely that there will a paucity of employment offers at such an hours level. That is, we expect that there will be intransigencies in the labour market hours states - the labour market is well-known to be rigid with regard to hours of work. If there are such intransigencies in the labour market, this is likely to be reflected in a multi-modal empirical distribution of observed hours worked. The Logit formulation is not particularly suited to such a phenomenon.

In this paper we suggest an alternative, non-IIA specification for the probabilities - the Dogit model of Gaudry and Dagenais (1979). This model appears ideal for modeling discrete labour supply especially with regard to microsimulation: a) it does not embody the IIA property; b) it nests the Logit model and provide simple tests for such; c) it has additional captivity parameters such that individuals may be "trapped", to a certain extent, in particular hours states, which means that in microsimulation of policy reforms, individuals are less likely to move from these captive states even in the face of potentially significantly different net incomes. We illustrate the potential benefits of such a model with an application to Australian data on lone parents.

The plan of the paper is as follows. In the following Section, the recent literature on discrete state labour supply modelling is briefly reviewed. In Section 3 the IIA property embodied by Logit models is discussed and the Dogit model described in Section 4. In Section 5 the data is described. Section 6 describes the empirical labour supply estimates. A selection of model evaluations are presented in Section 7. Section 8 contains some estimated responses to some policy reforms and finally and Section 9 concludes.

2 A Discrete Approach to Modelling Labour Supply

The following section briefly reviews the recent advances made by Callan and Van Soest (1996), Keane and Moffitt (1997) and Duncan and Giles (1998a) in labour supply modelling. The choice of labour supply model for such an analysis must be sufficiently flexible to incorporate a number of considerations. Firstly, taxes and benefits must be dealt with appropriately in estimation. The model should be able to differentiate effectively among those observed not to work: those who choose not to participate in work (often discouraged from seeking employment through fixed or search costs) and those involuntarily unemployed.

Following standard economic theory, individuals are assumed to derive utility from net household income Y (shared between current and future consumption) and leisure L thus

$$U = U(Y, L; X), \tag{1}$$

where X represents individual characteristics. Behavioural decisions are constrained to lie within a budget set defined in terms of: gross wage rates W;

total household income from assets and other unearned sources, V and; the tax system $T(H, W, V; X)$, where $H = T - L$ for some time endowment T. This yields the budget set

$$Y = WH + V - T(H, W, V; X) - FC(Z_c), \tag{2}$$

where $T(H, W, V; X)$ represents tax payments minus benefit receipts (assumed to depend on hours, wages, unearned income and household characteristics) and $FC(Z_c)$ the fixed cost of employment for someone with characteristics Z_c. Households are assumed to maximise (1) subject to (2) over a continuum of hours to give desired hours H^*

$$\max_H U(Y, T - H) \text{ s.t. } Y \leq WH + V - T(H, W, V; X) - FC(Z_c). \tag{3}$$

The strategy followed by Callan and Van Soest (1996), Keane and Moffitt (1997) and Duncan and Giles (1998a) is to replace the entire budget set with a finite number of points thereon, and optimise only over those discrete points. The procedure supposes that hours choices can be approximated by the discretised hours level $H_{(.)} \in \{H^1, H^2, .., H^J\}$ according to the grouping rule

$$\begin{aligned} H_{(.)} &= H^1 \quad \text{if } H \leq H_1^B \\ &= H^2 \quad \text{if } H_1^B < H \leq H_2^B \\ &\quad \ldots\ldots\ldots\ldots\ldots\ldots \\ &= H^{J-1} \text{ if } H_{J-2}^B < H \leq H_{J-1}^B \\ &= H^J \quad \text{if } H > H_{J-1}^B, \end{aligned}$$

giving J alternative values for $H_{(.)}$. Household net incomes are calculated for the set of discrete hours combinations $H_{(.)}$ as

$$Y[H_{(.)}] = WH_{(.)} + V - T(H_{(.)}, W, V; X) \text{ for } H_{(.)} \in \{H^1, H^2, .., H^J\}.$$

and the household is faced with the following optimisation problem

$$\max_{H_{(.)} \in \{H^1, H^2, .., H^J\}} U(Y_{H(.)}, T - H_{(.)}) \text{ for } H_{(.)} \in \{H^1, H^2, .., H^J\}. \tag{4}$$

We define a series of state-specific utilities to be enjoyed in each discrete hours regime $H_{(.)} \in \{H^1, H^2, .., H^J\}$ as

$$U_{H(.)} = U(T - H_{(.)}, Y_{H(.)}; X), \text{ for } H_{(.)} \in \{H^1, H^2, .., H^J\}, \tag{5}$$

where $Y_{H(.)}$ represents the net household income that would be enjoyed at $H_{(.)}$. Random state-specific disturbances are added to utilities in each state $H_{(.)} \in \{H^1, H^2, .., H^J\}$ to give random utilities

$$U^*_{H(.)} = U(T - H_{(.)}, Y_{H(.)}; X) + \varepsilon_{H(.)}, \tag{6}$$

Callan and Van Soest (1996), Keane and Moffitt (1997) and Duncan and Giles (1998a) all assume that the $\varepsilon_{H(.)}, H_{(.)} \in \{H^1, H^2, .., H^J\}$ in (6) follow a Type I Extreme Value distribution, resulting in a standard (Conditional) Logit Model (Maddala 1983) with associated probabilities of choosing state $H_{(.)} = H^j$ as

$$\begin{aligned} \Pr[H_{(.)} = H^j)] = & \Pr[U^*_{H^j} > U^*_{H^p} \text{ for all } j \neq p, p \in \{1, .., J\}] \\ = & \frac{\exp[U(T - H^j, Y_{H^j}; X)]}{\sum_{k=1}^{J} \exp[U(T - H^k, Y_{H^k}; X)]}. \end{aligned} \tag{7}$$

