New Zealand Labour Supply from 1991-2001: An Analysis Based on a Discrete Choice Structural Utility Model

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Abstract

This paper presents results for four separately estimated sets of discrete choice labour supply models using the Household Economic Surveys from 1991/92 up to 2000/01. The New Zealand working-age population is divided into sole parents, single men, single women, and couples. The labour supply models use imputed wages for the non-workers. Some of the preference parameters for work and income are made dependent on personal and household characteristics to allow for heterogeneity in preferences among households. In addition, allowance is made for unobserved heterogeneity in preferences. The estimated parameters for the different groups are used to calculate confidence intervals for expected labour supply and the probability of working at the different discrete hours points. The effect of particular characteristics on labour supply is illustrated by computing marginal effects across the samples. The wage elasticities fall within the range of values found in other studies.

Expected labour supply, predicted by using the estimated models, results in values close to the observed averages and confidence intervals around the expected values are reasonably narrow in most groups. The results are as anticipated and similar to results in other countries, with preferences for work being higher for people with higher education, who are in their thirties. Furthermore, for women the presence of young children decreases the preference for work. In addition to these variables, which are usually included in labour supply models, the "eligibility for New Zealand Superannuation" indicator and a "living with parents" indicator are included. For all groups, the delayed eligibility for the state provided superannuation scheme is found to increase labour supply. The indicator for living with one's parents is found to increase labour supply for sole parents (indicating that living with one's parents may be a childcare strategy), although the effect was not significant.

JEL CLASSIFICATION C25
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KEYWORDS New Zealand labour supply; discrete choice labour supply model; simulated maximum likelihood; simulated confidence intervals

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1 Introduction

This paper describes in detail the estimation of preference functions for hours of work and income for four subgroups of the New Zealand population, from which the expected hours of labour supply can be derived. The groups are the following: couples with and without children, single men, single women, and sole parents. Each of these groups is relatively homogenous and we specify one separate utility function for each group. The four groups together add up to a sample representing the New Zealand working-age population.

No individual structural labour supply models have been estimated for New Zealand. Chiao and Walker (1992) estimated a discrete choice model using four earnings levels instead of a choice model based on different levels of labour supply and Maloney (2000) estimated a reduced form labour supply and participation equation based on average labour supply and participation of groups of individuals with similar characteristics. The lack of information on earnings in the data he used complicated his analysis.

The model in this paper allows for the presence of fixed costs associated with working and for observed and unobserved heterogeneity in preferences for labour supply and income. A similar specification has been estimated for Australia (Kalb, 2002) allowing a comparison with the results from New Zealand. In addition, the estimation of similarly specified models for different groups allows us to compare the effect of characteristics on labour supply across the different demographic groups.

The emphasis of the basic framework is on the separation of income into different categories and on a correct representation of net income at all levels of gross income, taking taxes and benefit withdrawal rates into account. This results in a highly nonlinear and non-convex budget set which differs for each individual. Estimation of a continuous labour supply model for two persons, using this budget constraint, is complicated and computationally intensive, which is one of the reasons to discretise labour supply for all groups.[1] This simplification with regard to hours of work allows us to take the full details of the benefit and tax system into account. Following Van Soest (1995), we use a multinomial logit specification in the discrete choice model, which allows us to choose a relatively large number of labour supply points for both adults in the household.

The models estimated in this paper can be used to simulate the behavioural effects of policy changes, as long as these policy changes are of a financial nature, affecting net

[1] There has also been some evidence that a discrete presentation can be a more accurate representation of actual labour supply compared to a continuous specification (Van Soest, Woittiez and Kapteyn, 1990; Tummers and Woittiez, 1991). Often only a limited number of discrete hours points are available to people looking for employment.

household income levels, such as for example, a change in the withdrawal rate of a benefit payment, a change in the level of payment or a change in eligibility rules. For a policy simulation, the model is usually calibrated to make sure that the prediction in the starting situation is equal to the observed situation.

Section 2 briefly discusses the economic model. Section 3 describes the data. Section 4 contains the econometric details. 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 is presented. Finally, in Section 6 some conclusions are presented.

2 The Economic Model

2.1 Utility Maximisation

In the model chosen in this paper, 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 are available, which incorporate perhaps more realistic assumptions on utility maximization in the household or allow for home production to enter the model independently, these models would introduce additional complications[2]. To estimate a model where all household members have their own utility functions, 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. Therefore 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, rather than 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 retaining the complexity of the tax and transfer system would be very difficult.

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. Given the aim of incorporating the details of the tax and transfer system in the labour supply model, this literature is followed.

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 the households utility. Their utility depends on household consumption (which is assumed to be equal to net household income x[3]), on the amount of leisure time of adult 1, and the amount of leisure time of adult 2.

2 See for example, Bourguignon and Chiappori (1994), Browning et al. (1994), and Apps and Rees (1996, 1997, 2000).

3 There is no provision in the model for intertemporal transfers of money. However, the payout of dividends on investments and the payout of interest on savings in the current period are included in the "other income" variable.

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 utility function chosen, this approach allows for direct interdependencies between the two adults' labour supply or one adult's labour supply and household income. 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.

With regard to the assumption of free choice underlying this economic model; 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 rather than actual hours of work or to allow for the restrictions in actual hours caused by the demand for labour (see for example Euwals and Van Soest (1999) or Euwals (2001)). However, the information necessary to do this is not available in the data.

A simple utility maximizing model would look as follows:

$$\max U(x, l_1, l_2) \tag{1}$$

subject to:

$$T = l_1 + h_1 = l_2 + h_2$$

$$x = g(h_1, h_2) + n(y_1) + n(y_2) + n(B(c))$$

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,

$g(h_1,h_2)$ is the net income 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,

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

5 See for example, Laisney et al. (1992), Bingley and Walker (1997) or Duncan, Giles and MacCrae (1999).

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

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

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 first two restrictions are substituted in the third equation, the budget constraint may be written:

$$x + g(T - h_1, T - h_2) = g(T, T) + n(y_1) + n(y_2) + n(B(c)) \quad (2)$$

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

$$\max \quad U(x, l_1) \quad (3)$$

subject to:

$$T = l_1 + h_1$$

$$x = g(h_1) + n(y_1) + n(B(c))$$

Or combining the two restrictions:

$$x + g(T - h_1) = g(T) + n(y_1) + n(B(c)) \quad (4)$$

2.2 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). Estimating wages and labour supply simultaneously is computationally more demanding 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, 2003). For each non-participant we impute an expected value for the wage rate in the labour supply model. Some observed values for wage income seem unrealistically small when compared to the corresponding hours worked. In the estimation of the labour equation in this paper, the observed wage level for all persons earning less than half the minimum wage or more than $100 per hour have been replaced by the predicted value[8] as such low and high values seem likely to be due to measurement error[9]. Over the years the minimum wage levels varied. See Table A.1 in the appendix for the relevant minimum wage levels.

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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. An alternative approach is to use imputed values for all individuals in the sample.

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

8 17 sole parents, 51 single men, 27 single women, 71 married men and 132 married women fall into this group.

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

3 The Data

The Household Economic Surveys 1991-92 to 2000-01, all released by Statistics New Zealand (NZSTATS), have been used for the analyses. These surveys were released on a yearly basis from 1991/92 to 1997/98, but are currently undertaken only once every three years. The survey collects information on the sources and amounts of income received by persons resident in private dwellings throughout New Zealand, along with data on a range of characteristics for all individuals within the household. Individuals in each household are linked by a household number and family number, so that household characteristics such as income and the number and age of children can be derived by using information from other records in the same household. The detailed information on income allows the budget constraint to keep its full complexity. In order to combine the ten years into input for one model, the monetary variables from 1991/1992 to 2000/2001 are converted to the December 2001 level[10]. Furthermore, the observed nominal wages in these survey years are adjusted by the average wage increases for men or women as relevant.

The survey is held continuously over the year with around 2000 individuals interviewed every quarter during the financial year, except for 1992/93 when over 3000 individuals were surveyed per quarter. In the surveys from 1991/92 to 2000/01, information is available for 68,711 individuals.

3.1 Selection Criteria

In this section, the selection criteria to be included in the sample of analysis are discussed for each of the four groups.

The criteria for the *first* group, work-age couples, are the following:

- Only income units that consist of a man and a woman with or without dependants are included.[11]
- Self-employed are excluded from the analyses. 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 65 years and over, who are eligible for government age pensions in the current system, are excluded. They are expected to behave differently from younger people. In the earlier survey years, individuals were eligible for the New Zealand Superannuation at the younger age of 60 years, but this was gradually increased to 65 years of age[12]. This change during the survey period provides an

[10] For this the quarterly Consumer Price Index as published by Statistics New Zealand is used.

[11] There are 9 same-sex couples which are excluded because they are expected to behave differently in the labour market compared to the other couples.

