ESTIMATION OF A LABOUR SUPPLY AND WELFARE PARTICIPATION MODEL FOR THE AUSTRALIAN POPULATION

June 2005

Guyonne Kalb and Hielke Buddelmeyer*

Melbourne Institute of Applied Economic and Social Research,

University of Melbourne

Final report prepared for the Department of
Family and Community Services

Note:

The comments of 26 May 2005 have been addressed in this version of the report (for details, see the response to the comments). The report is complete except for the third specification of the model for couple families, which is the most complicated to run and will be added in the next week.

---

* We are grateful to the Department of Family and Community Services for funding this research and would like to thank Anthony Hulme for providing comments on an earlier version of the report. The views expressed in this paper are those of the authors and do not represent the views of the Minister for Family and Community Services, the Department of Family and Community Services or the Commonwealth Government

1 INTRODUCTION

The aim of this paper is to estimate a simultaneous model for labour supply and welfare participation for four separate subgroups of the Australian population. The groups are the following: couple families (with and without children), single men, single women, and sole parents.

The purpose of extending the discrete choice labour supply model with a welfare participation choice is to allow individuals in the population to forego welfare payments for which they would be in theory eligible. For example, a household may be eligible for $2 in benefits per week. It seems reasonable to assume that this household may consider the cost of applying for this benefit to be too high compared to the level of payment that is expected. A simultaneous welfare participation and labour supply model would take this into account by allowing for the possibility of a disutility (negative effect on utility) arising from welfare participation. This disutility can result from a financial cost of applying payments or from a stigma attached to the receipt of welfare payments.

This is an important issue given that the labour supply parameters are used as input in the Melbourne Institute Tax and Transfer Simulator (MITTS), which is designed to be used for predicting the effects of policy reforms. From the data and anecdotal evidence we know that not everyone who is eligible for a payment takes up the benefit. Therefore it would be important to relax the current assumption in MITTS that everyone who is eligible or everyone who is eligible for more than a certain amount takes up the relevant benefit.

We start from the basic discrete choice labour supply model that was estimated recently and is now underlying the behavioural results in MITTS (Kalb, 2002a). This model is based on the quadratic utility function and allows for the presence of fixed costs associated with working and for heterogeneity in preferences for labour supply and income. A multinomial logit specification is chosen in the discrete choice model with eleven labour supply points for most groups.

One variation on the labour supply model, estimated here, is to extend the utility function with a "stigma" parameter for welfare recipients and to add welfare participation to the choice set of individuals when they are eligible for a non-zero amount of benefits. For individuals working full-time hours, welfare participation is unlikely to be a choice. They would have to reduce their hours to become eligible. However, if there is a disutility associated with welfare participation, the option of not working (or working few hours only) and receiving social security benefits becomes less attractive than we would otherwise assume. A second variation on the labour supply model is to extend the model by allowing for involuntary unemployment through the use of observations on looking for full-time or part-time work for those who are not employed.

The newly estimated parameters could be used to simulate labour supply in MITTS. A simple (and perhaps not very realistic or relevant) simulation of a change in taper rate from 70 and 50 per cent to 30 per cent is used to illustrate the effect of using alternative specifications. Expected labour supply changes predicted from the different specifications are compared.

Section 2 briefly discusses the economic model. Section 3 describes the data. Large components of these two sections are similar to earlier reports that appeared on the estimation of labour supply. Section 4 contains the econometric details for the alternative specifications. The results from the models for the different groups are discussed in Section 5. First the estimated parameters are discussed, and then predicted labour supply using the estimated parameters and the simulation results that follow from the alternative specifications are presented. Finally, in Section 6 some conclusions are presented.

2. The Economic Model

2.1 Choice of population subgroups

The groups in which the population is subdivided are couple families (with and without children), single men, single women, and sole parents. Each of these groups is relatively homogenous, which allows us to specify one labour supply model for each group. The four groups together add up to a sample representing the Australian population over 15 years of age. Compared to groupings according to other criteria (such as education or age), it seems reasonable to assume that there is more difference between a single parent and a single man than there is between someone with a vocational qualification and someone with a degree or between someone aged 20 to 30 and someone aged 30 to 40. However, the choice for these groups because of their relative homogeneity does not imply that within each group there is no longer considerable heterogeneity. The model allows for this heterogeneity by including individual and household characteristics, such as age, education, and age and number of children in the model. In addition the model can allow for unobserved heterogeneity.

Further subdivision of the above groups could make the sample size of individual subgroups too small to consider separately in a model. For modelling reasons, single person households and couples need to be in separate groups, since the model for couples includes several parameters that are not relevant for a single person. The further subdivision into men and women is one that is commonly followed in the literature, given the observed differences in labour supply behaviour and in wage levels. Finally, a large part of the applied labour economic literature focuses on sole parents, as a particular group of interest. In comparison to other groups they are often found to be more responsive to financial incentives than other groups (Eissa and Hoynes, 1999; Blundell and Hoynes, 2000). Therefore, it seems sensible to estimate a separate model for this group as well. Few researchers have aimed to estimate labour supply for the complete population. Most articles dealing with labour supply thus focus on a subgroup and in the choice of subgroup similar groups to the four groups distinguished here are often selected. For example, couple households in Van Soest (1995) or Hoynes (1996), and sole parent households in Bingley and Walker (1997) or Duncan and MacCrae (1999). In contrast, single men and women have received relatively little attention in labour supply modelling[1].

2.2 Utility Maximization

In the type of model chosen in this report, the household is assumed to be the decision-making unit on labour supply and consumption. Thus, we use a household utility function or a unitary utility function, which does not explicitly take into account individual consumption or utility, but assumes there is one common utility function for the whole household. Although alternative models, incorporating more realistic assumptions on utility maximization in the household or allowing for home production to enter the model independently, are available[2], these models would introduce additional complications. To estimate a model where each household member has their own utility function, information is needed on the private consumption of individuals or on the amount of income allocated to them. No data set combines all necessary information on consumption or home production, income sources, and labour supply, so strong assumptions are often needed on how income is shared to allow estimation of collective utility models or on the value and amount of home produced goods to estimate models that explicitly allow for home production, instead of implicitly as in the unitary utility models. To deal with these additional complications other parts of the model need to be simplified and as a result keeping all the current detail of the tax and transfer system would be very difficult.

Given the aim of MITTS of simulating policy changes with regard to the tax and transfer system and assessing its effect on labour supply, priority is given to incorporating all possible detail on taxes and transfers. The literature that studies the effect of policy changes in taxation or social security systems mostly favours the neoclassical approach for its suitability to incorporate detailed budget constraints.

By setting up the model in the familiar neoclassical way, starting from utility maximization under a budget constraint, a logical and consistent framework can be built to analyse labour supply (see for example Deaton and Muellbauer, 1980; or Killingsworth, 1983). For example, take a two-adult household (with or without dependent children), where the adults choose their labour supply to optimise its utility. Their utility depends on

---

1 Euwals and Van Soest (1999) estimate one labour supply model for unmarried men and women with some separate parameters for men and women. However, their model also includes sole parents.

2 See for example, Bourguignon and Chiappori (1994), Browning *et al.* (1994), and Apps and

household consumption (which is assumed to be equal to net household income x), on the amount of leisure time[3] of adult 1, and the amount of leisure time of adult 2. This utility is maximized conditional on the restricted total amount of time available to each adult and the restricted amount of total household income. It is expected that utility increases with an increase in leisure and income. Usually more income means less leisure time for one of the adults, except when more income is obtained through social security benefits[4]. In short, maximizing a household's utility involves balancing the amount of leisure and income.

A simple utility maximizing model would look as follows:

(1) $\max U(x,l_1,l_2)$

subject to:

$T = l_1 + h_1$

$T = l_2 + h_2$

$$x = \int_0^{h_1} g_1(t_1,h_2)dt_1 + \int_0^{h_2} g_2(h_1,t_2)dt_2 + n(y_1) + n(y_2) + n(B(c))$$

where:

U( ) is the utility function of a two-adult household,

l_1 and l_2 indicate the aggregate of leisure time and home production time per week of the husband and wife (married or de facto) respectively,

x indicates net income per week,

T is the total available time for each person in the household,

h_1 and h_2 are the hours of work of husband and wife,

$g_1(,)$ and $g_2(,)$ are the marginal net wages of husband and wife at the different hours of work h_1 and h_2 taking into account taxation and withdrawal of benefits,

y_1 and y_2 are the non-labour incomes of husband and wife,

c is household composition,

B(c) is the amount of benefit a household is eligible for, given their household composition c,

n( ) is the amount of income after the deduction of taxes.

Rees (1996, 1997, 2000).

3 This leisure time is not pure leisure time but it also includes home production time.

4 In the current specification of the model it is assumed that everyone who is eligible for benefits takes them up.

The first two restrictions are time restrictions for the two adults. The third restriction, the budget constraint, denotes the level of available income in the household. If the three restrictions are taken together, the budget constraint may be written:

(2)
$$x + \int_{T-l_1}^{T} g_1(t_1, T-l_2)dt_1 + \int_{T-l_2}^{T} g_2(T-l_1, t_2)dt_2 =$$
$$\int_0^T g_1(t_1, T)dt_1 + \int_0^T g_2(T, t_2)dt_2 + n(y_1) + n(y_2) + n(B(c))$$

In this paper, the term ‘leisure’ is used to indicate both pure leisure time and home production time. The combination of leisure and income that delivers the highest utility to the household is regarded as the optimal choice.

The choice of labour supply is simultaneously determined for both adult members of the household. Depending on the choice of utility function, different interactions between household income and labour supply of both adults can be modelled.

In our specification we add one more argument to the utility function, welfare participation, following for example Moffitt (1983), Hoynes (1996) or Keane and Moffitt (1998). This results in:

(3) max $U(x,l_1,l_2,wp)$

subject to:

$$x + \int_{T-l_1}^{T} g_1(t_1, T-l_2)dt_1 + \int_{T-l_2}^{T} g_2(T-l_1, t_2)dt_2 =$$
$$\int_0^T g_1(t_1, T)dt_1 + \int_0^T g_2(T, t_2)dt_2 + n(y_1) + n(y_2) + wp\ n(B(c))$$

where:

wp is an indicator for welfare participation, wp=1 if the household receives welfare payments and wp=0 if the household does not receive these payments.

Households who decide not to participate in welfare do not receive the income component n(B(c)) even if they are eligible for payments. Their utility can be at a maximum while rejecting welfare payments if there is a cost or stigma associated with welfare participation. This cost can be estimated by estimating a parameter for wp in the utility function. The specification of this parameter is discussed in Section 4.

For households with only one adult, the model can be simplified by leaving out everything relating to the second adult:

(4) max U(x,l_1,wp)

subject to:

$T = l_1 + h_1$

$$x = \int_0^{h_1} g_1(t_1)dt_1 + n(y_1) + wp\ n(B(c))$$

Or combining the two restrictions:

$$x + \int_{T-l_1}^{T} g_1(t_1)dt_1 = \int_0^{T} g_1(t_1)dt_1 + n(y_1) + wp\ n(B(c)) \quad (5)$$

2.3. Allowing for preferred hours to be different from actual hours

With regard to the assumption of free choice underlying this economic model; in practice, it is often not known whether the observed labour supply is the optimal labour supply or, alternatively, whether people are restricted in their labour supply choice by demand side factors[5]. It would be interesting to analyse desired hours of work instead of actual hours of work or to allow for the restrictions in actual hours caused by the demand for labour. However, if a person works, it is unknown whether the hours of work are the same as the preferred labour supply. Therefore it is assumed that preferred hours equal actual working hours, because no information on the preferences of working respondents is available.