The model is made operational by the choice of functional form for $U(H,Y)$.Keane and Moffitt (1997) and Duncan and Giles (1998a) favour a quadratic direct utility function

$$U(H,Y) = \alpha_{YY} \times Y^2 + \alpha_{HH} \times H^2 + \alpha_{YH} \times YH + \beta_Y \times Y + \beta_H \times H. \quad (8)$$

For parameters $\phi = \{\alpha_{YY}, \alpha_{HH}, \alpha_{YH}, \beta_Y, \beta_H\}$ this function is tractable, yet permits a wide range of possible behavioural responses. Observed heterogeneity is introduced linearly through parameters β_Y and β_H as

$$\beta_Y = \beta_{y0} + \beta_y' X \quad (9)$$

$$\beta_H = \beta_{h0} + \beta_h' X. \quad (10)$$

The model can be further generalised to additionally incorporate random preference heterogeneity by adding error terms to equations (9) and (10)

$$\beta_Y^* = \beta_{y0} + \beta_y' X + v_Y \quad (11)$$

$$\beta_H^* = \beta_{h0} + \beta_h' X + v_H, \quad (12)$$

where $\{v_Y, v_H\}$ are assumed jointly normal with variances σ_Y, σ_H.

Finally fixed costs can also be factored into estimation by defining a fixed costs equation

$$FC = Z_{fc}\gamma + v_f, \quad (13)$$

where the unobserved fixed cost component v_f is distributed normally around zero mean and Z_{fc} are instruments to proxy fixed costs. v_f is allowed to be potentially correlated with the random preference parameters ε_Y and ε_H. As they only impact on workers, the utilities $U(T-H, Y_H; X)$ entering the likelihood function now become $U(T-H, Y_H - FC; X)$ for all states $H^j > 0$. To observe a worker in the presence of fixed costs therefore requires that

$$\max_{H_{(.)}\neq \mathbf{0}} U(T - H_{(.)}, Y_{H_{(.)}} - FC; X) > U(Y_{\mathbf{0}}, T; X). \tag{14}$$

Thus with all these elements in hand, the (log-)likelihood is obtained by summing the log probabilities for each particular state, where the probabilities are a combination of equations (14), (13) and (7). Net incomes for each hours state have to be calculated and enter directly into (8). Depending on the generality of the model, simulation methods may be required for estimation such that unobserved random elements can be numerically integrated out.

3 The Independence of Irrelevant Alternatives

From equation (7) it follows that

$$\frac{\Pr[H_{(.)} = H^j)]}{\Pr[H_{(.)} = H^k)]} = \frac{\exp[U(T - H^j, Y_{H^j}; X)]}{\exp[U(T - H^k, Y_{H^k}; X)]}, \text{ for all } j \neq k \tag{15}$$

which suggests that the probability of choosing one labour market state relative to another one is independent of all other choices in the choice set. This is an assumption that is likely to be violated in practice. For example, it implies that the probability of choosing full-time work relative to that of no work, is independent of there being part-time work available. This appears to be an untenable assumption and it would appear important to test for this. However, the literature suggests that standard tests for IIA have very poor power (Fry and Harris 1996). An alternative, and preferable procedure, therefore is to generalise the Logit probabilities such IIA is no longer embodied.

4 The Dogit Model

A convenient specification here would appear to be the Dogit model (Gaudry and Dagenais 1979). Dogit probabilities are given by

$$P[H_{(.)} = H^j)]^{Dogit} = \frac{\exp[U(T - H^j, Y_{H^j}; X)] + \theta_j \left[\sum_{k=1}^{J} \exp[U(T - H^k, Y_{H^k}; X)]\right]}{\left(1 + \sum_j \theta_j\right) \left(\sum_{k=1}^{J} \exp[U(T - H^k, Y_{H^k}; X)]\right)} \tag{16}$$

or more compactly

$$P_{ij}^{Dogit} = \frac{\exp\left(U_{ij}\right) + \theta_j \sum_{k=1}^{J} \exp\left(U_{ik}\right)}{\left(1 + \sum_{k=1}^{J} \theta_k\right) \sum_{k=1}^{J} \exp\left(U_{ik}\right)}. \tag{17}$$

Although there are very few applications of this model in the literature, it appears ideal for this purpose. Firstly, it does not embody the IIA property but nests the Logit in terms of appropriate parameter restrictions ($\theta_j = 0, \forall j$). Thus the Logit specification can be easily tested for by conventional methods.[2] Secondly, the probabilities have a relatively straightforward closed form expression. Thirdly, it contains J additional parameters θ_j, which are state specific and are most conveniently interpreted as the extent of "captive" choices. Unlike the Logit model, this model therefore easily allows for a multi-modal distribution of choices, and accounts for the fact that certain groupings of hours are more likely to be captive, for example those around zero and forty, primarily for institutional reasons.