[12] This is a universal state-provided pension for all New Zealand residents over a certain age, which is not income tested. The age of eligibility changed over time in quarters of years. The data only report the age in full years, which means the eligibility for superannuation is not certain for some individuals. In those cases where the eligibility is uncertain we represent eligibility by a value of 0.25 if the age of eligibility at the time of observation is for example 61.75 and the observed age is 61. Eligibility is represented by a value of 0.75 if the age of eligibility is for example 63.25 and the observed age is 63. For individuals who are eligible with certainty, that is the observed age is more than the age of eligibility, eligibility is represented by 1, whereas eligibility is represented by 0 for those individuals who are ineligible.

opportunity to examine the effect of this policy change on the preference for work of individuals aged between 60 and 64.

- All people temporarily or permanently unable to work because of illness or disability are excluded from the analysis.

- All full-time students are excluded.

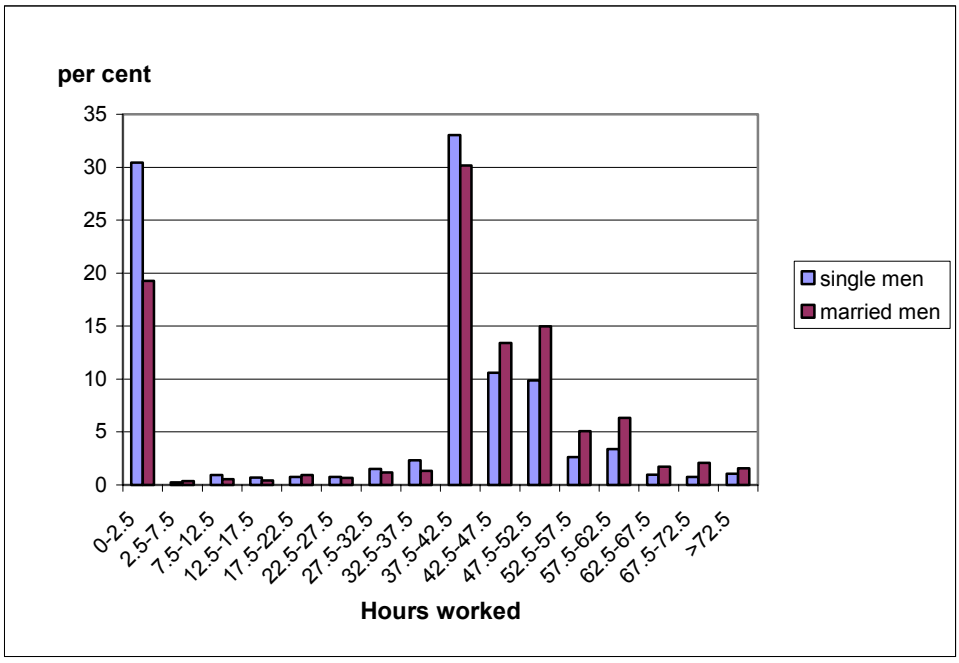
The criteria for the *second* group, working-age single men, are the same as above with the first criterion replaced by income units that consist of one adult man without dependants. The criteria for the *third* group, working-age single women, are also the same as above but with the first criterion replaced by income units that consist of one adult woman without dependants. Finally, the criteria for the *fourth* group, working-age sole parents, are the same as above with the first criterion replaced by income units that consist of single adults with dependants.

Missing values or outliers (which may be measurement errors) result in the deletion of a few additional households, all households who have zero net income or more than 4000 dollars at zero hours of work are excluded[13]. After this selection, a data set of 10250 couples is left for the labour supply analysis in group 1; 5671 single men in group 2; 4596 single women in group 3; and 1822 sole parents in group 4.

3.2 Distribution of hours worked

Hours of work is the dependent variable in this analysis. Figures 1 and 2 give frequency distributions of male and female working hours in the samples for the different groups. The difference between men and women is as expected. Relatively more women work part time and more men work full time (especially over 42.5 hours per week) in the different subsamples. There is also a clear difference between singles and couples.

Figure 1 – *Labour supply of men*

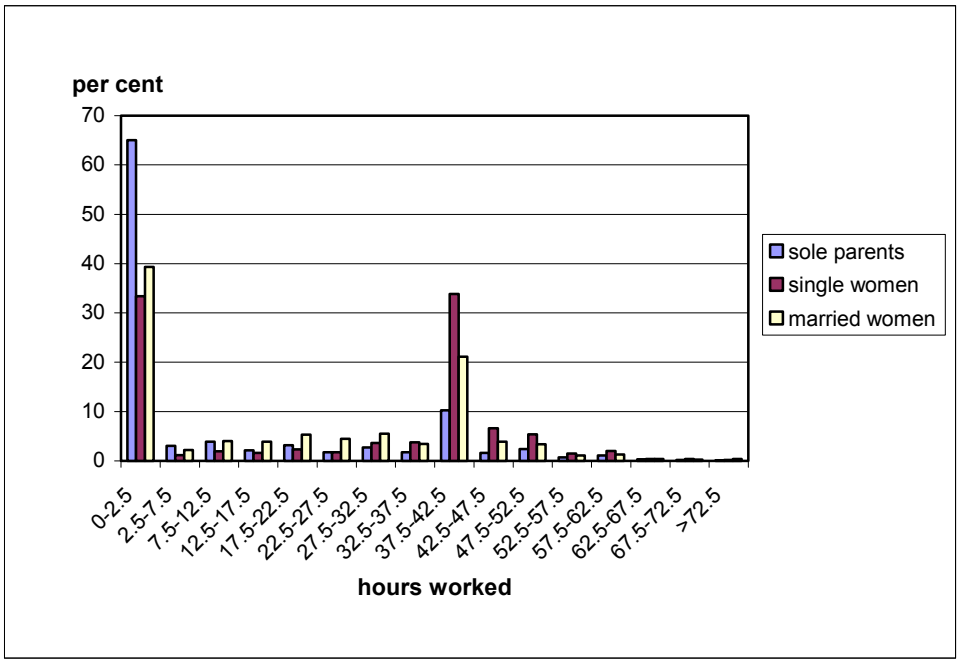


[13] 0 sole parents, 26 single men, 19 single women and 21 couples fall into this group.

Single men are more likely to be non-participants 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 2 shows that single and married women have different hours distributions. 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 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 relatively few hours.

Figure 2 – *Labour supply of women and sole parents*



3.3 Variables used in the Analyses

The variables explaining the hours of work are wage and other income, which enter the utility function in Section 2 directly, and personal and household characteristics, which affect the hours of work through the preference parameters for income and work. For example, women with young children are expected to have a lower preference for paid work. Table 1 gives summary statistics of the independent variables used in the analyses (averaged over the whole period). The selection of variables is based on findings in previous studies, (a priori) expectations and the available data. The background characteristics used to specify preferences in the utility function are listed below.

Age is observed in years. 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 a U-shaped relationship with age where the preference for leisure is reduced at first, followed by an increase in the preference for leisure after a certain age. Thus, younger and older persons are expected to have a higher preference for leisure.

Table 1 – Summary Statistics for the combined Household Economic Survey from 1991/92 to 2000/01

	married men	married women	single men	single women	sole parent
Average wage rate (if working)[a]	16.8786	12.8516	12.5321	12.3796	12.8554
Employment rate	0.8080	0.6104	0.6959	0.6678	0.3549
Average hours worked	37.2860	20.0629	30.2209	25.6088	10.7802
Woman					0.8805
age/10	4.1664	3.9132	3.0811	3.5310	3.4584
Education					
No qualification	0.2712	0.3060	0.2927	0.2808	0.4602
School certificate	0.1417	0.2199	0.1897	0.1820	0.2028
Bursary	0.0858	0.1205	0.1705	0.1725	0.0760
Vocational/trade certificate	0.3194	0.2097	0.1963	0.1682	0.1598
Bachelor degree/diploma	0.1058	0.0841	0.0830	0.1109	0.0389
Post-graduate qualification	0.0427	0.0250	0.0273	0.0327	0.0147
Part degree/other qualification	0.0186	0.0195	0.0215	0.0310	0.0229
Region of residence					
North North island	0.1738		0.1662	0.1491	0.2120
Auckland	0.2879		0.2968	0.3102	0.2711
Central north island	0.1375		0.1348	0.1254	0.1726
Wellington	0.1410		0.1409	0.1592	0.1172
Canterbury	0.1252		0.1176	0.1294	0.1177
South island	0.1345		0.1437	0.1268	0.1094
Number of children	1.1490[b]				1.7880
Age of youngest child is 0	0.0803				0.0952
Age of youngest child is 1 to 3	0.1577				0.2756
Age of youngest child is 4 to 5	0.0657				0.1282
Age of youngest child is 6 to 9	0.1012				0.2010
Age of youngest child is > 9	0.0671				0.1250
Living with parents			0.3781	0.2825	0.0691
Eligibility for NZ superannuation	0.0504	0.0201	0.0254	0.0575	0.0060
Aged 60 or over	0.0835	0.0375	0.0406	0.0905	0.0082
Quarterly unemployment rate by gender	8.5548	7.7923	8.6401	7.8696	7.8966
Number of observations	10028		4650	4220	2184

Note a: These averages are somewhat different from those reported in Kalb and Scutella (2003), because a few additional observations have been excluded in the selections for this analysis. The largest difference between the two sets of summary statistics is observed for couples, because complete information on all variables is needed for *both* members of the couple whereas this was not necessary in the wage and participation rate analysis.

b: 2.0753 when only couples with children are included.