For non-participants however, the question regarding whether they are looking for full-time or part-time employment could be used to allow for involuntary unemployment. This paper presents three specifications of the labour supply model. The first specification assumes there is no cost to welfare participation and all unemployed persons are voluntarily unemployed. The second specification allows for a cost to welfare participation and is presented in the previous subsection. The third specification also allows for involuntary unemployment and uses the information on whether part-time or full-time employment is sought, when estimating the labour supply model. This introduces more uncertainty as the exact desired labour supply is not known, and the outcome of the welfare participation decision is no longer known in all cases either. The utility function to be estimated remains the same as before, but the optimal choice changes to represent the preferred choice (which is only known as a range of values) rather than the actual choice. Conditional on observed actual labour supply, we can use the information on observed welfare participation to obtain a better estimate of the cost to welfare participation. In this third specification, an additional equation is estimated to reflect the probability of finding employment given that the individual has a preference for being employed over being out of the labour market.

---

5 See for example, Laisney *et al.* (1992), Bingley and Walker (1997) or Duncan and MacCrae

2.4. Unobserved Wages

Like other researchers in this area, we have to deal with unobserved market wages for people who are not working. In this paper, we use the popular approach of estimating the wage equation separately and using estimated wages as if they represented the true values of the unobserved wages[6]. To correct for a possible selection bias as a result of only observing wage rates for those gainfully employed the Heckman correction term for participation is included in the wage equation (Heckman, 1979). In future research, the possibility of incorporating unobserved wages within the likelihood function and estimate wages and labour supply simultaneously will be explored. However, this is computationally more difficult and it is not attempted very often[7].

Separate wage equations have been estimated for the five demographic groups. The specification of the wage equation is discussed in a separate paper (Kalb and Scutella, 2002). For each non-participant we impute an expected value for the wage rate in the labour supply model.

3. THE DATA

The Survey of Income and Housing Costs 1994-95, 1995-96, 1996-97 and 1997-98, all released by the Australian Bureau of Statistics (ABS), have been used for the analyses. They contain detailed income information for each person separately and for the household as a whole. This allows the budget constraint to keep its full complexity. In order to combine the four years into input for one model, the monetary variables from 1995/1996 to 1996/1997 are converted to March 1998 values[8]. Furthermore, the observed nominal wages in these survey years are adjusted by the average wage increases for men or women as relevant.

3.1. Selection Criteria for the Four Groups

In this section, the selection criteria for each of the groups are discussed. There are five criteria which are applied to each of the demographic groups:

- Self-employed are excluded from the analyses. The surveys used for the analyses do not report the number of hours worked for people in self-employment. In addition, for self-employed the relationship between total earned income and labour supply is not as simple as for many wage and salary earners, where total earned income equals labour supply multiplied by the wage rate.
- People of an age to be eligible for government paid age pensions are excluded. They

---

(1999).

6 Van Soest (1995) uses this approach and points out that most of the papers in a special issue on Taxation and Labor Supply in Industrial Countries of the Journal of Human Resources (Moffitt, 1990) follow this approach as well.

7 Exceptions are for example Fraker and Moffitt (1988), Gerfin (1993) and Murray (1996).

8 For this the Consumer Price Index as published by the Australian Bureau of Statistics (1998) is used.

are expected to behave differently from younger people.

- All people temporarily or permanently unable to work because of illness or disability are excluded from the analysis.
- People receiving a (military) service pension are not included, since these pensions are paid instead of age pension or in cases of disability.
- All full-time students are excluded.

After these selections, the four separate groups are defined in the following way. The criterion for the *first* group, work-age couples, is that only income units that consist of a head and a partner with or without dependants are selected. The criterion for the *second* group, work-age single men, is that only income units that consist of one adult man without dependants are selected. The criterion for the *third* group, work-age single women, is that only income units that consist of one adult woman without dependants are selected. Finally, the criterion for the *fourth* group, work-age sole parents, is that only income units that consist of one adult man or woman with dependants are selected.

Missing values or outliers (which may be measurement errors) result in the deletion of a few additional households. First, some observed values for wage income seem unrealistically small when compared to the corresponding hours worked. In Australia there is no Federal or state minimum wage covering all employees. Each award has its own minimum wage. Therefore, across states, occupations and industries, minimum wage levels vary. In addition, some workers, such as trainees, apprentices and supported workers, are not covered by an award and some employees may work in unpaid overtime. This makes it difficult to decide on a wage level, which distinguishes realistic from unrealistic wage levels. In the estimation of the labour equation in this paper, all persons earning less than $4 per hour[9] or more than $100 per hour are excluded[10] as such low and high values seem likely to be due to measurement error (the same selection is used to estimate the wage equation in Kalb and Scutella (2002))[11]. Second, all households who have zero net income at zero hours of work are excluded[12]. After these selection processes, a data set of 10249 income units is left for the labour supply analysis in group 1; 5730 income units in group 2; 4651 income units in group 3; and 1822 income units remain in group 4.

3.2. Variables used in the Analyses

Figures 1 and 2 give an overview of the sample frequency distribution of (categorized)

9 4 sole parents, 41 single men, 33 single women, 68 married men and 56 married women (where for 13 couples both partners are on an extremely low wage) fall into this group.

10 1 sole parent, 4 single men, 3 single women, 34 married men and 17 married women fall into this group.

11 None of the imputed wage rates fall into this category of wages that seem too low or too high.

12 2 sole parents, 62 single men, 55 single women and 0 couples fall into this group.

male and female working hours in the samples for the different groups. The difference between men and women is obvious and as expected. Relatively more women work part time and more men work full time (especially over 45 hours per week) in the different subsamples. There is also a clear difference between singles and couples. Single men are more likely to be nonparticipants or work part time than men in couples. They are also less likely to work more than 42.5 hours and in particular to work more than 47.5 hours per week.

Figure 1 Labour supply of men

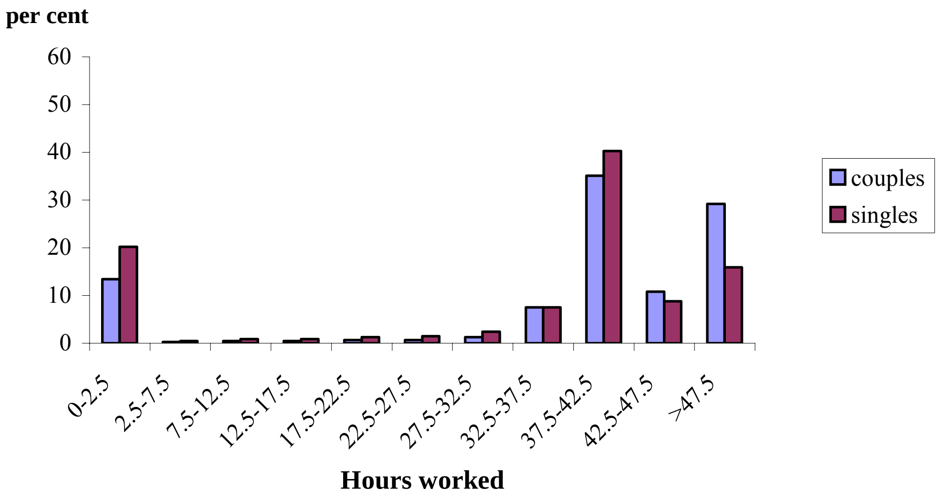

Figure 2 Labour supply of women and sole parents

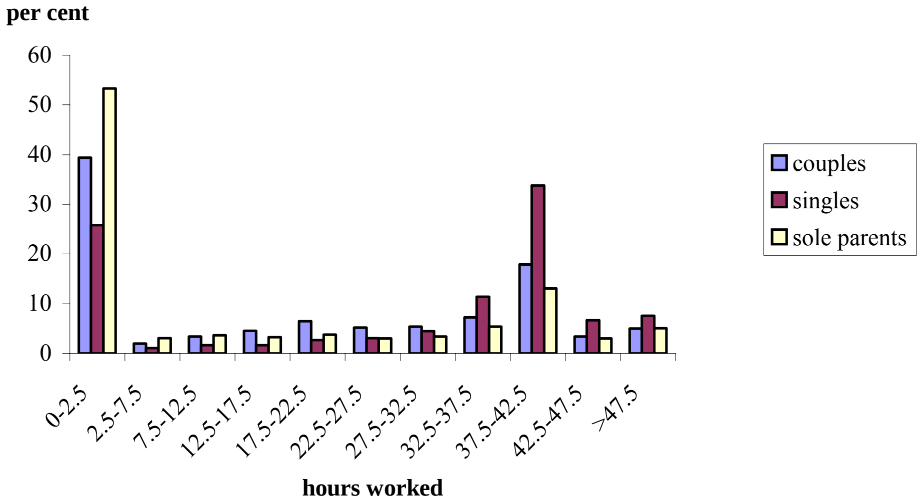

Figure 2 shows that single and married women behave differently as well. Single women work more hours and are less likely to work part time or be out of the labour force. The sole parents in this figure also contain the sole fathers, which is a rather small group. Sole parents are by far the least likely to participate in the labour force and if they

participate
they are more likely than the other groups to work in the lowest hours categories.

Table 1 gives summary statistics of the variables, which are used in the analyses. The table starts with information on the hours worked for heads and spouses, which are the dependent variables in our analysis together with welfare participation. The average number of hours worked is according to expectation, highest for married men and lowest for sole parents and married women. The proportion on payments, which are not associated with age, disability or illness, and excluding families on basic parenting payment only, is highest for the sole parent group, followed by single men. When adjusting the observed proportion on payments by excluding those households who are not eligible, the proportion of couples on payments is reduced the most. This is due to couple families reporting parenting payment (slightly) over the amount of the basic parenting payment. Singles have the largest proportion of involuntarily unemployed people as measured by their search for full-time or part-time employment. Sole parents are more likely to search for part-time employment than any of the other demographic groups.

The background characteristics used to specify preferences in the utility function are listed below.

Age is known exactly for those under 25 and those over 54 years of age, while the ages between 25 and 54 are known in five-year intervals. The midpoint values of each category are used in the analyses and to calculate the average age. Younger and older persons are expected to have a higher preference for leisure. Many studies include age and age squared to allow for a non-linear relation between age and the preference for leisure. Van Soest (1995), Aaberge, Colombino and Strøm (1999), Duncan and MacCrae (1999), Euwals and Van Soest (1999), and Van Soest, Das and Gong (2002) either find that age reduces the preference for leisure or they find a reduction of the preference for leisure at first, followed by an increase in the preference for leisure after a certain age.

Education is divided into the following categories:

- no qualifications
- vocational qualifications
- associate or undergraduate diploma
- higher or bachelor degree or postgraduate diploma

Education is expected to increase the preference for work, because time and money have been invested in human capital. Apart from the financial rewards, one would also expect a high-skill job to be more interesting than a low-skill job and hence more desirable. In accordance with the above expectation, Duncan and Harris (2002) find that having some qualifications increases the preference for labour supply and Duncan and MacCrae (1999) find that leaving school at 16 years of age decreases the preference for labour supply. Murray (1996) similarly finds that sole parents with some form of post-secondary school qualifications have a higher preference for work.

