ESTIMATING NET CHILD CARE PRICE ELASTICITY OF PARTNERED WOMEN WITH PRESCHOOL CHILDREN USING DISCRETE STRUCTURAL LABOUR SUPPLY-CHILD CARE MODEL

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Abstract: The purposes of paper are twofold. First, we construct and estimate a joint discrete structural model of labour supply and child care demand for partnered women with preschool children using the 'in-confidence' version of HILDA. As a methodological innovation, we impose a quantity constraint that the number of *total* child care hours (formal plus informal child care) is at least as large as the labour supply of the mother. Second, using simulations, we estimate the gross and net child care price elasticities for all mothers with preschool children and for various demographic sub-groups to shed light on labour supply behaviour and child care demand of women across income levels and socio-economic characteristics.

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1. INTRODUCTION

To encourage more women with young children to enter the labour market, many governments subsidise child care, often substantially. For example, in Australia, the government pays for over 50 per cent of the child care costs of most households through the combination of a means-tested program, Child Care Benefit (CCB), and a tax rebate, Child Care Rebate, which is not means-tested. The effectiveness of these subsidies depends crucially upon the labour supply responsiveness of women to child care costs. Thus it is essential to correctly measure such responsiveness in order to evaluate policy effects and alternatives. The child care price elasticity of labour supply is the most commonly estimated measure of this responsiveness.

Until recently the small econometric literature in Australia found that female labour supply was non-responsive to child care costs. In a previous paper, Gong et al. (2010) made an attempt to establish a relationship between child care price and women's labour supply and to understand why previous Australian papers had failed to find a relationship. Using newly available, more detailed data, they found a negative and statistically significant relationship between the price of child care and women's labour supply. The conclusion of Gong et al. (2010) was that measurement error in the way that the child care price variable was constructed was, at least partly, responsible for the previous authors' failure to find a relationship between child care price and women's labour supply. Gong et al. (2010) estimate that a one per cent increase in the price of child care leads to a 0.29 per cent decrease in labour supplied, holding all other things constant.

One limitation of Gong et al. (2010) is that their method and model, in a complex tax and transfer system, do not allow calculation of a net price elasticity or simulation of behaviour under relevant policy alternatives. Net price elasticities are more useful than gross price elasticities in the calculation of policy effects since gross price elasticities are themselves functions of the policies, unlike net price elasticities. The estimated gross price elasticities reported in Gong, et al. (2010) are a function of specific policy settings at the time of survey and their findings are difficult to generalize to alternative policy settings. Alternative policy settings may induce a different relationship between child care price and labour supply.

A net price elasticity, which describes the relationship between labour supply and net child care costs faced by a household, is also more appropriate to use in calculation of distributional effects when the labour supply responsiveness to child care cost differs across demographic groups (for example, by education) or where the means-testing of child care subsidies alters the mapping between the net and gross child care costs across demographic groups. Where there is some form of assistance with meeting the costs of child care, gross and net elasticities will generally differ from each other on average and for each household. These differences may not be constant across variables such as income and education.

The purpose of this paper, therefore, is to build upon the previous work and estimate a model which will be of more use to policy makers.

To estimate a net price elasticity and policy effects in environments of complicated tax and welfare settings, such as progressive tax or means-tested welfare systems, additional structure needs to be imposed on the model. Many studies take an approach of specifying and directly estimating the utility

function, including, for example, Blau and Robins (1988); Ribar (1992, 1995); Blau and Hagy (1998); Duncan et al. (2001); and Kornstad and Thoresen (2006, 2007). This approach, which Gong et al. (2010) label as the 'direct approach', has the advantage that it models the tax and welfare settings explicitly in the household budget constraint. Thus policy effects can be analysed as long as the policies can be quantified as changes to the household budget constraint. In addition, it is possible, using simulation, to calculate both gross and net price elasticities.