[2] A likelihood ratio test appears the most appropriate.

Specifically, in the Dogit model an individual is assumed either captive to one of the J outcomes or chooses freely from the full choice set. Therefore, the available choice set faced by the individual, $B_i = B \, \forall \, i$, comprises $J+1$ sets, J single outcome "captivity sets" and one set comprising all J outcomes from which "free choice" is (subsequently) exercised by the individual. The choice set generation process itself can be represented as a random utility maximization model with utilities given by

$$U_{ik}^{1} = W_{ik} + \eta_{ik}, \;\; i = 1, \ldots, n; \;\; k = 1, \ldots, J+1. \tag{18}$$

Under the assumptions that: η_{ik} are independent identically distributed Type 1 Extreme Value; $W_{ik} = \log(\theta_k)$ and; the normalization that $W_{iJ+1} = 0$, the probability of individual i choosing a single outcome (captive) choice set is given by

$$P_{ij} = \frac{\theta_j}{1 + \sum_{k=1}^{J} \theta_k}, \tag{19}$$

and the probability that individual i chooses the full choice set is

$$P_{iJ+1} = \frac{1}{1 + \sum_{k=1}^{J} \theta_k}. \tag{20}$$

For the outcome selection process the probability that an individual chooses the specified outcome j from a single outcome choice set is one and the probability that an individual chooses the specified outcome j from the full choice set is given by the standard RUM model that leads to the Logit in equation (7) above. Thus, utilizing the Manski (Manski 1977) framework, the Dogit model can be parameterised as

$$P_{ij}^{Dogit} = \frac{\theta_j}{1+\sum_{k=1}^{J}\theta_k} + \frac{1}{1+\sum_{k=1}^{J}\theta_k} \times P_{ij}^{Logit}. \quad (21)$$

This particular parameterization illustrates a further boundary condition on the admissible range for the θ_j values (in addition to $\theta_j \geq 0 \ \forall \ j = 1, \ldots, J$, which ensures a proper distribution function). In the limit, the proportion choosing outcome j in a sample, must be greater or equal to the proportion given by the captive probability $P_{ij}^{captive}$, where

$$P_{ij}^{captive} = \frac{\theta_j}{1+\sum_{k=1}^{J}\theta_k}.$$

Effectively, this places an upper bound on the admissible θ_j values.

In such a parameterization, the θ's can be interpreted as "preference", "loyalty" or "gravity" parameters or alternatively heterogeneity of the outcome(s). Of course, it is possible to generalise the Dogit model further by allowing these gravity parameters to be a function of observed heterogeneity, indeed, this is the parameterised Logit captivity model of Swait and Ben-Akiva (1987). However, this is not considered in this paper, as the model is already deemed to be sufficiently heavily parameterised. As we do not parameterise the preference parameters but treat them as fixed constants, they can be thought of as representing unobserved heterogeneity of the particular hours state, the strength of which can (and is almost certain to), vary across j, but be constant across i.

At one extreme, if the pull of these gravity parameters is large for any particular outcome they are likely to dominate the ultimate choice probabilities for that outcome - irrespective of observed personal heterogeneity. At the other extreme, a zero θ value for an outcome results in choice probabilities being driven solely by observed heterogeneity. In between these extremes, choice probabilities are a combination of the two. With regard to the labour supply process, these effects are most likely to represent a combination of institutional constraints and demand-side effects.

If there is such captivity in the "choice" process which is ignored in the traditional specification, will result in biased parameter estimates of the utility function, and hence to biased estimates of labour supply responses to policy shocks (see Section 8).

The parameters of the Dogit model can be consistently estimated using the maximum likelihood criterion. By defining an indicator variable d_{ij} as

$$d_{ij} = \begin{cases} 1 & \text{if individual } i \text{ chooses alternative } j \\ 0 & \text{otherwise} \end{cases}$$

the log-likelihood function will be

$$\ell^m(\phi) = \sum_{j=1}^{J} \sum_{i=1}^{N} d_{ij} \ln P_{ij}^{Dogit}, \tag{22}$$

where $\phi = \left[vec(\beta)', \theta'\right]'$.

In practice, it is likely that some, all, or none of the captivity parameters will go their boundary solutions. Moreover, it is also possible to set some of these captivity parameters to their lower boundary solutions for *a priori* reasons (as noted above $\theta_k = 0$, simply implies no captivity for outcome k).