Table 1: Summary Statistics for the Income and Housing Cost Survey 1994/1995 to 1997/1998

	Couples N=10249		Single men N=5730		Single women N=4651		Sole parents N=1822	
Continuous Variables	**mean**	**st.dev**	**mean**	**st.dev**	**mean**	**st.dev**	**mean**	**st.dev**
Average hours worked by head	36.81	15.94	31.76	17.65	27.13	18.08	14.47	17.97
Average hours worked by spouse	19.04	17.98						
Welfare participation by the household	0.12	0.37	0.15	0.35	0.11	0.32	0.65	0.48
Welfare participation **and** eligible according to the microsimulation model	0.07		0.14		0.10		0.63	
Look for part-time work by head	0.00	0.05	0.00	0.06	0.01	0.08	0.03	0.16
Look for full-time work by head	0.06	0.23	0.13	0.34	0.09	0.28	0.06	0.23
Look for part-time work by spouse	0.01	0.10						
Look for full-time work by spouse	0.02	0.15						
Age head	42.36	10.45	30.87	11.83	34.44	14.86	36.74	8.95
Age spouse	39.94	10.21						
Number of children in income unit	1.21	1.21					1.71	0.88
Percentage of households without a child	0.40	0.49						
Wage rate head	19.20	9.39	15.19	7.35	14.35	6.16	15.95	7.65
Wage rate spouse	16.22	7.56						
Dummy Variables								
Living in New South Wales	0.23	0.42	0.23	0.42	0.23	0.42	0.20	0.40
Residence of income unit in capital city	0.62	0.49	0.63	0.48	0.67	0.47	0.60	0.49
Gender(woman)							0.89	0.32
Education of head								
• No qualifications	0.43	0.49	0.56	0.50	0.57	0.49	0.65	0.48
• Vocational qualification	0.29	0.45	0.23	0.42	0.17	0.38	0.18	0.39
• Diploma	0.11	0.32	0.08	0.27	0.09	0.29	0.07	0.26
• University degree	0.17	0.38	0.12	0.33	0.17	0.37	0.09	0.29
Education of spouse								
• No qualifications	0.60	0.49						
• Vocational qualification	0.17	0.38						
• Diploma	0.09	0.29						
• University degree	0.14	0.35						
Youngest child in income unit is								
between 0 and 2	0.19	0.39					0.20	0.40
between 3 and 4	0.07	0.26					0.14	0.34
between 5 and 9	0.14	0.35					0.28	0.45
between 10 and 15	0.12	0.33					0.25	0.43
Employment status head								
Non participation	0.07	0.26	0.07	0.25	0.17	0.37	0.44	0.50
Unemployed	0.06	0.24	0.14	0.34	0.10	0.29	0.09	0.28
Employed	0.87	0.34	0.80	0.40	0.74	0.44	0.47	0.50
Employment status spouse								
Non participation	0.35	0.48						
Unemployed	0.04	0.19						
Employed	0.61	0.49						

The *number of dependent children* in each income unit is calculated by adding the number of dependent children from 0 to 24 years old. This variable is expected to be especially important for the female adult in the income units. Children are likely to increase the value of time at home, which is reflected in a higher preference for leisure in the model.

The survey records the *age of the youngest dependent child under 15 years of age* in the income unit. The effect of dependent children in the income unit on the preference for time spent in working is likely to be bigger when young children are present.

The expected effects with regard to children are found in several studies. The effects are particularly strong for women. Van Soest (1995) finds effects for both men and women, where the female effects are somewhat larger. Van Soest, Das and Gong (2002), Aaberge, Colombino and Strøm (1999), Fraker and Moffitt (1988), Hagstrom (1996) and Hoynes (1996) find effects for married women. Duncan and MacCrae (1999) find strong effects for sole parents (mostly women) and married women of both the age of the youngest child and the number of preschool children. Much lower (and often no) effects are found for men. Similar effects are found for sole parents in Australia (Murray, 1996).

Residence of income unit in capital city and *Living in New South Wales* are location variables for where the income unit lives in Australia. It is expected that the fixed cost of working is different for people in or outside the capital cities and in or out of New South Wales, in particular for people with children who may need childcare services (Duncan and Harris, 2002).

Finally, *men* and *women* are expected to have different preferences for "leisure" time. In the models for two-adult income units, person 1 is male and person 2 is female. None of the two-adult income units contain two adult men or two adult women. In the single-adult income units, models are estimated separately by gender. For sole parents, the male group is too small to estimate separate models, so therefore a dummy variable for gender is included in the preference for labour supply and income, and in the fixed cost parameter to explore whether gender affects the preferences in this group.

4. Econometric Specification of a Labour Supply Model

In Section 2 an economic model was introduced that serves as a starting point for the specification of an econometric model. In the following sections, the econometric specification is discussed.

4.1. Allowing for a Nonlinear and Non-convex Budget Set

Including taxes and benefits for two persons in the budget constraint produces a highly nonlinear constraint. Looking at the benefit and tax regimes of 1994/1995, 1995/1996, 1996/1997 and 1997/1998[13] leads us to expect many kinks in the budget constraint. Since we prefer to keep the representation of taxes and benefits as close to reality as possible, a complex budget constraint cannot be avoided. In the case where one only considers one potential worker at a time, the labour supply estimation can already be quite complex[14]. The complexity is even greater in the case where income units with two potential workers are analysed, subject to their joint budget constraint.

Restricting the number of possible working hours to a limited set of discrete values, as is done by other authors (for example Van Soest, 1995; Duncan and MacCrae, 1999; Keane and Moffitt, 1998) facing the same problem, appears an attractive solution. For this limited set of hours, one can calculate the level of utility that each possible combination of hours would generate, according to the specified utility function. An additional (computational) advantage of the discrete approach is that quasi-concavity does not have to be imposed before using maximum likelihood methods to estimate the model, as is necessary in the case of continuous labour supply for some utility functions (see Van Soest, Kapteyn and Kooreman, 1993), but can be checked after estimation. Another argument for the discrete point approach is that it may be a more accurate representation of the often restricted choice in labour supply, which households are actually facing, than the continuous range of labour supply approach.

Instead of being defined on a continuous set of working hours [0,T], in the discrete choice case the budget constraint is defined on a discrete set of points $h_1 \in \mathcal{A} = \{0, h_{11}, h_{12}, ..., h_{1m}\}$, $h_2 \in \mathcal{B} = \{0, h_{21}, h_{22}, ..., h_{2k}\}$, and $wp \in \mathcal{C} = \{0,1\}$. h_1 and h_2 are on the interval [0,T][15]. Using these sets, the net income $x(h_1, h_2)$ is calculated for all (m+1)×(k+1) combinations of h_1 and h_2 (where m+1 is the number of discrete points for h_1 and k+1 is the number of discrete points for h_2) when wp=0. For wp=1, net income $x(h_1, h_2)$ is calculated for all combinations of h_1 and h_2 where the household is still eligible for benefit payments. The Melbourne Institute Tax and Transfer Simulator can calculate net income at all chosen discrete labour supply points and welfare participation. By increasing the number of different hours in the choice set, the quality of the representation improves. However, the computational load also increases, so a compromise between quality and computational feasibility is necessary. Furthermore, some of the theoretically possible hours ranges may not be observed in the data such as low part-time hours for men, which may mean fewer discrete points are necessary in that range[16]. This

13 The Melbourne Institute Tax and Transfer Simulator (MITTS) contains all the necessary information to calculate net income from gross income for these years.

14 See e.g. Burtless and Hausman (1978), Hausman (1979), Hausman (1985) or Moffitt (1986) for a continuous labour supply approach with a nonlinear (non-convex) budget constraint.

15 0, h_{11}, h_{12}, etc represent the discrete values that labour supply can take.

16 The probabilistic nature of the model means that small changes in behaviour can still be captured

specification allows easy experimentation with different numbers of points. This paper compares the discretisation of labour supply into five-hourly intervals with the discretisation into ten-hourly intervals. Given the number of observations at the different hours of labour supply, five-hourly intervals seem to be the smallest feasible grouping. The choice for smaller intervals would result in groups with very few observations, which would be a problem in the estimation using a discrete choice model.

Net income x is dependent on labour supply and wage rates of both adults, on non-labour income, on household composition and on eligibility for benefits. Net income for the records originating from the 1994/1995, 1995/1996, and 1996/1997 data sets are inflated up to the 1997/1998 level by multiplying the amount by the relevant CPI. In this way, net incomes in the different years are comparable. Wage rates, non-labour income and household composition are exogenous in this model. The model becomes:

(6) $\max U(x,l_1,l_2,wp)$

subject to:

(7)
$$\begin{aligned} &l_1 + h_1 = T \\ &l_2 + h_2 = T \\ &\text{where } (h_1,h_2,wp) \in \mathcal{A} \times \mathcal{B} \times \mathcal{C} \end{aligned}$$

$$x = w_1h_1 + w_2h_2 + y_1 + y_2 + wp.B(c, w_1h_1 + w_2h_2 + y_1 + y_2) - \tau(wp.B, w_1h_1 + y_1, w_2h_2 + y_2, c)\}$$

w_1 and w_2 are the gross wage rates of husband and wife respectively,

$\mathcal{A}$, $\mathcal{B}$ and $\mathcal{C}$ are the sets of discrete points from which values can be chosen for h_1, h_2 and wp

B is the amount of benefit, for which the household is eligible, given household composition c and income,

τ is the tax function that indicates the amount of tax to be paid.

A likelihood function can be formed using the above utility function. Based on the assumption of utility maximization for each household the following can be stated. The contribution of each household to the likelihood function is the probability that its stated

by the model, because the probabilities of being at each of the labour supply points can shift by small amounts. Thus, although moving from one to the next labour supply point may be a big step, the probabilities of this happening are calculated. These probabilities can be small so that subtle changes are still recorded.

hours result in an optimal utility for the household of interest when compared with all other possible choices for hours. This probability looks as follows:

$$\text{(8)} \quad \Pr(U(x((h_1,h_2,wp)_r),(h_1,h_2,wp)_r,\varepsilon_r) \geq U(x((h_1,h_2,wp)_s),(h_1,h_2,wp)_s,\varepsilon_s) \text{ for all s})$$

where:

r stands for the combination h_1, h_2 and wp that is preferred,

s stands for all possible combinations that can be made, given the discrete choice sets for hours worked and welfare participation,

ε_r and ε_s represent error terms.

Adding an error term to the utility function prevents contributions to the likelihood in any data point from becoming zero. It allows for optimisation errors made by the household. Choosing an extreme value specification for the error term in (8) results in a multinomial logit model (see Maddala, 1983). If we can calculate utility levels for each of the possible combinations of leisure and income, and the error terms are specified, then for each possible combination we can calculate the probability of that combination being preferred according to the estimated model.

The log likelihood contribution for couples looks as follows:

$$\text{(9)} \quad \ln L = U_{i'j'k'} - \ln\left(\sum_{i,j,k} \exp(U_{ijk})\right)$$

where:

i is an index of the husband's labour supply;

j is an index of the wife's labour supply;

k is an index of the household's welfare participation;

i', j' and k' are the indices of the observed states of labour supply and welfare participation (combination r in equation 8);

U_{ijk} is the level of utility derived from the state where the husband has labour supply i, the wife has labour supply j and the household has welfare participation k.

Expression (8) denotes the probability that the utility in the observed combination of hours is higher than the utility in any other situation. The aim is to choose parameter values for the utility function that maximize the log likelihood function in the observed data points.

For single adult households this simplifies to:

$$(10) \qquad \ln L = U_{i'k'} - \ln\left(\sum_{i,k} \exp(U_{i,k}) \right)$$

4.2 Specification of the Utility Function

The utility function used in the basic model is a quadratic specification (following Keane and Moffitt, 1998). The quadratic specification is simple but quite flexible in that it allows for the leisure of each person and consumption to be substitutes or complements. This means the model can represent complex interactions. Furthermore, the quadratic utility function can be expressed as a function of labour supply rather than leisure without the need to choose a value for total endowment of time (T). T is not important in this specification, as it is a constant, which can be incorporated in the parameters to be estimated.

The above advantages make the quadratic utility function a good choice, even though this utility function is not automatically quasi-concave. However, the latter is not a problem in a discrete labour supply model, because if the two conditions outlined in Van Soest (1995) are fulfilled at a data point, then U is quasi-concave at that point. In the discrete approach taken here, these two conditions can be tested at all data points after estimation of the parameters. In a model with continuous hours of labour supply, these conditions would have had to be imposed a priori to guarantee coherency, as has been mentioned earlier.