Education is divided into the following categories:

- no qualifications
- school certificate
- bursary, scholarship or University Entrance (UE), which all three refer to qualifications obtained by 18yr olds (usually) at the end of secondary school.
- vocational or trade qualifications
- part degree or other qualification

- bachelor's degree or diploma
- postgraduate qualification

Comparing the education levels of the five demographic groups, we observe that married men and single women have the largest proportion with at least a bachelor's degree and the lowest proportion of persons without qualifications. Sole parents have the lowest level of education. 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 is associated with an increase in the preference for labour supply and Duncan and MacCrae (1999) find that leaving school at 16 years of age is associated with a decrease in 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.

The *number of dependent children* in each income unit consists of the number of dependent children from 0 to 18 years old. This variable is expected to be of particular importance for females, married or single. Children are likely to increase the value of time at home, which is reflected in a higher preference for leisure in the model.

From the surveys, the *age of the youngest dependent child* in the income unit can be derived. The effect of dependent children on the preference for time spent in work 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 strongest 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).

Region of residence are location variables for where the individual/household lives in New Zealand. It is expected that the fixed cost of working is different for people in or outside the larger cities and in or out of more remote areas, in particular for people with children who may need childcare services (Duncan and Harris, 2002).

Living with parents is an indicator variable used for singles and sole parents to indicate that they live with their parent(s). For sole parents, this could indicate a childcare opportunity that would enable them to work. For this reason, we expect this variable to influence the preference for work. In the case of singles, the cost of living is much lower when living with their parents and additional income may be received from the parents. As a result, it is expected that the preference for income is lower for singles living with their parents.[14]

The survey period includes an interesting policy change. In 1991, at the start of the survey period eligibility for the New Zealand Superannuation started at 60 years of age. During the ten years this age of eligibility gradually increased until it was 65 at the end of the

[14] A small group of individuals living with their parents is relatively old. This group may live with their parents so that they can take care of them.

survey period in April 2001. We expect this delayed eligibility to affect the preference for work. For this reason, an indicator variable *eligibility for New Zealand Superannuation* is included in the preference for work parameter. This change in eligibility only affects individuals who are aged between 60 and 65 years. Although a linear and quadratic term for age are already included, an additional dummy for age is introduced for those aged 60 or over to avoid picking up the effect of being in this age category when examining the effect of the changed eligibility.

Given the long time period over which data are available and the changes, in particular for female labour force participation, which occurred over this time, the inclusion of a *time trend* in the work preference parameter may capture these changes. It may also allow us to more accurately measure the effect of eligibility for New Zealand Superannuation. However, at the same time business cycles are occurring which may influence the availability of work. Although strictly speaking the *unemployment rate* does not belong in the labour supply model, it can be argued (particularly for sole parents and married women) that high unemployment discourages individuals trying to find work. We believe that including an unemployment measure (by gender and quarter) assists to identify a purer time trend.

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. The two-adult income units containing two adult men or two adult women have been excluded from the analysis. 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, 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. First, we examine the implications of nonlinear and non-convex budget sets in Section 4.1. Section 4.2 discusses the utility function and Section 4.3 describes how expected labour supply can be derived using the estimated model.

4.1 Allowing for Nonlinear and Non-convex Budget Sets

Including taxes and benefits for two persons in budget constraints produce highly nonlinear constraints. Looking at the benefit and tax regimes between 1991 and 2001 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 potential worker is considered at a time, the labour supply estimation is already quite complex[15]. The complexity is even greater in the case where income units with two potential workers are analysed, subject to their joint budget constraint.

[15] See for example Burtless and Hausman (1978), Hausman (1979), Hausman (1985) or Moffitt (1986) for a continuous labour supply approach with a nonlinear (non-convex) 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, Giles and MacCrae, 1999; Keane and Moffitt, 1998) facing the same problem, appears an attractive solution.[16] 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.

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 $h_1 \in A = \{0, h_{11}, h_{12}, ..., h_{1m}\}$ and $h_2 \in B = \{0, h_{21}, h_{22}, ..., h_{2k}\}$ on the interval [0,T]. 0, h_{11}, h_{12}, and etcetera represent the discrete values that labour supply can take. Using these sets, 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). The static microsimulation model at New Zealand Treasury, TaxMod, can be used to calculate net income at all chosen discrete labour supply points in the different survey years. It is assumed in these calculations that all benefits, for which the household is eligible, are taken up. 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.

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 earlier data sets are inflated up to the 2001 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 considered to be exogenous in this model. The model becomes:

$$\max \; U(x, l_1, l_2) \tag{5}$$

subject to:

$$l_1 + h_1 = T$$
$$l_2 + h_2 = T$$
$$\text{where } (h_1, h_2) \in A \times B$$

$$x = w_1 h_1 + w_2 h_2 + y_1 + y_2 + B(c, w_1 h_1 + w_2 h_2 + y_1 + y_2) - \tau(B(c, w_1 h_1 + w_2 h_2 + y_1 + y_2), w_1 h_1 + w_2 h_2 + y_1 + y_2) \tag{6}$$

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

A and B are the sets of discrete points from which values can be chosen for h_1 and h_2,

[16] A more extensive introduction of the estimation and specification of discrete labour supply models can be found in Creedy and Kalb (2003).

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

$\tau(.)$ is the tax function that indicates the amount of tax to be paid.

Adding an error term to the utility function allows for optimization errors made by the household, preventing contributions to the likelihood in any data point from becoming zero. 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 observed 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:

$$\Pr \{U[x((h_1, h_2)_r), (h_1, h_2)_r, \varepsilon_r] \geq U[x((h_1, h_2)_s), (h_1, h_2)_s, \varepsilon_s] \text{ for all s}\} \quad (7)$$

where:

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

s stands for all (k+1)×(m+1) possible combinations that can be made, given the discrete choice sets for hours worked,

ε_r and ε_s represent error terms.

Choosing an Extreme Value specification for the error term in (7) 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:

$$P_{i'j'} = \frac{\exp(U_{i'j'})}{\sum_{i,j} \exp(U_{ij})} \quad (8)$$

Taking the logarithm of this probability, the log likelihood contribution for couples looks as follows:

$$\log L = \log(P_{i'j'}) = U_{i'j'} - \log\left(\sum_{i,j} \exp(U_{ij})\right) \quad (9)$$

where:

i indicates the husband's labour supply;

j indicates the wife's labour supply;

i', j' are the preferred (observed) states of labour supply (combination r in equation 7);

U_{ij} is the level of utility derived from the state where the husband has labour supply i and the wife has labour supply j.

Expression (8) denotes the probability that the utility in the observed combination of hours is higher than the utility in any other situation. The log likelihood function for all households in the sample is formed by summing all individual contributions. 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 equation (8) simplifies to:

$$\log L = \log(P_{i'}) = U_{i'} - \log\left(\sum_i \exp(U_i)\right) \tag{10}$$

4.2 Specification of Utility Functions

The form of the utility function used here is a quadratic specification (following Keane and Moffitt, 1998). This specification is simple but flexible in that it allows for the leisure of each person and income (or 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 two simple conditions, outlined in Van Soest (1995), can be used to establish whether U is quasi-concave at any data 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 have to be imposed a priori to guarantee coherency, as has been mentioned earlier.

Many earlier models had the problem of overpredicting part-time hours and underpredicting non-participation. An intuitively appealing approach is to include a fixed 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 utility derived from leisure and income can be written as:

$$\begin{aligned} U(x,h_1,h_2) = {} & \beta_x(x-\gamma_1-\gamma_2)+\beta_1 h_1+\beta_2 h_2+\alpha_{xx}(x-\gamma_1-\gamma_2)^2+\alpha_{11}(h_1)^2+\alpha_{22}(h_2)^2+ \\ & \alpha_{x1}(x-\gamma_1-\gamma_2)h_1+\alpha_{x2}(x-\gamma_1-\gamma_2)h_2+\alpha_{12}h_1h_2 \end{aligned} \tag{11}$$

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

This 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 (described in Section 3.2). Simple linear specifications are chosen to include the observed heterogeneity in β_1, β_2, β_x, γ_1 and γ_2.

As an alternative to the individual characteristics in the fixed-cost-of-working parameters, we also estimated separate cost parameters for the different labour supply levels. This is equivalent to making the parameter dependent on the number of hours of work. Instead of specifying a single parameter for all hours of work, separate parameters are introduced for

categories of hours. Here parameters are specified for 1 to 10 hours of work, 11 to 20 hours of work, 21 to 30 hours and over 30 hours of work. In addition to allowing for the fixed cost of working, this specification also allows for different costs associated with different hours levels, such as for example the cost of part-time work which may be high if few jobs in this category are available, because a larger search effort is then required.

Adding unobserved heterogeneity to the linear equations in personal characteristics for the preference and fixed-cost-of-working 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. It is straightforward to obtain a simulated mean by: drawing error terms from the distribution based on the current parameter estimates for the covariance matrix for each observation in the sample; calculating the log likelihood function based on these draws; and averaging the log likelihood function over a certain number of draws. Van Soest found that 10 draws seemed sufficient, so the estimation of unobserved heterogeneity in this paper is carried out with the same number of draws.