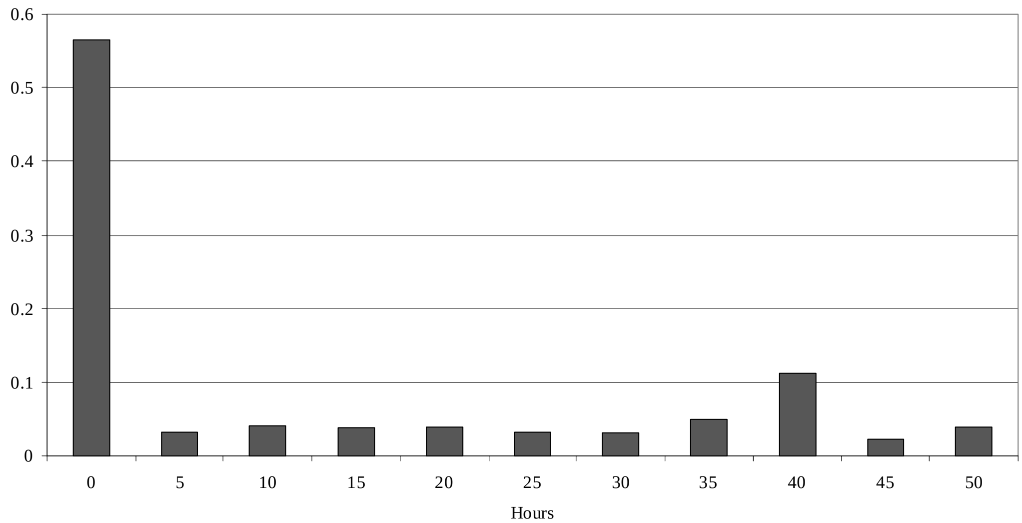
5 The Data

The data used in this analysis come from a pooled series of four IDS's, made available through the Australian Bureau of Statistics, over the years 1994-95 to 1997-98. The survey collects information on the sources and amounts of income received by persons resident in private dwellings throughout Australia. It provides fairly explicit information on the characteristics of income units and persons surveyed, for example, information on individual, family and household incomes, labour market attachment, as well as standard personal demographics. The survey is continuous throughout the financial year, with around 650 households interviewed each month. We exclude self-employed and retired households from the estimation sample, along with any extreme outliers and missing values, leaving a working sample of 1,610 sole parent households. Note that as the preference function for male and female sole parents are likely to be very different, we also exclude the small number of male sole parents from the data.

A plot of the empirical distribution of hours clearly illustrates the multimodal nature of the data (Figure 1). Presumably, primarily as a consequence of child care commitments, there is a large percentage of sole parents observed not to work. However, there is also clearly a secondary peak at the full-time hours band of around 40 hours per week (and also to a much lesser extent, at the part-time hours bands of around 15-20 hours). Thus from the raw data and also on *a priori* grounds, it appears likely that there will be significant captivity effects to these sections of the hours distribution.

To generate the required net incomes we use the Melbourne Institute Tax and Transfer Simulator - MITTS (Creedy and Duncan 1999a), a microsimulation model of the Australian tax and benefit system that calculates tax and medicare liabilities, allowance and pension entitlements and family payments for the four IDS years. The financial returns for each working age

Figure 1: Empirical Distribution of Hours



individual to employment at all possible hours are calculated using gross and net incomes at these levels. For the waged their current wage was assumed to remain unchanged, and for the unwaged, wages were imputed based on their personal characteristics. The use of MITTS allows us to generate highly accurate financial budget constraints for each individual in the sample.

6 The Results

To be consistent with the specifications already embodied in MITTS, we choose a labour supply regime with eleven hours states in which the sole parents are allocated one of the hours levels in the set $H_{(.)} = \{0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50\}$ such that each individual is allocated to the 'closest' discrete hours point. For example, $H_{(.)} = 35$ if observed hours H, are between 33 and 37. Note that in the estimations, there was little evidence of any random preference heterogeneity and therefore these results are not reported.

In Table 1 we therefore present two sets of results. Model (1) is a specification closely following the preferred one in Duncan and Harris (2002), and one currently in place in the MITTS. Model (2) contains the Dogit specification.

The control variables chosen to account for variation in tastes for work were: dummies for the age of the youngest child (0-2, 3-4 and 5-9); total number of children; age and age squared; and dummies for highest education attainment (vocational and diploma or higher). Those to account for variations in fixed costs were: a dummy representing residence in a capital city; number of pre-school aged children; number of school-aged children; and a dummy variable for residence in New South Wales.

The squared terms of hours and income and the interaction of these, are all significant in both specifications, apart from the latter in the standard setting. The signs of the hours squared term and the interaction terms are reversed in the Dogit model, However, this does not unduly affect the underlying preference structure as evidenced by the percentage of observations exhibiting quasi-concavity, increasing utility with income and convex indifference curves.

In terms of the control variables, none of them appear to adequately capture the linear preference for income term particularly well, with the exception of the total number of children. However, greater significance levels are achieved for the linear preference for the hours term. Moreover these coefficients are similar with regard to both magnitudes, signs and significance levels across the Logit and Dogit models. Finally, the same can ostensibly be said for the instruments for the fixed costs equation.