Many models encounter the problem of an overprediction of part-time hours and an underprediction of non-participation. An intuitively appealing approach is to include a cost-of-working parameter in the income variable x to indicate the cost of working versus non-participation (Callan and Van Soest, 1996). As a result of the inclusion in x, this cost of working parameter is measured in dollars per week. The disutility of welfare participation δ is modelled by subtracting a term $\varphi.wp$ from the utility. $\varphi.wp$ is 0 when the household does not participate in welfare. The utility derived from leisure and income can be written as:

$$(11) \qquad \begin{gathered} U(x,h_1,h_2) = \beta_x (x - \gamma_1 - \gamma_2) + \beta_1 h_1 + \beta_2 h_2 + \alpha_{xx}(x - \gamma_1 - \gamma_2)^2 + \alpha_{11}(h_1)^2 + \alpha_{22}(h_2)^2 + \\ \alpha_{x1}(x - \gamma_1 - \gamma_2)h_1 + \alpha_{x2}(x - \gamma_1 - \gamma_2)h_2 + \alpha_{12}h_1 h_2 - \varphi.wp \end{gathered}$$

where $\alpha_{..}$, $\beta_.$, and φ are preference parameters that have to be estimated; and γ_1 and γ_2 are the cost of working parameters to be estimated for husband and wife, they are zero when the relevant person is not working.

The quadratic utility function has a simple form and heterogeneity of preferences is easy to include. To account for differences in preferences between households, the parameters β, α, and γ can be made dependent on household and individual characteristics. In the first instance, it is assumed that only β_1, β_2, β_x, γ_1 and γ_2 depend on personal and household characteristics (see Section 3.2 for a description of the characteristics to be included). Simple linear specifications are chosen to include the observed heterogeneity in β_1, β_2, β_x, γ_1 and γ_2.

Adding unobserved heterogeneity to these parameters, in the form of a normally distributed error term with zero mean and unknown variance, is quite simple, although exact maximisation would involve a likelihood function with multiple integrals. However, Van Soest (1995) outlines an easier method, replacing the expectation of the log likelihood by a simulated mean and optimising an approximate likelihood function instead of the exact likelihood function. However, given the insignificance of these terms in the basic models (Kalb, 2002a), we leave this for the moment to keep the number of models to compare manageable.

4.3. Desired Labour Supply and the Probability of Employment

When allowing for involuntary unemployment, instead of knowing the exact hours of labour supply, it is only known whether an individual prefers to work part time (less than 35 hours) or full time (35 hours or more). As a result expression (8) changes into

$$
\begin{aligned}
&\Pr([U(x((h_1,h_2,wp)_{r_1}),(h_1,h_2,wp)_{r_1},\varepsilon_{r_1}) \geq U(x((h_1,h_2,wp)_s),(h_1,h_2,wp)_s,\varepsilon_s)] \text{ or} \\
&\quad [U(x((h_1,h_2,wp)_{r_2}),(h_1,h_2,wp)_{r_2},\varepsilon_{r_2}) \geq U(x((h_1,h_2,wp)_s),(h_1,h_2,wp)_s,\varepsilon_s)] \text{ or} \\
(12)\quad &\ldots\ldots \\
&\quad [U(x((h_1,h_2,wp)_{r_n}),(h_1,h_2,wp)_{r_n},\varepsilon_{r_n}) \geq U(x((h_1,h_2,wp)_s),(h_1,h_2,wp)_s,\varepsilon_s)], \\
&\qquad\qquad\qquad\qquad\qquad \text{for all } s)
\end{aligned}
$$

where indices r_j (j=1,…,n) represent the range of possible desired labour supply and welfare participation values.

The likelihood contribution further consists of the probability of employment for those who are not voluntarily unemployed. The employment equation is a probit with the probability of finding employment as the dependent variable. Independent variables are education, age, state of residence and living in a capital city. Employment equations are included to take the demand side of the labour market into account, so that preferred labour supply can be more accurately estimated. Note that the employment equation can only be included in the likelihood function for those who want to be employed. Although involuntary unemployment has now been taken into account, people who are employed are still assumed to be working at their preferred hours. In addition, it is assumed that if only one person is involuntarily unemployed then the other person does not adjust their labour supply, but works the number of hours selected in the overall preferred combination.

The log likelihood contribution for households where both adult members are working or voluntarily unemployed looks as follows:

$$(13)\quad \ln L = U_{i'j'k'} - \ln\left(\sum_{i,j,k} \exp(U_{ijk})\right) + d_1\left[d_{1e}\Phi(X_{1e}\beta_{1e}) + (1-d_{1e})(1-\Phi(X_{1e}\beta_{1e}))\right]$$
$$+ d_2\left[d_{2e}\Phi(X_{2e}\beta_{2e}) + (1-d_{2e})(1-\Phi(X_{2e}\beta_{2e}))\right]$$

where:

i', j', k' are the indices for the preferred states (combination r);

U_{ijk} is the level of utility derived from the state where the husband has labour supply i, the wife has labour supply j and the household has welfare participation k;

d_i is 1 if person i is working or involuntarily unemployed, d_i is 0 otherwise;

d_{ie} = 1 if person i is employed, 0 otherwise;

Φ represents the normal cumulative density function;

X_{ie} is a vector of variables explaining employment of person i;

β_{ie} is a vector of parameters indicating the effect of characteristics on person i.

Expression (13) denotes the probability that the utility in the preferred combination of hours and welfare participation is higher than the utility in any other situation. In addition to this probability, the employment probability is also part of the likelihood for those who are working or involuntarily unemployed.

The option of receiving welfare is only available when certain income requirements are fulfilled. This means that in most cases the household can only receive welfare payments when the number of working hours is sufficiently low. The participation in welfare according to the model above is assumed to be a voluntary decision together with the number of hours worked. However, the choice can be limited by a restriction in labour supply.

In the case where there is involuntary unemployment, the likelihood contribution changes. First of all, instead of actual hours we will use information on whether respondents, who are looking for work, want to work part time (less than 35 hours) or full time (35 hours or more). This is a range of worked hours rather than an exact number, which means we have to sum over the probabilities of discrete points falling within this range. Secondly, if the household is eligible for welfare at its actual hours (which is always zero hours in this specification), an additional term for the probability of welfare participation, conditional on the restricted labour supply, is added to the model. This will further assist in identifying the 'stigma' effect.

Three new variables $h_1^*, h_2^*, \text{and}\, d_W^*$ are defined, to distinguish actual labour supply and welfare participation from desired labour supply and welfare participation. The actual net income x* is defined by $x\left(h_1^*, h_2^*, d_W^*\right)$.

The likelihood contribution now becomes:

$$\ln L = \ln\left(\sum_{\substack{h_{1r}\in PLS_1 \\ h_{2r}\in PLS_2 \\ d_{Wr}\in WP}} \exp\left(U\left(h_{1r}, h_{2r}, d_{Wr}\right)\right) \right) - \ln\left(\sum_{i,j,k} \exp(U_{ijk}) \right) +$$

$$\text{(14)} \qquad \begin{aligned} & d_1\left[d_{1e}\Phi(X_{1e}\beta_{1e}) + (1-d_{1e})(1-\Phi(X_{1e}\beta_{1e}))\right] + \\ & d_2\left[d_{2e}\Phi(X_{2e}\beta_{2e}) + (1-d_{2e})(1-\Phi(X_{2e}\beta_{2e}))\right] + \\ & d_3\left[d_W^* \ln\left[P\left(d_W^* = 1 \middle| h_1^*, h_2^*\right)\right] + (1-d_W^*)\ln\left[P\left(d_W^* = 0 \middle| h_1^*, h_2^*\right)\right]\right] \end{aligned}$$

where

PLS_i = {all discrete labour supply points of 35 hours or more} if the preference is for full-time work, PLS_i={all discrete labour supply points of more than 0 and less than 35 hours} if part-time work is preferred, and $PLS_i=\{h_i^*\}$ if person i is working or voluntarily unemployed;

WP = {0} if at the preferred hours of work there is no welfare eligibility or if there is no actual welfare participation ($d_W^* = 0$), in all other cases WP={0,1};

d_3 = 1 if the household is eligible for welfare participation at the actual hours worked, 0 otherwise;

$P(d_W^*)$ = a binomial logit, defined as follows:

$$P\left(d_W^* = 1 \middle| h_1^*, h_2^*\right) = P\left(U\left(x_1, h_1^*, h_2^*, 1, \varepsilon_1\right) > U\left(x_0, h_1^*, h_2^*, 0, \varepsilon_0\right)\right) \text{ and}$$
$$P\left(d_W^* = 0 \middle| h_1^*, h_2^*\right) = P\left(U\left(x_0, h_1^*, h_2^*, 0, \varepsilon_0\right) > U\left(x_1, h_1^*, h_2^*, 1, \varepsilon_1\right)\right).$$

The first term in equation (14) contains less information than in equation (13), because for those involuntarily unemployed it is only known whether they want to work part time or full time (the exact number of hours is unknown) and the decision on welfare participation is often unknown as well. However, this is partly compensated by those households who are eligible for welfare participation at their actual hours worked. For these households, we know whether the household prefers to participate in welfare given the actual hours worked. The last term in equation (14), represents this additional information on the ranking of preferences. The probabilities in the first and last term of (14) are both based on the same utility function.

4.4. Expected Labour Supply

Once the complete model has been estimated, the results can be used to calculate the expected labour supply for people with certain known characteristics and under known social security and taxation rules.

To obtain the expected labour supply of the husband, we first calculate the utility $U(x(h_1,h_2, wp), h_1, h_2, wp)$ for each possible combination of labour supply for both adults in the household. This is achieved by substituting the estimated parameter values into equation (10) or (11) after calculating the net income for the relevant combination. Once the utility values are known, a simple logit transformation provides the probability of each possible combination occurring according to the estimated model:

$$(15)\quad p(h_1,h_2,wp) = \frac{\exp\left(U\left(x\left(h_1,h_2,wp\right),h_1,h_2,wp\right)\right)}{\sum\limits_{\substack{over\ \ all \\ h_1,h_2,wp}} \exp\left(U\left(x\left(h_1,h_2,wp\right),h_1,h_2,wp\right)\right)}$$

These probabilities can then be used to calculate the expected value of preferred labour supply for the husband by simply aggregating the probabilities over all possible values of h_2 and wp for each value of h_1. In this manner, the marginal probability of h_1 is obtained, which can then be used to calculate the expected value of h_1 in the usual way. The formula for this procedure looks as follows:

$$(16)\quad E(h_1) = \sum_{h_1}\left[\left(\sum_{h_2,wp} p(h_1,h_2,wp)\right)h_1\right]$$

The expected value for the wife's labour supply can be obtained in a similar way.

The expected value of actual hours worked can be obtained by multiplying (15) with the probability of employment, given that an individual prefers to work. This alternative value for $p(h_1, h_2,wp)$ can then be used in (16).

5. RESULTS

Labour supply is estimated using imputed wage values for the non-workers as described in Section 2.4. The next subsection presents the results of the labour supply models for couples. In the second subsection, the estimated results are used to predict labour supply probabilities so that predicted and actual results can be compared.

5.1. Discussion of the Labour Supply Results

To show how the results of a model as discussed in Section 4 are interpreted, we discuss the parameters of two-adult income units[17]. Table 2 gives the parameter estimates for the different specifications of the models.