4.3 Expected Labour Supply

Once the model has been estimated, the results can be used to calculate the expected labour supply from the probabilistic outcomes 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 $U(x(h_1,h_2), h_1, h_2)$ 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) along with 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:

$$p(h_1,h_2) = \frac{exp(U(x(h_1,h_2),h_1,h_2))}{\sum_{\substack{over\ all \\ h_1,h_2}} exp(U(x(h_1,h_2),h_1,h_2))} \tag{12}$$

These probabilities can 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 for each value of h_1. In this manner, the marginal probability of h_1 is obtained, which can be used to calculate the expected value of h_1 in the usual way. The formula for this procedure looks as follows:

$$E(h_1) = \sum_{h_1}\left[\left(\sum_{h_2} p(h_1,h_2)\right)h_1\right] \tag{13}$$

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

5 Results

Parameters of the preference functions are estimated using imputed wage values for non-workers as described in Section 2.2. The next subsection presents the results of the labour supply models for both couples and single adult units. 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 Estimated Parameters

To show how the results of a model as discussed in section 4 are interpreted, we first discuss the parameters of two-adult income units. Table 2 gives the parameter estimates of the quadratic specification of the utility function for a model with six discrete labour supply points for men and eleven points for women. The location of the points is defined in a footnote to the table.

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-percent level.

To begin with the parameterised preference for work for the male adult, a significant positive effect[17] 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 around 36 years of age after which it decreases with age. Thus young men and older men have a lower preference for labour supply. A positive effect is further observed for households where the man has a higher level of education. The partner's education tends to increase male labour supply as well, with the exception of partners with a postgraduate degree, the presence of which decreases the preference for work. There also seems to be an increase in the preference for work over time even after controlling for unemployment levels. It may be partly due to the change in the age of eligibility for the New Zealand Superannuation. This effect may not have been completely captured by the approximating variable constructed by us. None of the variables related to the number and age of dependent children in the household influence the preference for work.

The current unemployment rate amongst men has a negative effect on the preference for work. This is probably mostly due to involuntary unemployment but it could also be partly due to a discouraged worker effect, as may for example be reflected in early retirement decisions. Being older than 60 years of age has a negative effect in addition to the negative age squared term. More interestingly however, those who are eligible for the New Zealand Superannuation clearly have a lower preference for work than others even after controlling for being over 60.[18] The policy change has had a substantial effect. There

[17] This indicates a higher preference for work and thus a smaller taste for leisure.

[18] This parameter is a mixture of the effect of superannuation income and a change in preferences directly caused by the eligibility for New Zealand Superannuation. The HES data does not provide enough detail on age to determine eligibility for all individuals with certainty in TaxMod. As a result, net income cannot be determined with certainty at all discrete labour supply points and thus the effect of eligibility per se and the effect through changed net incomes cannot be separated completely.

even seems to be some effect from the partner's eligibility as well, which is however only significant at the 10-percent level.

Table 2 – Estimated Parameters of the Utility Function for Couples [a]

	Estimated coefficient	z-value[b]
Quadratic terms		
income× 100,000	-0.0177	-4.13
Labour supply husband × 100	-0.4990	-17.06
Labour supply wife × 100	-0.1339	-16.48
Crossproduct		
Inc. & lab. Sup. Husband × 10,000	-0.3826	-12.59
Inc. & lab. Sup. Wife × 10,000	-0.1930	-9.76
labour supply Husband & wife × 100	-0.0728	-11.52
Linear terms		
Income ×100		
constant	0.5215	20.13
Number of children	-0.0030	-1.20
Labour supply husband		
constant	0.2945	12.23
Youngest child <1 yr old	0.0039	1.31
Youngest child 1-3 yrs old	0.0036	1.49
Youngest child 4-5 yrs old	0.0005	0.16
Youngest child 6-9 yrs old	0.0033	1.23
Number of children	-0.0012	-1.09
Age/10	0.0487	8.94
Age squared/100	-0.0067	-9.79
Vocational education	0.0165	9.87
Certificate	0.0125	5.93
Bursary/scholarship	0.0135	4.96
Postgraduate degree/other	0.0127	2.41
Bachelor degree	0.0180	5.96
Postgraduate	0.0213	4.50
Vocational education (partner)	0.0020	1.07
Certificate (partner)	0.0076	4.31
Bursary/scholarship (partner)	0.0108	4.40
Postgraduate degree/other (partner)	0.0020	0.39
Bachelor degree (partner)	0.0017	0.52
Postgraduate (partner)	-0.0146	-2.68
Time trend	0.0009	2.12
Quarterly male unemployment rate	-0.0016	-2.89
Aged 60 or over	-0.0078	-2.01
Eligible for New Zealand Superannuation	-0.0236	-5.13
Partner is eligible for New Zealand Superannuation	-0.0096	-1.79
Labour supply wife		
constant	0.0465	3.33
Youngest child <1 yr old	-0.0637	-11.62
Youngest child 1-3 yrs old	-0.0672	-18.67
Youngest child 4-5 yrs old	-0.0584	-12.90
Youngest child 6-9 yrs old	-0.0383	-11.56
Number of children	-0.0058	-6.54
Age/10	0.0385	7.07
Age squared/100	-0.0064	-9.22
Vocational education	0.0201	10.17
Certificate	0.0133	7.12

Table 2 – Continued [a]

	Estimated coefficient	z-value[b]
Bursary/scholarship	0.0164	7.22
Postgraduate degree/other	0.0277	5.72
Bachelor degree	0.0298	9.69
Postgraduate	0.0410	7.81
Vocational education (partner)	-0.0081	-4.58
Certificate (partner)	-0.0039	-1.77
Bursary/scholarship (partner)	-0.0042	-1.58
Postgraduate degree/other (partner)	-0.0123	-2.42
Bachelor degree (partner)	-0.0189	-7.07
Postgraduate (partner)	-0.0226	-5.76
Time trend	0.0006	1.41
Quarterly female unemployment rate	-0.0009	-1.20
Aged 60 or over	-0.0034	-0.54
Eligible for New Zealand Superannuation	-0.0268	-2.58
Partner is eligible for New Zealand Superannuation	-0.0017	-0.45
Fixed cost husband/100	18.7221	14.50
Fixed cost wife/100		
Constant	8.0863	18.81
Youngest child <1 yr old	1.3763	3.20
Youngest child 1-3 yrs old	-0.7997	-2.97
Youngest child 4-5 yrs old	-1.7622	-4.92
Youngest child 6-9 yrs old	-1.8085	-6.02
Live in Wellington/Auckland	0.0962	0.78
Unobserved heterogeneity		
Variance in income parameter	0.0000	0.33
Variance in husband's labour supply	0.0000	0.00
Variance in wife's labour supply	0.0000	0.00
Variance in wife's fixed cost	0.0030	0.46
Log likelihood	-30565	

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 indicates the level of significance of the estimated coefficients. A value of 1.96 or more means that the parameter is significantly different from zero at the 5% level at least. The higher the z-value the more precise the estimated coefficient.

According to expectation, the preference for work of the female adult seems to be lower than that of her male partner, at least as far as this is reflected in the size of the constant term of β_2. A significant positive effect is observed for women with higher education levels. The effect of education seems more important for women than for men. This could be caused by the fact that almost all men 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. From the linear and quadratic age parameters it can be derived that the maximum preference for work is around 30 years of age.

All variables relating to children have a significant negative effect on a married woman's preference for work. The effect for children between six and nine years old is much smaller than for younger children. As expected, and as is seen in many other studies (Australian examples are Eyland, Mason and Lapsley, 1982; Ross, 1986; Murray, 1996; and Kalb, 2002), having a pre-school child under four years of age has a large negative effect on the female preference for work. Children of primary school age affect the mother's preference for work to a smaller extent. Finally, women with more children have a lower preference for work.

Similar to the effect for men, the eligibility for the New Zealand Superannuation clearly affects women's preferences for work as well. The partner's eligibility seems irrelevant for women.

To keep the model manageable the preference for income only depends on the number of children, which was significant for Australian data (Kalb, 2002). Similar to the Australian case a lower preference for income is estimated with an increase in household size, but the effect is not significant.[19]

The results for single men, single women and sole parents are presented in Table 3 and are discussed more briefly. Comparing the effects found for couples with those for singles and sole parents, similar variables are found to be important. High education levels increase the preference for work for all groups. The effect on the preference for income is less clear; higher education levels increase the preference for some whilst decreasing it for others.

The effect of age on the preference for work for single men is similar to that for married men. The preference is at a maximum around 35 years of age. Furthermore, single women's maximum preference for work occurs around 29 years of age, which is close to the age at which this occurs for married women. For sole parents, neither age nor age squared are significant. Similar effects are found for Australia (Kalb, 2002).

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, for sole parents the effect decreases much less than for married mothers when the youngest child's age increases, with the exception of moving from having a newborn child to having a 1 to 3 year old child (the effect of having a newborn child is not significant however). On the other hand, their preference for income is also at its highest when they have children in this age group, but this effect is insignificant as well.