Table 1: Model Estimates - MNL and DOGIT Probabilities, N=1,610

	Logit		Dogit	
$\alpha_{YY} \times 10$	-3.927	(1.26)**	-11.825	(1.63)**
$\alpha_{HH} \times 100$	0.067	(0.03)**	-0.224	(0.08)**
$\alpha_{YH} \times 100$	-0.479	(1.09)	2.804	(1.43)**
β_Y	6.632	(1.64)**	15.743	(3.24)**
×1 (youngest child 0-2)	0.644	(0.37)*	0.603	(0.84)
×1 (youngest child 3-4)	0.075	(0.47)	0.203	(0.77)
×1 (youngest child 5-9)	1.188	(0.39)**	0.752	(0.86)
# children	0.797	(0.25)**	1.902	(0.32)**
age	-0.882	(0.77)	-2.031	(1.44)
age^2	0.067	(0.09)	0.155	(0.18)
×1 vocational qualification	-0.277	(0.25)	-1.261	(0.44)**
×1 diploma or higher	0.268	(0.24)	0.708	(0.45)
β_H	-0.336	(0.06)**	-0.436	(0.15)**
×1 (youngest child 0-2)	-0.042	(0.02)**	-0.063	(0.04)*
×1 (youngest child 3-4)	-0.021	(0.02)	-0.045	(0.03)
×1 (youngest child 5-9)	-0.067	(0.02)**	-0.038	(0.04)
# children	-0.021	(0.01)**	-0.048	(0.01)**
age	0.120	(0.03)**	0.163	(0.05)**
age^2	-0.015	(0.00)**	-0.020	(0.01)**
×1 vocational qualification	0.025	(0.01)**	0.044	(0.01)**
×1 diploma or higher	0.012	(0.01)	-0.024	(0.02)
Fixed Costs/100	1.119	(0.10)**	1.232	(0.17)**
×1 capital city	0.030	(0.03)	0.005	(0.03)
# pre-school children	-0.082	(0.10)	-0.120	(0.10)
# school aged children	-0.277	(0.10)**	-0.067	(0.13)
×1 New South Wales	0.160	(0.04)**	0.094	(0.04)**
Captivity Parameters (Dogit only)				
$\theta_{H=0}, \theta_{H=5}$	0.004	(0.00)	0.037	(0.01)**
$\theta_{H=10}, \theta_{H=15}$	0.039	(0.01)**	0.020	(0.01)**
$\theta_{H=20}, \theta_{H=25}$	0.012	(0.00)**	0.008	(0.00)**
$\theta_{H=30}, \theta_{H=35}$	0.005	(0.00)*	0.007	(0.00)*
$\theta_{H=40}, \theta_{H=45}$	0.065	(0.01)**	0.000	-
$\theta_{H=50}$			0.021	(0.01)**
ℓ	-2,295		-2,195	
% *quasi*-concave	95		93	
% where $U \uparrow$ with y	97		93	
% where IC convex	95		93	

Standard errors in parentheses. ** and * significant at 5 and 10% size, respectively.

Turning to the additional parameters in the Dogit specification, one of the captivity parameters has gone to its lower boundary solution of zero (that for 45 hours of work), whilst the remaining ones are all statistically non-zero (recalling these are one-sided tests) with the exception of $\theta_{H=0}$. This is presumably because the fixed cost equation is explaining the bulk of non-participation. The largest effect appears, not surprisingly, appears to be afforded by full-time hours of work of $H_{(.)} = H_{(40)}$. The next largest effects, are those corresponding to primarily part-time casual employment hours of (in order) 10 and 5. Those for both very high hours of work (50) and the more usual part-time hours levels (of 15 and 20) also appear to be significant, but of a a smaller magnitude.

7 Model Evaluations

7.1 Predicted Probabilities

Due to the complexity of the above models, it is not clear how well they describe the data. In Table 2 sample proportions are presented along with the percentage predicted probabilities for each hours state (derived from so-called hit-miss tables). For both models two sets are presented; one from the usual hit-miss table (*Traditional*) and the other where the stochastic elements of the model are explicitly taken into account (over 1,000 random draws; *Simulated*). As the number of random draws increases both sets of probabilities tend towards the sample proportions.

In both models in the Traditional hit-miss setting, both models heavily over-predict the most heavily observed state (zero hours of work) at the ex-

Table 2: Percentage Predictions

State	Actual	Traditional Logit	Traditional Dogit	Simulated Logit	Simulated Dogit
$H \leq 2.5$	0.5646	0.8584	0.7789	0.5654	0.5260
$2.5 < H \leq 7.5$	0.0329	0.0006	0.0006	0.0219	0.0324
$7.5 < H \leq 12.5$	0.0410	0.0000	0.0019	0.0391	0.0407
$12.5 < H \leq 17.5$	0.0373	0.0019	0.0012	0.0463	0.0353
$17.5 < H \leq 22.5$	0.0391	0.0037	0.0050	0.0479	0.0421
$22.5 < H \leq 27.5$	0.0317	0.0062	0.0236	0.0467	0.0487
$27.5 < H \leq 32.5$	0.0311	0.0043	0.0398	0.0444	0.0480
$32.5 < H \leq 37.5$	0.0491	0.0068	0.0193	0.0437	0.0479
$37.5 < H \leq 42.5$	0.1118	0.0248	0.0578	0.0454	0.0926
$42.5 < H \leq 47.5$	0.0224	0.0199	0.0168	0.0479	0.0356
$H > 47.5$	0.0391	0.0733	0.0553	0.0512	0.0507