Table 2: Estimated Parameters of the Labour Supply Model using the quadratic utility function for couples (10,249 observations)

	Basic model[a]		**With disutility**		**With disutility and employment equation**	
	Estimated coefficient	z-value	Estimated coefficient	z-value	Estimated coefficient	z-value
Quadratic terms						
income×*100,000*	-0.0126	-3.04	-0.0369	-6.92		
Labour supply man ×*100*	-0.6431	-63.18	-0.6132	-60.68		
Labour supply woman ×*100*	-0.2040	-22.26	-0.1873	-20.70		
Cross product						
Inc. & l.s. man ×*10,000*	-0.3418	-12.06	-0.5310	-23.78		
Inc. & l.s. woman ×*10,000*	-0.1448	-8.49	-0.2606	-14.38		
l.s. man & woman ×*100*	-0.0417	-7.22	-0.0227	-3.94		
Linear terms						
Income ×100						
constant	0.6246	32.21	0.8655	46.61		
Number of children	-0.0074	-3.20	-0.0083	-2.80		
Labour supply man						
constant	0.3612	27.21	0.3357	26.26		
Youngest child 0-2 yrs old	0.0033	1.31	0.0049	1.90		
Youngest child 3-4 yrs old	0.0012	0.37	0.0029	0.92		
Youngest child 5-9 yrs old	0.0002	0.06	0.0015	0.58		
Number of children	0.0006	0.55	0.0024	2.41		
Age/10	0.0660	12.75	0.0570	10.96		
Age squared/100	-0.0088	-14.80	-0.0076	-12.70		
Vocational education	0.0088	5.41	0.0082	4.98		
diploma	0.0069	2.80	0.0059	2.39		
degree	0.0122	4.86	0.0107	4.25		
Voc. education (partner)	0.0025	1.33	0.0027	1.43		
diploma (partner)	0.0006	0.22	0.0011	0.41		
degree (partner)	0.0023	0.87	0.0035	1.32		
Labour supply woman						
constant	0.0511	4.02	0.0271	2.12		
Youngest child 0-2 yrs old	-0.0599	-25.30	-0.0609	-25.37		
Youngest child 3-4 yrs old	-0.0411	-13.85	-0.0419	-13.99		
Youngest child 5-9 yrs old	-0.0225	-9.80	-0.0222	-9.58		
Number of children	-0.0089	-10.80	-0.0079	-9.73		

17 The results for single men, single women and sole parents are presented in Tables A.1 to A.4 in appendix A and are discussed more briefly, comparing the results with the results for couples.

Table 2: Continued

	Basic model[a]		With disutility		With disutility and employment equation	
	Estimated coefficient	z-value	Estimated coefficient	z-value	Estimated coefficient	z-value
Age/10	0.0483	8.31	0.0428	7.27		
Age squared/100	-0.0082	-11.29	-0.0074	-10.12		
Voc. education (partner)	0.0006	0.38	0.0006	0.35		
diploma (partner)	-0.0033	-1.44	-0.0029	-1.29		
degree (partner)	-0.0058	-2.62	-0.0047	-2.07		
Vocational education	0.0100	5.41	0.0095	5.11		
diploma	0.0196	8.18	0.0178	7.36		
degree	0.0337	14.81	0.0313	13.64		
Fixed cost man/100						
constant	18.2392	27.16	13.2507	37.60		
Fixed cost woman/100						
constant	6.7839	24.05	4.9903	28.93		
Disutility parameter			1.1355	17.10		

a Six discrete points of labour supply are distinguished for each man: 0 hours for non-participants and people working less than 2.5 hours, 10 hours for people working from 2.5 to 15 hours, 20 hours for people working from 15 to 25 hours, 30 hours for people working from 25 to 35 hours, 40 hours for people working from 35 to 45 hours, and 50 hours for people working more than 45 hours. Eleven discrete points of labour supply are distinguished for each woman: 0 hours for non-participants and people working less than 2.5 hours, 5 hours for people working from 2.5 to 7.5 hours, 10 hours for people working from 7.5 to 12.5 hours, 15 hours for people working from 12.5 to 17.5 hours, 20 hours for people working from 17.5 to 22.5 hours, 25 hours for people working from 22.5 to 27.5 hours, 30 hours for people working from 27.5 to 32.5 hours, 35 hours for people working from 32.5 to 37.5 hours, 40 hours for people working from 37.5 to 42.5 hours, 45 hours for people working from 42.5 to 47.5 hours, and 50 hours for people working more than 47.5 hours.

b The z-value is equal to the coefficient estimate divided by its standard deviation. A coefficient is significant at the 5 per cent level if the z-value is more than 1.96 or less than –1.96. The larger positive or negative the z-value is the more significantly different the coefficient is from zero.

The linear terms

The effects of different characteristics on the preference for leisure of both adults in the household are the first results to be discussed. We only discuss those parameters that are significant at the 5-per cent level. The quadratic utility model uses labour supply instead of leisure time as one of the arguments in utility.

To begin with the parameterised preference for work for the male adult, a significant positive effect[18] is found for the linear term of age. This means that older men have a higher preference for work and thus a lower preference for leisure. However, on the other hand the quadratic term for age seems to have a significant negative effect on the preference for work, which combined with the linear effect of age means that the preference for work increases for men up to 37 years of age after which it decreases with age. All models find the same age at which the preference for leisure is at its lowest. Thus young men and older men have a lower preference for labour supply. A positive effect on the preference for

18 This indicates a higher preference for work and thus a smaller taste for leisure.

labour supply is further observed in all models for households where the man has a higher level of education. A vocational education seems more relevant than a diploma. The partner's education does not seem relevant. None of the variables related to the age of dependent children in the household influence the preference for work. However, in the specification allowing for disutility of welfare participation, the number of children has a positive (small but significant) effect on the preference for labour supply. The latter effect is more as expected; the preference for work of the male partner increases when family responsibilities increase.

According to expectation, the preference for work of the female adult seems to be affected significantly by the presence of children, no matter which specification is chosen. All variables related to children have a significant negative effect on married women's preference for work. The younger the children, the larger the negative effect is. As expected, and as is seen in many other studies (Australian examples are Eyland, Mason and Lapsley, 1982 and Ross, 1986), having a newborn child or a child between three and four years of age has a large negative effect on the female preference for work. Children of primary school age, however, do seem to affect the mother's preference for work to a smaller extent. Finally, women with more children have a lower preference for work.

A significant positive effect is observed in all models for women with higher education levels. The effect of education seems more important for women than for men. The cause of this could be that almost all men of working age are working or looking for work, whereas women's labour supply is more variable. Additionally, if the partner's education level is higher, then a woman's preference for work is reduced to some extent. However, the effects are smaller than those resulting from her own education and only when the partner has a degree or higher is the effect significant. From the linear and quadratic age parameters in the different model specifications it can be derived that the maximum preference for work is around 29 years of age.

To keep the model manageable the preference for income only depends on the number of children. Other characteristics were not significant and did not improve the model. One would expect a higher preference for income when the household size increase, however the reverse appears to be true. This could be a spurious relationship reflecting the often-observed correlation between low income and the number of children, which may both be driven by similar household and personal characteristics.[19]

Comparing the effects found for couples with those for singles and sole parents, similar variables are found to be important (see Table A.1). High education levels increase the preference for work for all groups. Like for married men, single men with a vocational

19 Unemployment may play a role in this relationship, so perhaps allowing for involuntary

degree seem to have a slightly higher preference for labour supply than single men with a diploma. The effect on the preference for income is less clear; higher education levels increase the preference for some whilst decreasing it or being irrelevant for others.

The effect of age on the preference for work for single men is somewhat different compared to married men. The preference is at a maximum around 45 years of age. Similarly, single women's maximum preference for work is observed around 35 years of age, some years over the age at which this occurs for married women. For sole parents, this maximum lies around 37 years of age, perhaps partly reflecting their children's age.

Comparing the effect of children for sole parents and married women it is obvious that the age of the youngest child is important for both groups. However, it is remarkable that sole parents seem to have the lowest preference for work when their youngest child is in the age group five to nine. On the other hand, their preference for income is also at its highest when they have children in this age group. This will have opposite effects on the labour supply outcome. Children in the age group 3 to 4 seem to have less effect on both income and leisure preferences than the older and younger age group.

Finally the model for sole parents contains one additional explanatory variable, gender, because this group consists of both men and women. The coefficient shows that sole mothers have a lower preference for work than sole fathers.

Although parameter estimates are somewhat different between the alternative specifications for some groups, the outcomes for expected labour supply and for behavioural simulations could remain similar because the amount of labour supply and income are of course correlated. In Section 5.3 we use the estimated parameters in a simple simulation. From the results of these simulations, we will learn whether different or similar outcomes are generated by the alternative specifications.

Quadratic and cross product terms

Besides the linear terms, there are also quadratic terms involved in the quadratic utility function. Taking the first derivative with respect to labour supply of men, the following expression for the marginal utility of labour supply for men is obtained:

$$U_1 = \beta_1 + 2\alpha_{11}h_1 + \alpha_{12}h_2 + \alpha_{x1}(x - \gamma_1 - \gamma_2)$$

Similar expressions can be formulated for labour supply of women and for net income. From this formula and the results in the first two columns of Table 2, we conclude that couples seem to see each other's labour supply as substitutes. If one of the two persons works more, the marginal utility of work of the other person decreases (since α_{12}= -0.0417). However, the parameter was positive in earlier alternative specifications (Kalb, 2002b). This

---

unemployment in the labour supply model will reduce this effect.

is similar to other Australian studies where it is found that if one in a couple had more leisure time than the other's marginal utility for leisure time increased (Kalb, 1999, 2000).

The model presented here does not directly provide information on the effect of characteristics on labour supply like in a simple regression model. Instead, it provides the effect of characteristics on preferences for leisure of each person and on the preference for income. These preferences affect labour supply indirectly through the level of utility that can be obtained at each labour supply point. Therefore a positive cross product term for labour supply of the two adult household members indicates a preference for joint leisure time, but the labour supply outcomes are only partly driven by this cross product term. Other factors in the model influence labour supply as well. Thus, from a positive cross product term for the preference for labour supply of both members of the household, it does not automatically follow that if the husband reduces labour supply that the spouse will then also reduce her labour supply. However, a positive cross product term would make this more likely to happen.

There is also a significant effect of income on the marginal utility of labour supply or vice versa at the 5-per cent level for both the husband and wife. Both effects are negative indicating that the marginal utility of labour supply goes down when income goes up and that the marginal utility of income goes down when the amount of labour supply goes up. A significant negative effect is also estimated for the models of the other groups.

Fixed cost of working

In the quadratic model, the fixed-cost-of-working parameter can be expressed as a dollar amount, because the parameter is incorporated in the net income variable. This is an intuitively appealing way of specifying fixed-cost-of-working parameter.

The fixed-cost-of-working parameters seem very large in all model specifications for couples, particularly for men. The fixed costs parameters are not estimates of the actual costs of working, because they also include non-monetary costs and they probably also pick up the lack of people working part-time. The latter may make it look like people do not want to work for an income below the full-time rate. Comparing the basic model with the model including a disutility parameter, it is clear that this additional parameter has reduced the size of the fixed cost parameter to some extent. This is as expected because combining part-time work with social security payments is less attractive when taking the disutility of welfare participation into account. Therefore this part of the cost of part-time work no longer is included in the fixed cost parameter. Furthermore, the lack of people working part time may be at least partly a labour demand issue rather than a labour supply issue. This is reflected in the further reduction of the fixed cost parameter, when involuntary unemployment is taken into account in the third specification.

Comparing the estimated fixed costs of this model with the other models in the appendix, the explanation above is supported by the fact that we see the largest fixed costs for those who work part time the least. For example, sole parents have the lowest fixed cost and from some of the characteristic-specific components of the fixed costs it is clear that characteristics associated with a higher probability of part-time work reduce the amount of predicted fixed costs. This would explain why having a youngest child in between 5 to 9 years reduces fixed costs by the largest amount. That is, with younger children the parent is more likely to be a non-participant whereas with older children the parent may be more likely to prefer full-time work.

The high fixed costs of working parameters in all models, except for single women and sole parents, are combined with an increase in utility for part-time labour supply increases. This makes the low part-time hours the least attractive and the latter effect compensates part of the fixed costs with the positive effect of labour supply on utility at higher labour supply levels. Euwals and Van Soest (1999) find a similar effect for some individuals in their sample.

Disutility of welfare participation

The parameter representing the disutility of welfare participation is positive and significant for all groups in both specifications with a disutility parameter. This indicates that there is a price to receiving unemployment-related payments and even parenting payments for working-age individuals. The disutility could be caused for example by the time needed to apply for payments or by a "social stigma" associated with benefit receipt. This disutility parameter serves to make benefit recipience a less attractive option for all households with heads and spouses of working age in the population.