The time trend is nearly significant for sole parents, indicating an increase in the preference for work over time, similar to the effect for married men and women. The unemployment rate is nearly significant for single men. Eligibility for the New Zealand Superannuation is significant for all groups and it reduces the preference for work, as it did for married men and women.

The models for one-adult households include an additional variable, which indicates whether the individual lives with one or both parents. Surprisingly, the effect is only significant for single men and the sign is opposite to expectations. The preference for income is higher when a single man lives with his parents. Perhaps this picks up a motivational effect where individuals who have a high preference for income, are more likely to be frugal and save for future events, which can be achieved by living at home with their parents and thus saving on living expenses. The effect for single women is positive

[19] This negative effect is likely to be a spurious relationship reflecting the often-observed correlation between low income and the number of children, which may be driven by similar household and personal characteristics.

as well but insignificant. Although insignificant, the coefficient in the preference for work parameter has the expected sign for sole parents, indicating a larger preference for work when living with one's parents, possibly because of the potential childcare that can be provided by the parents.

Table 3 – Estimated Parameters of the Utility Function for One-Adult Households

	Single men		Single women		Sole parents	
	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]
Quadratic terms						
Income × 100,000	-0.1747	-2.98	-0.4846	-5.33	-0.0448	-0.94
Labour supply × 100	-0.2998	-8.46	-0.2600	-10.37	-0.0222	-0.96
Cross product						
Inc. & lab. sup. × 10,000	-1.4016	-9.11	-1.5650	-7.47	-0.1917	-1.07
Linear terms						
Income × 100						
constant	1.0377	5.30	2.0119	7.75	0.6118	2.55
Youngest child <1 yr					1.1686	1.24
Youngest child 1-3 yrs old					0.0384	0.55
Youngest child 4-5 yrs old					0.0624	0.98
Youngest child 6-9 yrs old					-0.0069	-0.20
Number of children					0.0161	1.48
Age/10	0.1990	2.17	0.0032	0.03	-0.1205	-1.83
Age squared/100	-0.0171	-1.35	0.0016	0.10	0.0152	1.78
Vocational education	-0.1123	-2.39	-0.0462	-0.69	-0.0549	-1.86
Certificate	-0.0899	-2.16	-0.0242	-0.36	-0.0483	-1.77
Bursary/scholarship	-0.1833	-4.08	-0.1340	-1.94	-0.0142	-0.54
Postgraduate degree/other	-0.2291	-2.80	0.1177	0.96	-0.0239	-0.44
Bachelor degree	-0.0851	-1.36	0.2237	2.30	0.0555	1.07
Postgraduate	0.0787	0.80	0.4139	2.66	0.0186	0.32
Live with parents	0.0636	3.08	0.0491	0.84		
female					-0.2281	-2.37
Labour supply						
constant	0.1685	6.03	0.0947	4.21	0.0288	0.48
Youngest child <1 yr					-0.0608	-1.37
Youngest child 1-3 yrs old					-0.0301	-3.18
Youngest child 4-5 yrs old					-0.0381	-4.05
Youngest child 6-9 yrs old					-0.0319	-4.89
Number of children					0.0003	0.10
Age/10	0.0295	3.34	0.0308	4.72	0.0079	0.32
Age squared/100	-0.0041	-3.48	-0.0051	-5.86	-0.0013	-0.41
Vocational education	0.0140	3.44	0.0250	7.50	0.0230	3.70
Certificate	0.0113	2.90	0.0195	6.46	0.0044	0.64
Bursary/scholarship	0.0008	0.20	0.0262	7.87	0.0294	3.45
Postgraduate degree/other	0.0000	0.00	0.0249	4.18	0.0334	2.11
Bachelor degree	0.0056	1.06	0.0280	6.40	0.0595	5.68
Postgraduate	0.0102	1.23	0.0303	3.06	0.0457	2.92
female					-0.0603	-4.83
Time trend	-0.0001	-0.14	-0.0003	-0.44	0.0017	1.73
Unemployment rate	-0.0013	-1.79	-0.0012	-1.04	0.0004	0.24
Aged over 60	-0.0154	-1.75	-0.0212	-2.32	-0.0254	-0.37
Eligible for NZ superannuation	-0.0374	-2.61	-0.0309	-2.63	-0.1793	-1.97
Live with parents					0.0090	1.33
Fixed costs/100						
Constant	5.9696	11.18	2.7718	12.96	12.6306	2.20
Live in capital city	-0.0182	-0.22	0.1618	3.08	-0.1990	-0.48
Youngest child <1 yr					-10.5666	-1.87
Youngest child 1-3 yrs old					0.4599	0.18
Youngest child 4-5 yrs old					-2.3726	-1.02
Youngest child 6-9 yrs old					-0.7688	-0.45
Female					1.4647	1.25

Table 3 – Continued

	Single men		Single women		Sole parents	
	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]
Unobserved heterogeneity						
Variance income	0.0000	0.14	0.0003	0.43	0.0000	0.18
Variance labour supply	0.0000	0.23	0.0000	0.58	0.0000	0.26
Variance fixed cost	0.0017	0.29	0.0016	0.66	0.0033	0.46
Covariance inc. & labour supply	0.0000	0.27	0.0000	-0.34	0.0000	-0.44
Covariance inc. & fixed cost	-0.0002	-0.15	-0.0006	-0.46	0.0000	-0.20
Covariance lab.sup. & fixed cost	0.0000	-0.25	0.0000	0.56	0.0000	0.32
Log likelihood	-7660		-7280		-2796	

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 The z-value indicates the level of significance of the estimated coefficients. A value of 1.96 or more means that the parameter is significantly different from zero at the 5% level at least. The higher the z-value the more precise the estimated coefficient.

c For sole parents people with a degree are categorized in a group with those having a diploma, because of the limited number of observations on sole parents with a higher level of education.

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 and income than sole fathers.

Overall, the characteristics included in the labour supply model had the expected effects on the preferences for labour supply. That is, the preference for employment goes up with age at first and declines again after an age of about 30 (for women) and 35 (for men) is reached. Well-educated individuals have higher labour supply preferences. Children decrease female preferences for labour supply, in particular when it concerns preschool children. The effect on male preferences is not significant, similar to what is found in other studies (Section 3 briefly discusses the results from other research). The increase in the age of eligibility for the New Zealand Superannuation is found to affect all groups significantly by increasing the relevant individuals' preferences for labour supply.

Quadratic and crossproduct terms

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:

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

Similar expressions can be formulated for labour supply of women and for net income. From this formula and the results in 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}=-0.0730). This is contradictory to other studies where it is found that if one in a couple had more leisure time then the other's marginal utility for leisure time increased (Kalb, 1999, 2000). The parameter was also positive for the data used here before the inclusion of the fixed costs of working parameter. The fixed cost of working parameter is discussed in the next subsection.

The model presented here does not directly provide information on the effect of characteristics on labour supply as 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 (such as household income and wage levels) influence the final decision on labour supply as well. Thus, from a negative cross product term for the preference for labour supply of both members of the household, it does not automatically follow that if the husband increases labour supply that the spouse will then reduce her labour supply. Although the negative cross product term makes this more likely to happen, the effect from this factor is likely to be small compared to the effects of other factors.

There is also a significant effect of income on the marginal utility of labour supply or vice versa at the 5-percent 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, except for sole parents, where the effect is negative but insignificant.

Fixed cost of working

The fixed-cost-of-working parameters seem large in the model for couples, particularly for men. The fixed costs parameters are not estimates of actual costs of working, because they also include non-pecuniary 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 under the full-time rate. For predictive purposes this is not a problem, but the model will need some further work to understand more clearly the reasons for the large fixed-cost parameters. For example, the lack of people working part time may be a labour demand issue rather than a labour supply issue.

Comparing the estimated fixed costs of this model with the models for one-adult households, the explanation above is supported by the fact that we see the largest fixed costs for those who are least likely to work part time. For example, married women have lower fixed costs than married men 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 4 and 9 years reduces fixed costs of married women by the largest amount[20]. 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. For sole parents, non-participation is high compared to the other groups but also compared to sole parents in other countries. For example, labour force participation of sole parents in Australia was around 47 per cent on average between 1994 and 1998, whereas it was around 35 per cent in New Zealand between 1991 and 2001.[21] In New Zealand, the participation rate of sole parents increased from about 33 per cent to 42 per cent between 1994 and 1998. The relatively low participation rate could be

[20] Van Soest, Das and Gong (2002) find a similar result.

[21] Comparing the labour force participation of sole parents over time, an increase can be observed from around 25 per cent in 1991 to around 48 per cent in 2001. Although the number of sole parents in the separate years is quite small, this indicates there has been a substantial increase in recent years. This is also apparent from the estimated time trend for sole parents, which is quite high although only significant at the 10-percent level (see Table A.2). However, the average number of hours worked by participants seems fairly constant over time.

at least partly explained by high marginal tax rates. Nolan (2002) shows a budget constraint for a sole parent on a low wage with a marginal effective tax rate of 100 per cent from around 20 to 46 hours of work per week. In addition, childcare assistance rates are relatively low (compared to the level available in Australia) and only available for up to 37 hours, which means a full-time job may not be possible when including travel time and lunch time. The estimated fixed cost of working is quite high for sole parents.