pense of all other hours states. Because of this, focus is on the Simulated approach. Here, predicted probabilities closely replicate sample proportions, although now the Dogit specification actually under predicts the zero hours state by some 4 percentage points. Where the Dogit model clearly surpasses the Logit specification, is in predicting the traditional full-time working week state of ($37.5 < H \leq 42.5$), presumably as a result of the strong captivity parameter corresponding to this hours alternative. Moreover, there are strong *a priori* (institutional) reasons as to why individuals are captive to this hours level, in addition to that as determined by personal characteristics. That is, there are presumably relatively few employment opportunities at the margin of the usual full-time hours ones.

8 Simulating Employment Responses to Policy Reform

How then, do these two models compare in terms of microsimulation? We undertake this following the approach in Duncan and Harris (2002). That is, the estimated preference function for sole parent households, varying by observed characteristics, is brought together with the level of net incomes to be enjoyed at each possible hours alternative. This yields an optimal employment choice under some benchmark tax system. Note, however, that there is nothing that ensures that the hours state corresponding to the maximum predicted utility corresponds to the observed hours state.

Next, a new tax system following some policy reform, is instigated. This alters the budget constraint and therefore, potentially, also the optimal choice of hours post the policy reform. By comparing the simulated employment optima for a large and representative sample of sole parent households, it is possible to build a pattern of employment transitions which indicate both the direction and degree of behavioural response to the tax reform. Microsimulation methods of this sort are necessarily supply-side in nature, as including potential demand-side and price impacts of labour supply responses, would be computationally infeasible.

The approach followed in this paper follows that of Duncan and Harris (2002) by respecting the probabilistic form of the discrete model. Specifically, the estimated model is used to predict the probability of choosing each hours level in the set $H_{(.)} = \{0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50\}$ under the March 1998 tax system, and under a range of alternative policy scenarios.

Resampling methods were used to generate estimates of the probability of transition from one labour market state to another following a policy reform in the following manner:

1. drawing repeated realisations of the random elements of the model;

2. allocating each individual to the most preferred labour market state following each random draw; and

3. averaging these resampled transitions frequencies to arrive at simulated transitions probabilities for each observation in the sample.

By aggregating individual transitions probabilities, it is possible to simulate the overall labour supply response to a tax policy reform, and to model how those simulated transitions might affect the cost to the Federal Government of the reform.

For the traditional Logit probabilities we use equation (6) and add Type 1 Extreme Value error terms to the base utilities. For the Dogit model, we follow Fry and Harris (1996) in adopting the two-stage generation process as described in Section 4. This requires two sets of draws from the Type 1 Extreme Value distribution; one in the first stage of equation (18) and another one in the Logit part of equation (21) in the second stage.

As in Duncan and Harris (2002) the reforms considered are:

- **Reform 1:** reduce the Single Parent Pension withdrawal taper from 50% to 40%;

- **Reform 2:** reduce the withdrawal tapers for Family Payment from 50% to 30% (for the Basic payment) and from 100% to 30% (for higher payments);

- **Reform 3:** abolish the Single Parent tax rebate;

- **Reform 4:** increase the standard rate of income tax from 20% to 30%.

The data we use are from the IDS year 1997/98 and the (base) tax system was that in place as of March, 1998. We only use one year, to ensure consistency with the tax system and the observations.

The results from Reform 1 are presented in Table 3. This reform, which makes part-time employment relatively more attractive, was implemented in July 2000. Indeed, with regard to the Logit results, in line with Duncan and Harris (2002), we do predict a significant movement of sole parents out of no employment in to primarily the part-time hours spectrum of 11 to 40 hours. The Dogit probabilities mirror the directions of transitions, but they appear to more pronounced. The movement out of non-employment is over two-and-a-half percentage points greater, with the bulk of the additional movements being into the 21-40 hours range.

Reform 2 was implemented in July 2000 and the simulated responses presented in Table 4. In both specifications, there is modest movement out of non-employment and low levels of hours, into twenty and over hours per week.

Reform 3 consists of abolishing the Single Parent Tax Rebate, which has the effect of penalising sole parent tax payers. The estimated simulated responses are in Table 5. The Logit results reflect this with a big rise in the