Employment equation

The results for the single adult families are presented together in Table A.4. The usual effects are observed, although the effects for sole parents appear less strong than for single men and women. The probability of employment increases at first with age (up to an age of around 40 for single men and women) after which the probability decreases with age. It also increases with the level of education and is higher in New South Wales and in capital cities than in other places. The probability of employment seems equally high in the territories, which is probably due to the high employment levels in the Australian Capital Territory.[20]

Quasi concavity

The quadratic utility function is not automatically regular. Therefore, one needs to check for quasi-concavity in each of the observed data points after estimating the model. It

[20] The SIHC does not allow us to separate the Northern Territory from the Australian Capital Territory.

is found that the two conditions, which are necessary for quasi concavity, are fulfilled at the observed hours in 100 per cent of the cases for all models except for sole parents. For sole parents the conditions are fulfilled in 99 per cent of the cases in the specification including the disutility term and in 100 per cent of the cases for the basic specification. Thus, it can be concluded that the utility function is quasi-concave in a majority of the cases in these models using the first two specifications. Using the third specification, it is not clear which labour supply level should be used to check quasi-concavity, given that for those who are involuntarily unemployed, we only know whether they would like to work part time or full time, without knowing the exact number of hours. Checking quasi-concavity at the observed actual labour supply, the percentage for which the two conditions are fulfilled has decreased somewhat but is still high. It is 90 per cent for single men, 97 per cent for single women and 92 per cent for sole parents.

5.2. Goodness of Fit

This section of the study compares the actually observed levels of labour supply to those predicted by the model (see Tables 3a to 3e). The probabilities of being in each of the categories of labour supply are reported. From the table, it is clear that the lowest part-time hours categories are somewhat underpredicted and the category with the highest hours are somewhat overpredicted. It is also clear that the model cannot capture the peak around 40 hours per week in the observed hours. As a result this category is underpredicted, whereas the neighbouring categories are overpredicted. For the two alternative models, welfare participation is predicted with labour supply as well.

These under- and over-predictions of hours categories in the labour supply model are not transferred to the policy simulations by using the following approach. The impact of prediction errors in the labour supply model on the simulation results is reduced by basing the starting point of the simulations on the actual working hours (and welfare participation if relevant) in the data. That is, labour supply and welfare participation before the reform is fixed on observed labour supply and welfare participation. This prevents prediction errors in the model from impacting on the distribution of working hours in the base situation.

The error term included in the labour supply model to account for optimisation errors (see equation 8) is used to calibrate the model in such a way that observed labour supply is always the starting point. Basically, the procedure is that we draw from the possible values for the error term and only accept those draws for the calculation of the expected labour supply before and after the reform that places the individual at the observed labour supply in the pre-reform situation. The approach uses the unobserved characteristics (the value of the error term) as well as the observed characteristics (such as age or family composition which are used in the calculation of expected utility levels at each labour supply level). The two components jointly determine which labour supply point an individual prefers.

Table 3a: Actual and Expected Labour Supply of married men

	Actual proportion		Expected proportion				
Hours per week			**basic**	**With disutility**		**With disutility and employment equation**	
	No welf.	Welf. part.		No welf.	Welf. part.	No welf.	Welf. part.
0-2.5	0.071	0.063	0.134	0.071	0.063		
2.5 – 15	0.007	0.004	0.000	0.000	0.000		
15 – 25	0.013	0.002	0.010	0.009	0.001		
25 – 35	0.035	0.001	0.120	0.117	0.004		
35 – 45	0.493	0.003	0.390	0.384	0.004		
> 45	0.307	0.001	0.347	0.345	0.002		
Exp. Hours	36.71		36.75	36.71			

Table 3b: Actual and Expected Labour Supply of married women

	Actual proportion		Expected proportion				
Hours per week			**basic**	**With disutility**		**With disutility and employment equation**	
	No welf.	Welf. part.		No welf.	Welf. part.	No welf.	Welf. part.
0-2.5	0.328	0.066	0.395	0.334	0.060		
2.5 – 7.5	0.018	0.001	0.019	0.017	0.001		
7.5 – 12.5	0.032	0.001	0.029	0.026	0.003		
12.5 – 17.5	0.045	0.001	0.042	0.040	0.004		
17.5 – 22.5	0.063	0.002	0.058	0.055	0.002		
22.5 – 27.5	0.051	0.000	0.072	0.070	0.002		
27.5 – 32.5	0.054	0.000	0.083	0.082	0.001		
32.5 – 37.5	0.073	0.000	0.087	0.086	0.001		
37.5 – 42.5	0.179	0.000	0.084	0.083	0.000		
42.5 – 47.5	0.034	0.000	0.073	0.073	0.000		
> 47.5	0.050	0.000	0.058	0.059	0.000		
Exp. Hours	19.10		19.06	19.08			

Table 3c: Actual and Expected Labour Supply of single men

	Actual proportion		Expected proportion				
Hours per week			**basic**	**With disutility**		**With disutility and employment equation**	
	No welf.	Welf. part.		No welf.	Welf. part.	No welf.	Welf. part.
0-2.5	0.082	0.125	0.207	0.085	0.121	0.083	0.123
2.5 – 7.5	0.003	0.002	0.000	0.000	0.000	0.000	0.000
7.5 – 12.5	0.006	0.003	0.001	0.001	0.000	0.001	0.000
12.5 – 17.5	0.007	0.001	0.005	0.003	0.001	0.003	0.001
17.5 – 22.5	0.010	0.002	0.014	0.011	0.003	0.010	0.002
22.5 – 27.5	0.014	0.001	0.035	0.032	0.003	0.029	0.002
27.5 – 32.5	0.023	0.001	0.074	0.072	0.002	0.068	0.002
32.5 – 37.5	0.074	0.000	0.128	0.126	0.002	0.125	0.001
37.5 – 42.5	0.400	0.000	0.176	0.175	0.001	0.178	0.001
42.5 – 47.5	0.087	0.000	0.193	0.192	0.001	0.198	0.001
> 47.5	0.159	0.000	0.167	0.167	0.000	0.172	0.000
Exp. Hours	32.02		32.03	32.02		32.32	

Table 3d: Actual and Expected Labour Supply of single women

	Actual proportion		Expected proportion				
Hours per week			**basic**	**With disutility**		**With disutility and employment equation**	
	No welf.	Welf. part.		No welf.	Welf. part.	No welf.	Welf. part.
0-2.5	0.175	0.088	0.263	0.172	0.092	0.170	0.093
2.5 – 7.5	0.006	0.005	0.003	0.002	0.001	0.002	0.001
7.5 – 12.5	0.012	0.005	0.008	0.005	0.002	0.004	0.001
12.5 – 17.5	0.014	0.003	0.016	0.013	0.003	0.011	0.002
17.5 – 22.5	0.026	0.001	0.032	0.030	0.003	0.027	0.002
22.5 – 27.5	0.029	0.001	0.060	0.060	0.002	0.056	0.002
27.5 – 32.5	0.044	0.000	0.098	0.098	0.001	0.095	0.001
32.5 – 37.5	0.112	0.000	0.134	0.132	0.001	0.132	0.001
37.5 – 42.5	0.335	0.000	0.149	0.146	0.000	0.150	0.000
42.5 – 47.5	0.066	0.000	0.136	0.135	0.000	0.141	0.000
> 47.5	0.075	0.000	0.101	0.103	0.000	0.110	0.000
Exp. Hours	27.24		27.24	27.24		27.65	

Table 3e: Actual and Expected Labour Supply of sole parents

	Actual proportion		Expected proportion				
Hours per week			**basic**	**With disutility**		**With disutility and employment equation**	
	No welf.	Welf. part.		No welf.	Welf. part.	No welf.	Welf. part.
0-2.5	0.050	0.483	0.533	0.045	0.488	0.045	0.488
2.5 – 7.5	0.003	0.029	0.022	0.002	0.022	0.002	0.020
7.5 – 12.5	0.004	0.033	0.033	0.004	0.028	0.004	0.026
12.5 – 17.5	0.007	0.026	0.040	0.009	0.027	0.009	0.026
17.5 – 22.5	0.013	0.026	0.045	0.019	0.024	0.018	0.023
22.5 – 27.5	0.011	0.019	0.047	0.031	0.017	0.028	0.018
27.5 – 32.5	0.026	0.008	0.049	0.040	0.011	0.037	0.013
32.5 – 37.5	0.049	0.004	0.052	0.046	0.007	0.045	0.009
37.5 – 42.5	0.128	0.003	0.055	0.053	0.004	0.053	0.006
42.5 – 47.5	0.030	0.000	0.060	0.058	0.002	0.061	0.003
> 47.5	0.049	0.001	0.064	0.062	0.000	0.066	0.001
Exp. Hours	14.50		14.49	14.50		14.83	

Although, we aim to increase the percentage that is correctly predicted, we also need to look at the distribution over the different hours categories. For example, by putting all married women at zero hours we could increase the percentage of correctly predicted observations to 46.8 per cent, but this is of course not a preferred option.

Fewer labour supply points are allowed for married men given the low number of married men working part-time hours (which can be caused by factors on both the supply and the demand side). However, given the probability approach used in the simulation of changes, small changes in labour supply can still be captured even in a ten-hour interval labour supply specification. A small change in labour supply means they may, for example, have a small probability of moving from 30 to 40 hours.

The results of the models can be summarized by calculating the expected hours of labour supply. The expected hours are given in the second last row of Tables 3a to 3e and mostly correspond well to the actual average hours of labour supply. Most values are quite close and the different specifications seem to perform equally well.

Welfare participation appears to be predicted reasonably accurately for the different demographic groups, with of course higher percentages at zero hours and low part-time hours of work. When percentages in particular labour supply categories are over- or under-estimated, the welfare participation in those categories appears to be over- or under-estimated to a similar extent. Allowing for involuntary unemployment, results in a slight overestimate of the predicted hours of work. However, the changes to the distribution of individuals across the labour supply levels and welfare participation does not change to a large extent. The advantage of this approach is that it allows labour supply and labour demand to be separated in the estimation and if required in the simulation. Calculating the distribution of desired labour supply and welfare participation, without accounting for the fact that some individuals cannot find employment, would result in higher levels of labour supply and lower rates of welfare participation. This is as expected and due to the fact that potential labour supply is higher than what can be observed through the actual labour supply levels.

5.3. Simulations

The expected effects of certain policy changes can be calculated by computing the expected numbers in each of the categories, accounting for the changed tax and benefit rules in the computer programs, and comparing these results to the expected numbers using the current tax and benefit rules. In this paper, we use the SIHC 1997/98 as the base data set for our simulations, so the tax and transfer system as it was in March 1998 is used. The models estimated in Section 5.1 are used to evaluate the same policy change of reducing all taper rates from 50 and 70 per cent to 30 per cent. Then the predicted effects are compared.

A summary of the labour supply responses resulting from this policy change is reported in Table 4 for all models and demographic groups. From this table it becomes clear that the results from the different simulations correspond with each other to some extent, but there are some clear differences. The largest difference in outcomes is found for sole parents and married men, who are less affected by the change in taper rate when allowing for the disutility of welfare participation than in the basic model. This can be explained by noting that allowing for non-take up of benefit payments, changes to the payments are likely to affect fewer people, because some households are disinclined to take up benefits for which they are eligible.