The high fixed costs of working parameters in all models 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 at somewhat higher labour supply levels. Euwals and Van Soest (1999) find a similar effect.

Penalty of part-time work

In an alternative specification of the cost of working, we distinguish between the cost of working 1 to 10 hours, 11 to 20 hours, 21 to 30 hours and more than 30 hours. The pattern is the same for all groups, the cost of working goes up when a larger number of part-time hours is worked, but for full-time work the fixed cost of working is slightly lower. This indicates a component of the fixed cost is likely to be associated with the part-time nature of jobs. It has been suggested in other research (Van Soest 1995) that the demand for part-time workers may be low, thus requiring more effort to find part-time employment, making it more costly. Compared to Australia, where the lowest part-time hours have the highest fixed costs, the effect seems much smaller. For married men, convergence problems occur when the full-time hours (over 30 hours per week) are included. The direction of the parameter seemed to be towards a negative fixed cost for full-time hours and a high positive cost for part-time employment. Relatively few men are not working or working part time. For this group, only costs for part-time hours are estimated relative to not working and full-time work. The fixed costs are all positive and increase slightly with an increase in part-time hours.

The direction of the effects of other characteristics remains the same as before for significant results, although the size of the effect changes for some characteristics. The “penalty” variables for the different levels of labour supply pick up a lot of the overprediction of part-time hours.

Unobserved heterogeneity

Finally, in all the models described here we allowed for unobserved heterogeneity in the linear labour supply preference parameters, the linear income preference parameter and in the fixed cost parameters by adding a normally distributed error term to these parameters. We found the estimated covariance parameters to be very small, highly insignificant and their inclusion had no effect on the estimated values of the other parameters or on the log likelihood value.

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. For all groups, except sole parents, it 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 sole parents, in 97 per cent of the cases the two conditions are fulfilled. From the above results, it can be concluded that the utility function is quasi-concave in the relevant regions of the model for the majority of households.

5.2 Marginal effects

It is difficult to derive the effect of characteristics on labour supply directly from the estimated model. The results of the model can be summarized by calculating the expected hours of labour supply and the probability of non-participation. To facilitate the interpretation of the results, Table 4 presents the average expected level of labour supply and non-participation for the five subgroups when one of the characteristics is held fixed at a specific value, while all other characteristics are as observed in the sample. This allows us to isolate the average effect of a change in one particular characteristic across the samples.

Table 4 – Expected Labour Supply and Non-participation[a]

	Married men	Married women	Single men	Single women	Sole parents
Expected hours per week					
all	34.73	19.72	29.26	25.28	10.55
Wage increase of 10%	35.56	20.50	31.10	27.35	10.91
Youngest child 1-3	33.95	9.93			6.46
No child <9	35.33	25.56			17.07
Postgraduate	36.95	26.30	27.03	28.00	16.54
No qualification	32.25	16.29	25.44	20.46	6.80
Partner postgraduate	31.22	16.21			
Partner no qualification	33.57	21.07			
Male					14.60
Female					9.90
Age+10%	32.89	17.85	28.60	24.37	10.27
Partner's age+10%	34.44	19.41			
Selection: people over 60	13.86	6.50	6.40	6.09	3.61
Not eligible for NZ super	17.85	8.37	9.94	8.34	6.84
Eligible for NZ super	10.51	4.37	3.87	4.71	0.59
Partner not eligible for NZ super	14.77	12.12			
Partner eligible for NZ super	11.66	10.72			
Expected non-participation in %					
all	19.2	39.3	30.5	33.5	65.1
Wage increase of 10%	17.5	37.3	26.1	28.8	64.3
Youngest child 1-3	21.7	60.8			77.2
No child <9	17.6	27.2			47.9
Postgraduate	15.1	26.3	37.1	32.0	53.5
No qualification	23.8	47.0	39.6	43.6	75.3
Partner postgraduate	25.4	46.9			
Partner no qualification	21.8	37.0			
Male					62.7
Female					65.2
Age+10%	23.2	43.7	32.0	35.8	65.7
Partner's age+10%	20.0	40.3			
Selection: people over 60[b]	65.2	75.3	83.5	78.4	90.0
Not eligible for NZ super	55.6	69.6	74.6	71.6	81.3
Eligible for NZ super	72.9	81.6	89.5	82.4	97.6
Partner not eligible for NZ super	63.3	60.2			
Partner eligible for NZ super	70.7	64.6			

Note a: Expected labour supply is calculated at the sample characteristics except for the variable named in the first column of the row, which is set to one for all individuals and the dummy variables for the other categories of the same variable are set to zero. Except for the age variable, which is a continuous variable and increased by 10 per cent for all individuals in the sample. Average unweighted expected hours of work are computed across the samples.

b: This subgroup is quite small for sole parents at just 18 individuals.

The first rows in the two sections of the table give the average expected labour supply and non-participation in the labour force across the unweighted sample for all demographic groups. The predicted values are similar to the observed values. The second rows in the

two sections, presents the effect of an increase in wage levels by 10 per cent for all individuals. For all groups, the expected hours worked increases and expected labour force participation increases. The average wage elasticities implied by the effect are 0.63, 0.82 and 0.34 for single men, single women and sole parents respectively. For married men and women, the wage increase of the partner also affects their labour supply. The elasticity of changing both wage rates by the same percentage is 0.24 and 0.40 respectively. The own wage elasticity is expected to be somewhat higher, because when only their own wages are increased there would not be a counteracting income effect from their partners' wages.

The next two rows look at the effect of having a child aged between 1 and 3 years old compared to not having a child aged less than 9 years. This is of course only relevant for couples and sole parents. The table shows clearly that married men are much less affected by the presence of children than married women or sole parents, although a slight reduction in labour supply is visible. Education also has a much larger effect for women and sole parents than for men, but the effect of education on male labour supply is higher than the effect of having children for men. Similarly, the effect of partner's education is more pronounced for married women than men. An individual's own age has a relatively larger effect on female labour supply than on male labour supply and is higher for couples than for single-adult households. Partner's age appears much less relevant. Finally, amongst sole parents the effect of being male is to work more hours and be slightly more likely to participate. The effects found here are quite similar to the results found by Maloney (2000) who used more highly aggregated data, fewer variables, a reduced form model, and did not estimate separate models for subgroups.[22]

To explore the effect of the change in the eligibility for the New Zealand Superannuation, the sample is restricted to those who are 60 or older. The predicted labour supply is shown in the relevant row and it is obvious that overall labour supply is much lower for this group. For this subgroup, the indicator for being eligible for the Superannuation is put to zero and one respectively. This clearly shows the relatively large effect of being eligible, which is at least as high for men as for women, if not higher. The effect of the partner's eligibility is larger for men as well. As noted before, the effect is a mixture of income and direct preference effects. The available income at the different hours points was not changed in this calculation, which means the numbers in Table 4 are likely to underestimate the effect.

5.3 Goodness of Fit

The final analysis in this study compares actual observed levels of labour supply with those predicted by the model (see Tables 5 to 7). The probabilities of being in each of the categories of labour supply and the expected hours of labour supply are reported. Using a simulation procedure, drawing 1000 times from the estimated parameter distribution, empirical confidence intervals are constructed around the expected number of hours and the probabilities of being in each of the categories of labour supply (following Van Soest, 1995). This procedure incorporates the uncertainty associated with the parameter estimates as they are reflected in the estimated standard deviations.

[22] The aim of his study was different from the aim of this paper, in that he was interested in the overall effect of particular welfare reforms, whereas this paper aims to reveal the effect of changes in net wage rates and benefit or other income more generally at an individual level. Therefore the level of aggregation could be higher in his study. In fact it was necessary to construct the pseudo panel data on which his analysis was based.