Table 3: Simulated Percentage Employment Transitions Following Reform 1

				post reform hours range					
hours	before	after	difference	0	1-10	11-20	21-30	31-40	40+
Logit									
0	59.4	54.5	-4.8	54.5	0.2	1.3	1.5	1.2	0.8
1-10	6.8	6.5	-0.2	0.0	6.1	0.2	0.2	0.1	0.1
11-20	6.6	8.7	2.2	0.0	0.0	6.4	0.1	0.1	0.0
21-30	6.2	8.5	2.3	0.0	0.0	0.0	6.1	0.0	0.0
31-40	15.3	15.6	0.3	0.0	0.2	0.6	0.5	14.1	0.0
40+	5.8	6.1	0.3	0.0	0.1	0.3	0.2	0.0	5.2
Dogit									
0	59.4	51.9	-7.5	51.8	0.1	1.6	3.0	2.2	0.7
1-10	6.8	6.7	0.0	0.0	6.5	0.1	0.1	0.0	0.0
11-20	6.6	8.8	2.3	0.0	0.0	6.2	0.2	0.1	0.0
21-30	6.2	10.5	4.3	0.0	0.0	0.1	6.0	0.0	0.0
31-40	15.3	16.5	1.2	0.0	0.0	0.6	0.7	14.0	0.0
40+	5.8	5.6	-0.2	0.0	0.0	0.3	0.5	0.1	4.8

Table 4: Simulated Percentage Employment Transitions Following Reform 2

				post reform hours range					
hours	before	after	difference	0	1-10	11-20	21-30	31-40	40+
Logit									
0	59.4	59.2	-0.2	59.2	0.0	0.0	0.0	0.0	0.1
1-10	6.8	6.5	-0.3	0.0	6.5	0.0	0.1	0.1	0.1
11-20	6.6	6.4	-0.2	0.0	0.0	6.3	0.1	0.1	0.1
21-30	6.2	6.5	0.4	0.0	0.0	0.0	6.0	0.1	0.1
31-40	15.3	15.4	0.0	0.0	0.0	0.1	0.3	15.0	0.0
40+	5.8	6.1	0.3	0.0	0.0	0.0	0.1	0.1	5.6
Dogit									
0	59.4	59.1	-0.2	59.1	0.0	0.0	0.0	0.0	0.1
1-10	6.8	6.7	-0.1	0.0	6.7	0.0	0.0	0.1	0.0
11-20	6.6	6.0	-0.6	0.0	0.0	5.9	0.2	0.3	0.2
21-30	6.2	6.5	0.3	0.0	0.0	0.0	5.8	0.3	0.1
31-40	15.3	15.7	0.4	0.0	0.0	0.1	0.4	14.9	0.0
40+	5.8	5.9	0.1	0.0	0.0	0.0	0.1	0.2	5.5

Table 5: Simulated Percentage Employment Transitions Following Reform 3

hours	before	after	difference	post reform hours range 0	1-10	11-20	21-30	31-40	40+
Logit									
0	59.4	66.2	6.8	59.3	0.0	0.0	0.0	0.0	0.0
1-10	6.8	6.3	-0.5	0.8	5.8	0.0	0.0	0.0	0.1
11-20	6.6	4.6	-2.0	1.5	0.1	4.6	0.1	0.1	0.2
21-30	6.2	4.3	-1.9	1.5	0.1	0.0	4.2	0.1	0.2
31-40	15.3	12.6	-2.8	2.3	0.2	0.0	0.0	12.3	0.6
40+	5.8	6.1	0.3	0.8	0.0	0.0	0.0	0.0	5.0
Dogit									
0	59.4	65.7	6.4	59.4	0.0	0.0	0.0	0.0	0.0
1-10	6.8	6.4	-0.4	0.4	6.3	0.0	0.0	0.0	0.0
11-20	6.6	4.2	-2.4	1.8	0.0	4.1	0.1	0.2	0.3
21-30	6.2	3.5	-2.7	2.2	0.0	0.0	3.4	0.2	0.4
31-40	15.3	13.5	-1.8	1.4	0.0	0.0	0.0	13.1	0.9
40+	5.8	6.7	0.9	0.7	0.0	0.0	0.0	0.0	5.1

predicted number of non-employed single parents, primarily at the expense of those women previously working in the hours range 11-40 hours per week. Again these results are relatively closely mirrored by the Dogit specification, although the magnitudes are somewhat different. The Dogit specification predicts a marginally smaller movement into non-employment. However, in the Dogit model, again there are much bigger movements out of the 21-30 hours per week hours, and also out from 11-20 hours range. There was also significantly less predicted movement out of 31-40 hours range, than predicted by the Logit probabilities.

Finally, Reform 4 investigated the likely effects of reducing the basic rate of income tax. The predicted simulation responses are tabulated in Table 6. As expected, the Logit probabilities predict a significant movement into non-employment and noticeably from those females in full-time employment.

Table 6: Simulated Percentage Employment Transitions Following Reform 4

				post reform hours range					
hours	before	after	difference	0	1-10	11-20	21-30	31-40	40+
Logit									
0	59.4	64.1	4.8	59.3	0.0	0.0	0.0	0.0	0.0
1-10	6.8	7.7	0.9	0.1	6.7	0.0	0.0	0.0	0.0
11-20	6.6	6.1	-0.4	0.6	0.1	5.7	0.0	0.1	0.1
21-30	6.2	4.8	-1.4	1.1	0.2	0.1	4.6	0.1	0.1
31-40	15.3	11.9	-3.5	2.2	0.5	0.3	0.1	11.7	0.6
40+	5.8	5.4	-0.4	1.0	0.1	0.1	0.0	0.0	4.6
Dogit									
0	59.4	63.8	4.4	59.3	0.0	0.0	0.0	0.0	0.0
1-10	6.8	7.1	0.3	0.1	6.7	0.0	0.0	0.0	0.0
11-20	6.6	6.1	-0.4	0.7	0.0	5.7	0.0	0.1	0.1
21-30	6.2	4.3	-1.9	1.5	0.1	0.1	4.0	0.2	0.2
31-40	15.3	12.9	-2.5	1.4	0.1	0.2	0.2	12.6	0.9
40+	5.8	5.8	0.1	0.9	0.0	0.1	0.0	0.0	4.7

Again, the Dogit responses follow the direction of the Logit ones, but magnitudes differ. Once more movements seem to be more pronounced in the 21-30 hours range.