Table 4 Simulated responses of labour supply

Behavioural Response	Couples		Singles		
	Men	Women	Men	Women	Sole Parents
Basic labour supply model					
Workers(% base)	58.87	45.26	54.87	44.04	42.71
Workers(% reform)	60.48	44.7	56.22	45.74	50.07
Non-work --> work (%)	2.23	1.26	1.46	1.84	7.62
Work --> non-work (%)	0.62	1.82	0.10	0.13	0.26
Workers working more	0.42	0.22	0.09	0.07	1.93
Workers working less	1.69	0.89	0.95	2.28	2.49
Average hours change	0.45	-0.47	0.33	0.14	2.29
Labour supply model with disutility					
Workers(% base)	58.87	45.26	54.87	44.04	42.71
Workers(% reform)	59.88	44.2	56.38	44.67	45.73
Non-work --> work (%)	1.63	1.57	1.62	0.71	3.22
Work --> non-work (%)	0.62	2.63	0.10	0.07	0.21
Workers working more	1.32	0.54	1.54	0.88	1.75
Workers working less	2.95	1.44	3.64	2.03	3.91
Average hours change	0.18	-0.62	0.32	0.06	0.43
Welfare participation:					
% welfare part (pre)	7.99		8.43	4.54	62.92
% welf.part.&work (pre)	1.85		0.89	0.81	14.89
% welf.part.&no work (pre)	6.13		7.54	3.73	48.03
% welfare part (post)	14.94		15.30	8.18	68.82
% welf.part.&work (post)	9.83		8.84	4.77	23.60
% welf.part.&no work (post)	5.34		6.57	3.51	45.53
movers off welfare (ppt)	0.18		0.00	0.00	0.00
movers on welfare (ppt)	7.13		6.87	3.64	5.90
Labour supply model with disutility and employment equations					
Workers(% base)					
Workers(% reform)					
Non-work --> work (%)					
Work --> non-work (%)					
Workers working more					
Workers working less					
Average hours change					
Welfare participation:					
% welfare part (pre)					
% welf.part.&work (pre)					
% welf.part.&no work (pre)					
% welfare part (post)					
% welf.part.&work (post)					
% welf.part.&no work (post)					
movers off welfare (ppt)					
movers on welfare (ppt)					

Examining welfare participation, the table shows that before the reform only a small proportion is working while receiving a social security payment; most recipients are not in paid work. After the reform, this has reversed. This has largely occurred through drawing households onto payments, who were previously ineligible while working or for whom the additional payment was not worthwhile applying for before the change. However, the table also shows that the percentage of the population on welfare payments who are not combining social security payments with work has decreased at the same time.

The conclusions regarding the effect of the policy change, based on the results from the two simulations, are the following. The largest positive labour supply response is observed for sole parents both in terms of average hours worked and labour market participation. The smaller effect for sole parents in the alternative specification is caused by a lower increase in labour force participation and a larger number of sole parents reducing their hours of work. Married women are expected to decrease their average labour supply by around half an hour and to decrease their labour force participation by about 0.5 to 1 per cent. There is an increase in married men's labour supply by about 0.2 to 0.5 hour and increase labour force participation by over 1 per cent. For single men, there is a small positive response particularly with regard to labour force participation. Although there is some increase in labour force participation, the labour supply effect is quite small for single women because a substantial number reduce their hours of work.

6 CONCLUSIONS

In this paper, three different specifications of labour supply models for couples, single men, single women and sole parents are compared. The preference parameters for labour supply/leisure time and income and the parameters for fixed costs include observed heterogeneity in the form of the number and age of children in the income unit, age and education of the head and partner (if present), and the place of residence of the income unit.

We start from the basic discrete choice labour supply model that was estimated at an earlier stage and is now underlying the behavioural results in MITTS (Kalb, 2002a).[21] This model is based on the quadratic utility function and allows for the presence of fixed costs associated with working and for heterogeneity in preferences for labour supply and income. A multinomial logit specification is chosen in the discrete choice model with eleven labour supply points for most groups.

The extensions to the above model, estimated here, are the addition of welfare participation as a "choice" and allowing for involuntary non-participation (that is, unemployment).

The results from the different models are broadly similar, with the preference for labour supply highest for people with a high education level, who are in their thirties. The

[21] The results for the basic models presented in the tables in this paper are an updated version of those presented in Kalb (2002a) and they are the parameters that are currently underlying the labour supply responses in the MITTS model.

preference for labour supply is lower for women with children, in particular when the children are young. Finally, the predicted distribution over the different labour supply hours is similar to the actual distribution.

The two specifications which include a parameter for the disutility arising from welfare participation, show that for all groups this parameter is positive and significant. This indicates that there is a (financial or psychological) cost to welfare participation. The inclusion of this parameter could be important in allowing households to decide not to participate in welfare in our simulation analyses. The decision of non-participation is more likely as the amount of benefits for which a household is eligible is lower.

Another important extension which is shown to be relevant is to allow for involuntary unemployment. A certain proportion of non-working individuals would prefer to work, but cannot find employment. Accounting for this involuntary unemployment allows a separation of labour supply and labour demand factors that play a role in the actual employment outcome. This can be used in simulation to analyse the desired labour supply changes. The separate employment equations can be used to analyse the actual labour supply outcomes under alternative labour demand assumptions. The estimated parameters of the employment equation are according to expectations. That is age increases the probability of employment up to about 40 years of age, and a higher education level and living in New South Wales, the territories (probably mostly due to the labour market in the Australian Capital Territory) or a capital city increase the probability of employment.

In using a labour supply model in microsimulation modelling, policy makers would be concerned about the validity of predictions from the model out of sample and after policy changes. A way of getting some information on the validity of results would be to carry out evaluations after new policies have been introduced and compare the outcomes of the evaluation with the predictions of the model. This is not easy, since finding a suitable policy change and data at the right points in time and selecting appropriate comparison groups can be quite complicated. For example, Blundell and Hoynes (2000) and Cai *et al.* (2004) attempt such a comparison and discuss the difficulties they encounter.

APPENDIX A: ADDITIONAL LABOUR SUPPLY MODELS

Table A.1: Estimated Parameters of the Labour Supply Model using the quadratic utility function for single men (5730 observations)

	Basic model[a]		With disutility		With disutility and employment equation	
	Estimated coefficient	z-value	Estimated coefficient	z-value	Estimated coefficient	z-value
Quadratic terms						
Income $\times$*100,000*	-0.0145	-0.55	0.1078	2.17	0.1014	1.44
Labour supply $\times$*100*	-0.4227	-12.65	-0.3786	-10.70	-0.3579	-9.72
Cross product						
Inc. & lab. sup. $\times$*10,000*	-0.5434	-3.89	-1.1997	-8.28	-1.6549	-10.33
Linear terms						
Income $\times$*100*						
constant	0.2348	2.82	0.5336	5.57	0.4758	3.65
Age/10	0.1450	4.25	0.2717	5.06	0.4138	5.35
Age squared/100	-0.0158	-3.64	-0.0308	-4.31	-0.0431	-4.27
Vocational education	0.0218	1.82	0.0310	1.58	0.0325	1.12
diploma	0.0010	0.05	-0.0044	-0.13	-0.0485	-0.92
degree	0.0142	0.76	0.0027	0.09	0.0184	0.38
Labour supply						
constant	0.1456	4.63	0.1276	4.75	0.1425	6.05
Age/10	0.0775	8.24	0.0659	8.44	0.0619	7.90
Age squared/100	-0.0100	-7.82	-0.0087	-8.23	-0.0087	-8.69
Vocational education	0.0168	4.69	0.0140	4.89	0.0118	3.88
diploma	0.0143	2.34	0.0136	2.80	0.0149	2.76
degree	0.0237	4.51	0.0210	4.93	0.0134	2.91
Fixed costs/100						
Constant	16.5559	6.26	9.4290	12.66	6.3840	10.44
Live in capital city	-0.3163	-1.54	-0.2058	-1.38	-0.0075	-0.02
Live in NSW	-0.2851	-1.19	-0.1881	-1.10	0.4097	2.23
Disutility parameter			0.9324	10.53	1.2937	12.48

a Eleven discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 5 hours for people working from 2.5 to 7.5 hours, 10 hours for people working from 7.5 to 12.5 hours, 15 hours for people working from 12.5 to 17.5 hours, 20 hours for people working from 17.5 to 22.5 hours, 25 hours for people working from 22.5 to 27.5 hours, 30 hours for people working from 27.5 to 32.5 hours, 35 hours for people working from 32.5 to 37.5 hours, 40 hours for people working from 37.5 to 42.5 hours, 45 hours for people working from 42.5 to 47.5 hours, and 50 hours for people working more than 47.5 hours.

b Six discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 10 hours for people working from 2.5 to 15 hours, 20 hours for people working from 16 to 25 hours, 30 hours for people working from 26 to 35 hours, 40 hours for people working from 36 to 45 hours, 50 hours for people working more than 45 hours.

Table A.2: Estimated Parameters of the Labour Supply Model using the quadratic utility function for single women (4651 observations)

	Basic model[a]		**With disutility**		**With disutility and employment equation**	
	Estimated coefficient	z-value	Estimated coefficient	z-value	Estimated coefficient	z-value
Quadratic terms						
Income $\times$*100,000*	-0.1257	-1.37	-0.0411	-0.47	-0.0625	-0.57
Labour supply $\times$*100*	-0.2497	-10.44	-0.1804	-7.44	-0.1640	-6.86
Cross product						
Inc. & lab. sup. $\times$*10,000*	-1.8571	-7.29	-2.1584	-12.71	-2.4474	-12.42
Linear terms						
Income $\times$*100*						
constant	0.9137	5.29	0.8347	5.84	0.8645	4.96
Age/10	0.1128	1.42	0.3411	3.93	0.3925	3.87
Age squared/100	-0.0027	-0.26	-0.0370	-3.31	-0.0380	-2.92
Vocational education	-0.0252	-0.67	-0.0336	-0.83	-0.0777	-1.61
diploma	0.0269	0.48	0.0071	0.11	-0.0317	-0.39
degree	0.1487	2.60	0.0845	1.44	0.0032	0.04
Labour supply						
constant	0.0127	0.78	-0.0140	-0.92	0.0215	1.39
Age/10	0.0868	13.14	0.0690	10.85	0.0583	8.12
Age squared/100	-0.0122	-14.16	-0.0098	-11.84	-0.0093	-10.10
Vocational education	0.0047	1.68	0.0041	1.56	0.0068	2.09
diploma	0.0203	5.40	0.0191	4.93	0.0191	3.66
degree	0.0289	7.42	0.0273	6.47	0.0347	5.04
Fixed costs/100						
Constant	4.3908	8.51	3.9545	15.03	3.0092	12.76
Live in capital city	-0.0646	-0.54	-0.0140	-0.15	0.1637	1.65
Live in NSW	0.0527	0.44	0.0384	0.36	0.1414	1.32
Disutility parameter			1.7830	19.22	2.0226	17.75

a Eleven discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 5 hours for people working from 2.5 to 7.5 hours, 10 hours for people working from 7.5 to 12.5 hours, 15 hours for people working from 12.5 to 17.5 hours, 20 hours for people working from 17.5 to 22.5 hours, 25 hours for people working from 22.5 to 27.5 hours, 30 hours for people working from 27.5 to 32.5 hours, 35 hours for people working from 32.5 to 37.5 hours, 40 hours for people working from 37.5 to 42.5 hours, 45 hours for people working from 42.5 to 47.5 hours, and 50 hours for people working more than 47.5 hours.

b Six discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 10 hours for people working from 2.5 to 15 hours, 20 hours for people working from 16 to 25 hours, 30 hours for people working from 26 to 35 hours, 40 hours for people working from 36 to 45 hours, 50 hours for people working more than 45 hours.