Table 5 – Actual and Expected Labour Supply for men (proportion in each category)

	single					married				
		Mean	Confidence interval				Mean	Confidence interval		
Hours per week	**Actual**		**5%**	**Median**	**95%**	**Actual**		**5%**	**Median**	**95%**
11 discrete labour supply points										
0-2.5	0.3045	0.3017	0.2856	0.3024	0.3141					
2.5 – 7.5	0.0024	0.0004	0.0002	0.0004	0.0006					
7.5 – 12.5	0.0095	0.0014	0.0008	0.0014	0.0020					
12.5 – 17.5	0.0069	0.0039	0.0028	0.0038	0.0051					
17.5 – 22.5	0.0075	0.0094	0.0076	0.0093	0.0112					
22.5 – 27.5	0.0075	0.0214	0.0191	0.0213	0.0236					
27.5 – 32.5	0.0151	0.0463	0.0439	0.0462	0.0488					
32.5 – 37.5	0.0234	0.0894	0.0860	0.0892	0.0933					
37.5 – 42.5	0.3303	0.1438	0.1381	0.1436	0.1499					
42.5 – 47.5	0.1060	0.1870	0.1821	0.1870	0.1920					
> 47.5	0.1869	0.1955	0.1865	0.1954	0.2043					
6 discrete labour supply points										
0-2.5						0.1928	0.1917	0.1854	0.1917	0.1977
2.5 – 15						0.0118	0.0007	0.0006	0.0006	0.0007
15 – 25						0.0164	0.0128	0.0119	0.0128	0.0136
25 – 35						0.0207	0.1023	0.0990	0.1022	0.1060
35 – 45						0.4258	0.3209	0.3153	0.3209	0.3264
> 45						0.3326	0.3717	0.3640	0.3719	0.3793
Expected hours by age										
all	30.22	29.26	28.75	29.22	29.85	34.73	34.75	34.46	34.75	35.02
Age<30	31.32	30.16	29.53	30.13	30.86	35.73	35.60	34.95	35.61	36.18
Age 31-50	32.62	32.19	31.43	32.18	33.02	38.02	38.07	37.74	38.07	38.40
Age>50	18.79	17.79	16.61	17.76	19.02	26.37	26.46	25.90	26.47	27.00

Table 6 – Actual and expected labour supply for women (proportion in each category)

	single					married				
		Mean	Confidence interval				Mean	Confidence interval		
Hours per week	**Actual**		**5%**	**Median**	**95%**	**Actual**		**5%**	**Median**	**95%**
0-2.5	0.3341	0.3328	0.3206	0.3330	0.3438	0.3935	0.3925	0.3847	0.3925	0.4001
2.5 – 7.5	0.0114	0.0046	0.0034	0.0046	0.0060	0.0223	0.0219	0.0205	0.0218	0.0235
7.5 – 12.5	0.0197	0.0107	0.0088	0.0106	0.0129	0.0404	0.0310	0.0296	0.0310	0.0324
12.5 – 17.5	0.0164	0.0183	0.0162	0.0182	0.0205	0.0387	0.0410	0.0396	0.0410	0.0422
17.5 – 22.5	0.0235	0.0279	0.0259	0.0279	0.0300	0.0531	0.0513	0.0499	0.0513	0.0528
22.5 – 27.5	0.0175	0.0424	0.0403	0.0423	0.0446	0.0444	0.0618	0.0601	0.0618	0.0637
27.5 – 32.5	0.0363	0.0672	0.0647	0.0671	0.0699	0.0554	0.0716	0.0696	0.0716	0.0736
32.5 – 37.5	0.0379	0.1024	0.0986	0.1024	0.1062	0.0342	0.0794	0.0776	0.0794	0.0813
37.5 – 42.5	0.3384	0.1330	0.1286	0.1330	0.1370	0.2110	0.0840	0.0826	0.0840	0.0855
42.5 – 47.5	0.0659	0.1407	0.1374	0.1407	0.1439	0.0389	0.0847	0.0826	0.0847	0.0866
> 47.5	0.0991	0.1202	0.1142	0.1203	0.1260	0.0681	0.0809	0.0772	0.0809	0.0847
Expected hours by age										
all	25.61	25.28	24.84	25.27	25.71	19.72	19.75	19.48	19.75	20.02
Age<30	28.90	28.46	27.89	28.46	29.08	20.58	20.17	19.71	20.17	20.62
Age 31-50	28.87	28.88	28.19	28.88	29.52	20.70	21.01	20.66	21.01	21.34
Age>50	14.82	14.30	13.62	14.26	15.06	15.52	15.28	14.74	15.27	15.81

Table 7 – Actual and expected labour supply for sole parents (proportion in each category)

	Actual	Mean	Confidence interval		
Hours per week			**5%**	**Median**	**95%**
0-2.5	0.6502	0.5155	0.2402	0.5559	0.6427
2.5 – 7.5	0.0302	0.0594	0.0289	0.0455	0.1389
7.5 – 12.5	0.0389	0.0542	0.0299	0.0442	0.1143
12.5 – 17.5	0.0211	0.0492	0.0300	0.0419	0.0944
17.5 – 22.5	0.0316	0.0453	0.0300	0.0399	0.0791
22.5 – 27.5	0.0174	0.0427	0.0302	0.0388	0.0675
27.5 – 32.5	0.0270	0.0416	0.0312	0.0388	0.0611
32.5 – 37.5	0.0174	0.0423	0.0335	0.0399	0.0580
37.5 – 42.5	0.1021	0.0447	0.0364	0.0431	0.0584
42.5 – 47.5	0.0160	0.0489	0.0380	0.0480	0.0616
> 47.5	0.0481	0.0561	0.0401	0.0561	0.0713
Expected hours					
all	10.55	13.07	10.53	12.50	17.87
Age<30	5.33	8.65	5.30	7.91	14.75
Age 31-50	13.68	15.65	13.34	15.05	19.88
Age>50	10.00	13.19	9.60	12.48	19.59

From the tables, it is clear that the lowest part-time hours categories are somewhat underpredicted and the category with the highest hours is somewhat overpredicted. It is also clear that the model cannot capture the peak in observed hours at around 40 hours per week. As a result this category is underpredicted, whereas the neighbouring categories are overpredicted. The peak at 40 hours is likely to have been caused by institutional factors, which are not captured by the model.

Fewer labour supply points are allowed for married men given the low number of married men working part-time hours (which could have been 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.

From the range in the confidence intervals, it can be seen that most estimates are relatively precise, but the results for sole parents are clearly less accurate than for the other groups. This is not unexpected, when we compare the precision of the estimated parameters between the different groups. Besides the wider range of the expected hours or the probability of being at the different hours points, the mean and median are further from the actually observed values. When the expected hours are calculated at the point estimates the predicted levels are close to the observed values (see Table 4), but when drawing repeatedly from the distribution of parameters, the expected hours are overestimated.

In addition to predicted values for the whole sample, the tables also present expected labour supply for three age categories in the last rows of table 4 to 6 and correspond well to the actual average hours of labour supply in the different age groups. Expected labour supply by subgroup appears to follow the movements in actual hours quite closely. For the smaller subcategories (such as individuals over 50 years old) the confidence intervals become wider, because individual deviations from the predicted values play a larger role, whereas in larger groups these are averaged out.

Comparing the labour supply in the three age groups for the different demographic groups, it is clear that labour supply is highest in the age category of 31 to 50 years for single and married men. Labour supply is only slightly lower for the youngest age group, but individuals over 50 years seem to reduce their labour supply considerably. Not unexpectedly, married women and sole parents behave differently. Married women have a similar level of labour supply when they are younger than 30 and when they are between 31 and 50 years of age. There is also much less decrease in the labour supply of sole parents and married women going from the middle to the older aged group. An altogether different pattern is observed for sole parents, who have the lowest labour supply when they are under 30 and the highest when they are between 31 and 50 years of age, which only reduces slightly for those over 50. This is most likely linked to the age of their children.

The expected effects of certain policy changes could be calculated by computing the expected hours in each of the categories, accounting for the changed tax and benefit rules in the computer programs, and comparing these results to the expected hours using the current tax and benefit rules. Calibration is often used to fix the results in the base case to the observed discretised values, so that the simulation starts from these values. Examples of policy simulations using similar models to the ones described in this paper can be found in Creedy, Kalb and Kew (2003) or Kalb, Kew and Scutella (2003).

6 Conclusion

In this paper, four separate basic labour supply models for couples, single men, single women and sole parents are estimated for New Zealand. The preference parameters for labour supply 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. It was found that adding unobserved heterogeneity did not change the estimated values of the other parameters and the unobserved heterogeneity parameters were all very small and insignificant.

The results are similar for all demographic groups. The basic results seem sensible (and similar to results found in other countries, such as Australia and to earlier more aggregate results for New Zealand), with the preference for labour supply highest for people who are in their thirties with a high education level, although education levels (including those of the partner) seem somewhat more important for women than for men. The preference for labour supply is lower for women with children, in particular when the children are young, whereas no effect is found for married men. Finally, the predicted distribution over the different labour supply hours using the point estimates of the parameters is similar to the actual distribution. This leads us to conclude that the four models in this paper seem a good starting point for further experimentation with alternative specifications and extensions in future research and as the basis for policy simulations. However, the model for sole parents may need to be refined further.

The available data from 1991 to 2001 allowed us to include some variables in the preference parameters, which do not usually form part of labour supply models. The most interesting of these was the eligibility for New Zealand Superannuation indicator. In addition to this variable, a time trend, a dummy variable for being 60 years or older and an unemployment rate were included to take out possible other effects that might pollute the eligibility parameter. For all groups, a significant effect is found for the Superannuation indicator, even after controlling for the other possible influences. The delayed eligibility for

this state provided superannuation scheme has increased labour supply for all groups. Finally, an indicator for living with one's parents was included to explain labour supply preferences and found to have the expected sign for sole parents (indicating that living with one's parents may be a childcare strategy for sole parents), although the effect was not significant.

The models estimated in this paper can be used to simulate the behavioural effects of policy changes, as long as these policy changes are of a financial nature, affecting net household income levels, such as for example, a change in the withdrawal rate of a benefit payment, a change in the level of payment or a change in eligibility rules. For a policy simulation, the model is usually calibrated to make sure that the prediction in the starting situation is equal to the observed situation.