In summary of these results, it is clear that those hours ranges that correspond to large estimated captivity effects (for example, $H = 40$, 5 and 10, respectively) are little affected by policy reform - essentially the reform has to work hard to coax individuals out of these ranges. Note that the presentation above disguises this somewhat (for example, the 31-40 hours range, comprises of one large captivity effect and one very small one).

On the other hand, the bigger movements are afforded by those hours ranges with the smaller captivity effects. This is clearly illustrated by Table 7, which contains the predicted extent of captivity for each hours state and the disaggregated hours predicted transitions. The salient points of Table 7

Table 7: Simulated Percentage Employment Transitions: Full Hours Distribution

hours	Captive Probability	Reform 1 Logit	Reform 1 Dogit	Reform 2 Logit	Reform 2 Dogit	Reform 3 Logit	Reform 3 Dogit	Reform 4 Logit	Reform 4 Dogit
0	0.003	-4.8	-7.5	-0.2	-0.2	6.8	6.4	4.8	4.4
5	0.030	-0.3	0.0	-0.1	0.0	0.2	0.0	0.4	0.1
10	0.032	0.1	0.0	-0.2	-0.1	-0.7	-0.4	0.5	0.2
15	0.016	0.9	0.6	-0.1	-0.2	-0.9	-1.0	-0.1	-0.1
20	0.010	1.3	1.7	-0.1	-0.3	-1.0	-1.4	-0.4	-0.3
25	0.007	1.3	2.4	0.1	0.1	-0.9	-1.1	-0.5	-0.6
30	0.004	1.0	1.9	0.2	0.2	-1.0	-1.6	-0.9	-1.3
35	0.006	0.7	1.2	0.1	0.3	-0.9	-0.9	-0.9	-1.1
40	0.053	-0.4	-0.1	-0.1	0.0	-1.9	-0.9	-2.5	-1.3
45	0.000	0.4	0.1	0.2	0.2	0.2	0.2	-0.2	-0.2
50	0.017	-0.1	-0.3	0.1	0.0	0.1	0.7	-0.2	0.2

are that for those hours states which exhibit a significant amount of captivity, primarily $H_{(.)} = 40, 10$ and 5, respectively, the Logit results clearly overstate to the likely transitions from these states. For example, with regard to the institutionally determined full-time hours range of *circa* 40 hours, it is obviously difficult for sole parents to change this at the margin. This effect cannot be accounted for in the traditional Logit setting. Thus while under Reform 4 for example, the Logit results predict an (arguably) unrealistically large movement out of $H_{(.)} = H_{(40)}$, an effect which is much dampened in the Dogit setting.

9 Conclusions

This paper has investigated the appropriateness of Dogit probabilities underlying the discretised labour supply decision using data on Australian sole parents. Dogit probabilities expand on Logit ones by allowing for potential captivity in the choice process. Indeed, there appears to be a significant extent of captivity in this demographic's labour supply choice decision. In particular there was strong captivity to the hours state corresponding to full-time employment, and to a lesser extent, to part-time employment. There was little estimated captivity to non-employment, although the fixed costs equation is probably accounting for this.

The Dogit model appears ideal for modeling such a discretised labour supply problem, as the additional captivity parameters capture the well-known labour market rigidities in the number of hours worked. Once one takes such captivity into account, the model appears to predict the observed responses with much better accuracy. Moreover the microsimulated results to policy reforms, appear to yield much more believable responses to policy shocks, with less movement out from the (primarily) institutionally determined captive hours states (most notably full-time employment).

In summary, the Dogit model is quite clearly to be preferred on theoretical (and subsequently, statistical) grounds. It can easily handle multi-modal distributions and allow for the phenomenon of captivity to particular hours states. In the empirical example, the model appeared to be more consistent with the underlying data generating process. This was firstly illustrated by its superior predictive properties. It was also evident in the simulation process, where in numerous instances it was not possible to draw the random elements of the Logit specification such that the underlying preference function was consistent with the observed behaviour of particular individuals. On the other hand, it was always possible in the Dogit specification to take random draws that were consistent with observed behaviour.

Finally, the Dogit specification yielded (what we consider) to be more realistic transitions following policy reforms. That is, although the change in net incomes might be such that the reform alters the optimal hours choice for the individual, it is important to simultaneously recognise the inflexibilities in the labour market with regard to the available options for hours of work.

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