Table A.3: Estimated Parameters of the Labour Supply Model using the quadratic utility function for sole parents (1822 observations)

	Basic model[a]		With disutility		With disutility and employment equation	
	Est. coef.	z-value	Est. coef.	z-value	Est. coef.	z-value
Quadratic terms						
Income $\times$*100,000*	-0.5258	-2.47	-0.5755	-2.22	-0.3999	-1.74
Labour supply $\times$*100*	-0.0191	-0.50	0.0194	0.50	0.0595	1.65
Cross product						
Inc. & lab. sup. $\times$*10,000*	-1.2665	-2.25	-1.2930	-2.56	-1.7315	-3.71
Linear terms						
Income $\times$*100*						
constant	1.3075	1.14	1.5489	1.53	1.3418	1.51
Youngest child 0-2 yrs old	0.6228	1.77	0.3055	1.26	0.3594	1.65
Youngest child 3-4 yrs old	0.2582	0.78	0.0254	0.12	0.0259	0.14
Youngest child 5-9 yrs old	0.7317	2.30	0.5297	2.50	0.4960	2.73
Number of children	0.0623	0.72	0.0113	0.16	0.0252	0.38
Age/10	0.3590	0.66	0.5106	1.04	0.4411	1.00
Age squared/100	-0.0447	-0.70	-0.0759	-1.30	-0.0580	-1.07
Vocational education	-0.0797	-0.54	-0.0491	-0.36	-0.1077	-0.87
Diploma or degree	-0.0958	-0.66	-0.1154	-0.79	-0.1379	-0.98
female	0.0123	0.05	0.3085	1.22	0.1911	0.91
Labour supply						
constant	-0.0689	-1.90	-0.0953	-2.43	-0.0877	-2.46
Youngest child 0-2 yrs old	-0.0426	-2.56	-0.0395	-3.01	-0.0423	-3.67
Youngest child 3-4 yrs old	-0.0286	-2.13	-0.0232	-2.10	-0.0250	-2.55
Youngest child 5-9 yrs old	-0.0500	-3.36	-0.0466	-3.95	-0.0420	-4.30
Number of children	0.0007	0.20	0.0021	0.59	0.0011	0.32
Age/10	0.0564	3.45	0.0403	2.25	0.0478	2.87
Age squared/100	-0.0078	-3.87	-0.0054	-2.40	-0.0069	-3.28
Vocational education	0.0183	4.17	0.0182	3.65	0.0187	3.72
Diploma or degree	0.0287	4.74	0.0264	3.56	0.0308	4.10
female	-0.0465	-3.53	-0.0656	-4.23	-0.0555	-4.77
Fixed costs/100						
Constant	2.3612	5.73	2.1806	6.16	1.9402	5.96
Live in capital city	0.0452	0.79	0.0415	0.87	0.0784	1.37
Children 0-4 yrs old	0.0843	0.31	0.1834	1.31	0.2648	1.84
Youngest child 5-9 yrs old	-0.4850	-1.88	-0.3091	-2.36	-0.2451	-1.93
Live in NSW	0.2514	3.39	0.2317	3.89	0.2519	3.61
Female	-0.4964	-1.60	-0.7864	-2.39	-0.6316	-2.25
Disutility parameter			1.1962	9.62	0.9330	7.65

a Eleven discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 5 hours for people working from 2.5 to 7.5 hours, 10 hours for people working from 7.5 to 12.5 hours, 15 hours for people working from 12.5 to 17.5 hours, 20 hours for people working from 17.5 to 22.5 hours, 25 hours for people working from 22.5 to 27.5 hours, 30 hours for people working from 27.5 to 32.5 hours, 35 hours for people working from 32.5 to 37.5 hours, 40 hours for people working from 37.5 to 42.5 hours, 45 hours for people working from 42.5 to 47.5 hours, and 50 hours for people working more than 47.5 hours.

b Six discrete points of labour supply are distinguished for each person: 0 hours for non-participants and people working less than 2.5 hours, 10 hours for people working from 2.5 to 15 hours, 20 hours for people working from 16 to 25 hours, 30 hours for people working from 26 to 35 hours, 40 hours for people working from 36 to 45 hours, and 50 hours for people working more than 45 hours.

Table A.4: Estimated Parameters of the Employment Equations

	Single men		Single women		Sole parents	
	Estimated coefficient	z-value	Estimated coefficient	z-value	Estimated coefficient	z-value
constant	0.2223	1.14	-0.5920	-2.39	-0.4730	-0.61
Age/10	0.4578	3.92	0.9756	6.35	0.4040	0.99
Age squared/100	-0.0588	-3.68	-0.1225	-5.93	-0.0223	-0.42
Vocational education	0.2376	4.37	0.0850	1.17	0.1999	1.61
Diploma[a]	0.3205	3.66	0.3508	3.21	0.3211	2.42
degree	0.6495	7.41	0.4892	5.35		
Victoria	-0.2004	-2.97	-0.0430	-0.51	0.0461	0.30
Queensland	-0.1633	-2.30	-0.1375	-1.57	0.1164	0.73
South Australia	-0.3017	-3.88	-0.3092	-3.18	-0.0329	-0.19
Western Australia	-0.1846	-2.45	-0.0356	-0.35	0.1669	0.95
Tasmania	-0.3932	-4.21	-0.1391	-1.19	0.3441	1.62
The Territories	0.0407	0.40	0.0679	0.51	0.5287	2.34
Capital city	0.1507	3.08	0.2108	3.40	0.1420	1.31

Note a: For sole parents, this variable represents having a diploma or a degree. The two categories are not estimated separately like for the other groups.

REFERENCES

Aaberge, R., Colombino, U. and Strøm, S. (1999) Labour supply in Italy: an empirical analysis of joint household decisions with taxes and quantity constraints. *Journal of Applied Econometrics*, 14, 403-22.

Apps, P.F. and R. Rees (1996). Labour supply, household production and intra-family welfare distribution. *Journal of Public Economics*, 60, 199-219.

— (1997). Collective Labor Supply and Household Production. *Journal of Political Economy*, 105(1), 178-190.

— (2000). Household Production, Full Consumption and the Costs of Children. Discussion Paper no. 157, Institute for the Study of Labor (IZA), Bonn.

Australian Bureau of Statistics (1998), *Consumer Price Index*, catalogue number 6401.0, June quarter.

Bingley, P. and I. Walker (1997). The labour supply, unemployment and participation of lone mothers in in-work transfer programmes. *Economic Journal*, 107, 1375-1390.

Blundell, R. and H. Hoynes (2000). Has 'In-Work' Benefit Reform Helped the Labour Market. preliminary paper prepared for the CEP-IFS-NBER Premier League Meeting, December 8-9, 2000.

Bourguignon, F. and P.-A. Chiappori (1994). The collective approach to household behaviour. in *The measurement of household welfare* ed. by R. Blundell, I. Preston and I. Walker, Cambridge: Cambridge University Press.

Browning, M., F. Bourguignon, P.-A. Chiappori and V. Lechene (1994). Income and outcomes: a structural model of intrahousehold allocation. *Journal of Political Economy*, 102(6): 1067-1096.

Burtless, G. and J.A Hausman (1978). The effect of taxation on labor supply: evaluating the Gary Negative Income Tax experiment. *Journal of Political Economy*, 86(6), 1103-1130.

Cai, L., Kalb, G., Tseng, Y. and Vu, H. (2004), Financial Incentives for Mothers to Enter Paid Work: The Current Tax and Transfer System. Final report for the Department of Family and Community Services.

Callan, T. and A. van Soest (1996). Family Labour Supply and Taxes in Ireland. Discussion paper, mimeo, Tilburg University.

Deaton, A. and J. Muellbauer (1980). *Economics and Consumer Behavior*. New York: Cambridge University Press.

Duncan, A. and Harris, M.N. (2002) Simulating the effect of welfare reforms among sole parents in Australia. *Economic Record*, 78, 249-63.

Duncan, A., and J. MacCrae (1999). Household labour supply, childcare costs and in-work benefits: modelling the impact of the working families tax credit in the UK. Mimeo, *Institute for Fiscal Studies*, London.

Eissa, N. and H.W. Hoynes (1999). The earned Income Tax Credit and the Labor Supply of Married Couples. Discussion Paper no. 1194-99, Institute for Research on Poverty, University of Wisconsin-Madison.

Euwals, R. and A. van Soest (1999). Desired and actual labour supply of unmarried men and women in the Netherlands. *Labour Economics*, 6, 95-118.

Eyland, E.A., C.A. Mason and H.M. Lapsley (1982). Determinants of female employment. *Economic Record*, 58, 11-17.

Fraker, T. and R. Moffitt (1988). The effect of food stamps on labor supply: a bivariate selection model. *Journal of Public Economics*, 35, 25-56.

Gerfin, M. (1993). Simultaneous discrete choice model of labour supply and wages for married women in Switzerland. *Empirical Economics*, 18, 337-356.

Hagstrom, P.A. (1996). The food stamp participation and labor supply of married couples; an empirical analysis of joint decisions. *Journal of Human Resources*, **31**(2), 383-403.

Hausman, J.A. (1979). The econometrics of labor supply on convex budget sets. *Economics Letters*, 3, 171-174.

— (1985). The econometrics of nonlinear budget sets. *Econometrica*, 53, 1255-82.

Heckman, J.J. (1979). Sampled selection bias as a specification error. *Econometrica*, 47(1), 153-161.

Hoynes, H.W. (1996). Welfare transfers in two-parent families: labor supply and welfare participation under AFDC-UP. *Econometrica*, 64(2), 295-332.

Kalb, G. (1999). Labour Supply and Welfare Participation in Australian Two-adult Households; Comparing 1986/1987 with 1994/1995. Working Paper No. BP-34, Centre of Policy Studies, Monash University, Australia.

Kalb, G. (2000). Labour Supply and Welfare Participation in Australian Two-Adult Households: Accounting for involuntary unemployment and the 'cost' of part-time work. Working Paper No. BP-35, Centre of Policy Studies, Monash University, Australia.

Kalb, G. (2002a), "Estimation of Labour Supply Models for Four Separate Groups in the Australian Population", Melbourne Institute Working Paper Series, WP No. 24/02, Melbourne Institute of Applied Economic and Social Research, The University of Melbourne.

Kalb, G. (2002b), Estimation of Alternative Labour Supply Model Specifications for the Australian Population. Final report for the Department of Family and Community Services.

Kalb, G. and Scutella. R. (2002), "Estimation of Wage Equations in Australia: Allowing for Censored Observations of Labour Supply", Melbourne Institute Working Paper Series, WP No. 8/02, Melbourne Institute of Applied Economic and Social Research, The University of Melbourne.

Keane, M. and R. Moffitt (1998). A Structural Model of Multiple Welfare Program Participation and Labor Supply. *International Economic Review*, 39(3), 553-589.

Killingsworth, M.R. (1983). *Labor Supply*. New York: Cambridge University Press.

Laisney, F., M. Lechner, A. van Soest and G. Wagenhals (1992). A life cycle labour supply model with taxes estimated on German panel data: the case of parallel preferences. *Discussion Paper* no. 93-01, Zentrum für Europäische Wirtschaftsforschung GmbH, Labour Economics and Human Resources Series.

Maddala, G.S. (1983). *Limited Dependent and Qualitative Variables in Econometrics*. New York: Cambridge University Press.

Moffitt, R. (1983). An economic model of welfare stigma. *American Economic Review*, **73**(2), 1023-35.

— (1986). The econometrics of piecewise-linear budget constraints: a survey and exposition of the maximum likelihood method. Journal of Business and Economic Statistics, 4(3), 317-328.

— (1990). Taxation and Labor Supply in Industrial Countries. *Journal of Human Resources*, 25(3), 313-558.

Murray, J. (1996). Modelling the labour supply behaviour of sole parents in Australia. In M. McAleer, P.W. Miller and C. Ong, *Proceedings of The Econometric Society Australasian Meeting 1996*, 4: Microeconometrics. Perth: University of Western Australia, 507-546.

Ross, R.T. (1986). Analysis of the 1980 Sydney Survey of Work Patterns of Married Women: further results. *Economic Record*, 62, 325-337.

Van Soest, A. (1995). Structural models of family labor supply; a discrete choice approach. *Journal of Human Resources*, 30(1), 63-88.

Van Soest, A., A. Kapteyn and P. Kooreman, (1993). Coherency and regularity of demand systems with equality and inequality constraints. *Journal of Econometrics*, 57, 161-188.

Van Soest, A., M. Das and X. Gong (2002). A structural labour supply model with flexible preferences. *Journal of Econometrics*, 107, 345-374.