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Appendix

Table A.1 – Minimum wage rates between 1991 and 2001

Time period	minimum wage in $/hour for those	
	20 years of age and over	under 20 years of age
1991 to April 1994	6.125	n.a.
April 1994 to April 1995	6.125	3.680
April 1995 to April 1996	6.250	3.750
April 1996 to April 1997	6.375	3.825
April 1997 to April 2000	7.000	4.200
April 2000 to April 2001	7.550	4.550
	18 years of age and over	under 18 years of age
April 2001 to April 2002	7.700	5.400

Table A.2 – Models for couples with alternative fixed cost of working[a,b]

	Estimated coefficient	z-value[c]
Quadratic terms		
income× 100,000	-0.0127	-3.70
Labour supply husband × 100	-0.1298	-22.61
Labour supply wife × 100	-0.3199	-17.80
Crossproduct		
Inc. & lab. Sup. Husband × 10,000	-0.2143	-10.94
Inc. & lab. Sup. Wife × 10,000	-0.2956	-14.45
labour supply Husband & wife × 100	-0.0170	-2.34
Linear terms		
Income ×100		
constant	0.5324	28.52
Number of children	-0.0161	-6.88
Labour supply husband		
constant	-0.0319	-2.59
Youngest child <1 yr old	0.0042	1.42
Youngest child 1-3 yrs old	0.0039	1.56
Youngest child 4-5 yrs old	0.0002	0.06
Youngest child 6-9 yrs old	0.0026	0.98
Number of children	0.0006	0.86
Age/10	0.0483	9.04
Age squared/100	-0.0066	-10.13
Vocational education	0.0163	9.41
Certificate	0.0122	5.91
Bursary/scholarship	0.0129	4.38
Postgraduate degree/other	0.0124	2.45
Bachelor degree	0.0174	5.92
Postgraduate	0.0200	4.39
Vocational education (partner)	0.0018	0.88
Certificate (partner)	0.0076	4.10
Bursary/scholarship (partner)	0.0108	4.32
Postgraduate degree/other (partner)	0.0018	0.34
Bachelor degree (partner)	0.0009	0.28
Postgraduate (partner)	-0.0157	-3.17
Time trend	0.0009	2.10
Unemployment rate	-0.0016	-2.81
Aged 60 or over	-0.0077	-2.08
Eligible for New Zealand Superannuation	-0.0227	-4.97
Partner is eligible for New Zealand Superannuation	-0.0104	-1.78
Labour supply wife		
constant	0.1723	9.17
Youngest child <1 yr old	-0.0796	-25.36
Youngest child 1-3 yrs old	-0.0608	-25.44
Youngest child 4-5 yrs old	-0.0439	-14.33
Youngest child 6-9 yrs old	-0.0247	-9.71
Number of children	-0.0094	-9.64
Age/10	0.0418	7.78
Age squared/100	-0.0068	-9.91
Vocational education	0.0211	10.80
Certificate	0.0138	7.35
Bursary/scholarship	0.0171	7.03
Postgraduate degree/other	0.0289	6.03
Bachelor degree	0.0316	11.29
Postgraduate	0.0440	9.97
Vocational education (partner)	-0.0073	-4.11
Certificate (partner)	-0.0032	-1.47
Bursary/scholarship (partner)	-0.0028	-1.04
Postgraduate degree/other (partner)	-0.0112	-2.30
Bachelor degree (partner)	-0.0168	-6.33
Postgraduate (partner)	-0.0198	-5.39

Table A.2 – Continued [a,b]

	Estimated coefficient	z-value[c]
Time trend	0.0006	1.44
Unemployment rate	-0.0009	-1.22
Aged 60 or over	-0.0027	-0.48
Eligible for New Zealand Superannuation	-0.0254	-2.72
Partner is eligible for New Zealand Superannuation	-0.0034	-0.88
Fixed cost husband/100		
0-10 hours	7.2060	22.01
11-20 hours	7.5002	22.43
21-30 hours	7.6978	23.47
Fixed cost wife/100		
0-10 hours	9.3387	22.87
11-20 hours	11.8440	19.43
21-30 hours	13.9671	17.84
>30 hours	13.0489	15.28
Log likelihood	-29542	

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 This specification does not include unobserved heterogeneity terms, because no convergence took place, with the heterogeneity terms remaining at their starting values and the other parameters at the values estimated without the unobserved heterogeneity term.

c The z-value indicates the level of significance of the estimated coefficients. A value of 1.96 or more means that the parameter is significantly different from zero at the 5% level at least. The higher the z-value the more precise the estimated coefficient.

Table A.3 – Models for singles and sole parents with alternative fixed cost of working

	Single men		Single women		Sole parents	
	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]
Quadratic terms						
Income × 100,000	-0.1241	-3.55	-0.2948	-4.96	-0.0505	-1.66
Labour supply × 100	-0.8778	-12.02	-0.6814	-11.81	-0.2794	-4.74
Cross product						
Inc. & lab. sup. × 10,000	-1.6333	-9.73	-1.8331	-8.67	-0.5342	-2.69
Linear terms						
Income ×100						
constant	0.9509	7.42	1.5547	9.62	0.5902	2.97
Youngest child <1 yr					0.1221	1.92
Youngest child 1-3 yrs old					0.0514	1.70
Youngest child 4-5 yrs old					0.0030	0.13
Youngest child 6-9 yrs old					-0.0201	-1.17
Number of children					0.0138	1.60
Age/10	0.1430	2.67	0.0568	0.76	-0.0973	-1.61
Age squared/100	-0.0118	-1.61	-0.0052	-0.54	0.0120	1.55
Vocational education	-0.0469	-1.74	-0.0204	-0.49	-0.0570	-2.33
Certificate	-0.0542	-2.14	-0.0324	-0.80	-0.0516	-2.33
Bursary/scholarship	-0.1022	-3.83	-0.0883	-2.08	-0.0102	-0.44
Postgraduate degree/other	-0.1611	-2.99	0.0758	0.90	-0.0177	-0.45
Bachelor degree	-0.0423	-1.13	0.1971	3.19	0.0602	1.59
Postgraduate	0.0528	0.83	0.3318	3.31	0.0487	0.92
Live with parents	0.0352	4.38	0.0682	3.20		
female					-0.1629	-3.71
Labour supply						
constant	0.4866	9.07	0.3600	8.65	0.2089	2.83
Youngest child <1 yr					-0.0117	-0.43
Youngest child 1-3 yrs old					-0.0213	-1.72
Youngest child 4-5 yrs old					-0.0398	-3.39
Youngest child 6-9 yrs old					-0.0357	-4.18
Number of children					0.0025	0.61
Age/10	0.0487	3.44	0.0336	3.39	-0.0071	-0.22
Age squared/100	-0.0056	-2.91	-0.0053	-4.12	0.0005	0.12
Vocational education	0.0109	1.59	0.0236	4.45	0.0117	1.37
Certificate	0.0052	0.79	0.0167	3.26	-0.0068	-0.73
Bursary/scholarship	-0.0100	-1.46	0.0190	3.57	0.0283	2.50
Postgraduate degree/other	-0.0220	-1.61	0.0317	3.28	0.0317	1.69
Bachelor degree	0.0020	0.21	0.0453	6.06	0.0702	4.74
Postgraduate	0.0206	1.39	0.0586	4.79	0.0610	2.55
female					-0.0836	-5.22
Time trend	0.0000	-0.03	-0.0001	-0.19	0.0018	1.84
Unemployment rate	-0.0013	-1.78	-0.0011	-0.99	0.0003	0.21
Aged over 60	-0.0153	-1.82	-0.0204	-2.37	-0.0261	-0.46
Eligible for NZ superannuation	-0.0339	-2.51	-0.0259	-2.37	-0.1545	-2.09
Live with parents					0.0085	1.28
Fixed costs/100						
0-10 hours	7.5338	12.98	4.1489	12.91	13.4319	3.19
11-20 hours	11.2123	12.04	5.8588	11.78	17.7789	3.16
21-30 hours	14.1347	12.22	7.1534	11.54	21.3914	3.09
>30 hours	13.7870	11.56	6.8353	10.58	20.2658	3.00

Table A.3 – Continued

	Single men		Single women		Sole parents	
	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]	Estimated coefficient	z-value[b]
Unobserved heterogeneity						
Variance income	0.0000	0.25	0.0000	0.16	0.0000	0.06
Variance labour supply	0.0000	0.33	0.0000	0.77	0.0000	0.19
Variance fixed cost	0.0021	0.42	0.0010	0.78	0.0078	0.52
Covariance inc. & labour supply	0.0000	0.29	0.0000	0.20	0.0000	0.09
Covariance inc. & fixed cost	-0.0001	-0.25	-0.0001	-0.20	0.0000	-0.05
Covariance lab.sup. & fixed cost	0.0000	-0.31	0.0000	0.54	0.0000	-0.04
Log likelihood	-7434		-7093		-2775	

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 The z-value indicates the level of significance of the estimated coefficients. A value of 1.96 or more means that the parameter is significantly different from zero at the 5% level at least. The higher the z-value the more precise the estimated coefficient.

c For sole parents people with a degree are categorized in a group with those having a diploma, because of the limited number of observations on sole parents with a higher level of education.