The purposes of paper are twofold. First, we construct and estimate a joint discrete structural model of labour supply and child care demand for partnered women with preschool children.[2] We focus on mothers with preschool children because mothers are the primary caregivers in most households.[3] We exclude mothers with only school-aged children (who do not have pre-school children) because the relationship between their labour supply and child care of school-aged children are not as closely linked as for the mothers with preschool children. Modelling child care for school-aged children is also complicated by the fact that the children are at school for most of the week. We assume that women choose work hours and hours of formal child care from a small set of realistic values which reflect typical work hour patterns and typical time slots which are available through child care providers. The framework may be used to estimate the effects of quantifiable policy changes on labour supply, income distribution, and public expenditure.

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[2] In this paper, partnered women with young children include married women and women in de facto relationships. These women are also referred to as 'the mothers' or the individual, and their spouses/partners are referred to as 'the fathers'.

[3] There are signs that more men are sharing the care responsibilities so that their decisions should be treated endogenously in the future modelling practices especially when appropriate data are available.

Second, using simulations, we estimate the gross and net child care price elasticities for all mothers with preschool children and for various demographic sub-groups to shed light on labour supply behaviour and child care demand of women across income levels and socio-economic characteristics. These elasticities, unlike those in Gong et at (2010), are with respect to the child care price specific to preschool children. We also wish to explore, by using yet another approach, the relationship between labour and the child care costs.

As a methodological innovation, we impose a quantity constraint that the number of *total* child care hours (formal plus informal child care) is at least as large as the labour supply of the mother. Without such constraints, it would be unrealistically possible that the mother is able to work more hours than the hours during which children need to be cared for. Duncan et al. (2001) are the first to impose similar constraints in their model and show that failure to do so would lead to biased child care price effects. Kornstad and Thoresen (2006, 2007) are the only other known studies that also impose such constrains. However, Duncan et al. (2001) restrict the connection only to the number of *paid* (or *formal*) child care hours consumed instead of the total child care hours, and Kornstad and Thoresen (2006, 2007) assume that paid child care hours are the same as hours of work. This contradicts the fact (born out in our data as well) that for many households observed formal child care hours are less than the hours worked by the mother. The constraints applied in previous research have ignored the role of informal child care.

To the best of our knowledge, this is the first paper that explicitly includes child care as an argument of the utility function of similar discrete choice models. Attempts have been made to incorporate child care into such models but in quite restrictive ways. Kalb and Doiron (2005) included child care costs in the budget

constraint of a standard discrete labour supply model. Kornstad and Thoresen (2006, 2007) allow the choice set to depend upon different modes of child care but still restrict the utility to depend only upon leisure and consumption.

The data used for the analysis are drawn from the fifth to seventh waves of the 'in-confidence' version of the Household, Income, and Living Dynamics in Australia (HILDA) Survey (covering the period from 2005 to 2007). We focus on the labour supply of partnered mothers with preschool children and the demand for formal child care for preschool children in these households.

The model of this paper, based on directly estimating a utility function, is more challenging to estimate than the approach of Gong et al. (2010). The direct approach of estimating the utility function requires greater care to eliminate unobserved heterogeneity which may be related to preferences. For this reason, this paper uses a subset of data from Gong et al. (2010) which should help to reduce unobserved heterogeneity. One result of this is that the point estimates for elasticities differ between this paper and Gong et al. (2010), although importantly this difference is not statistically significant. The papers are consistent in their finding of a negative and statistically significant relationship and the confidence intervals for the various point estimates overlap with one another. Given the use of very different estimation methods and a different sample it is not surprising that point estimates differ. Despite these differences, the results are within reasonable statistical distance of each another.

The rest of the paper is organised as follows. In the next section (Section 2) we discuss the model, the estimation method, and the simulation. Section 3 describes the data. In Section 4, we first present the estimation results, followed

by discussions of the simulation results using the model estimates. Section 5 concludes.

2. MODEL AND ESTIMATION

2.1 The discrete choice model of labour supply and child care

The model used in the analysis is a discrete, structural model of the joint decision regarding hours of labour supplied by partnered women and household-level child care demand for families with preschool children. The theoretical framework in this paper is similar to earlier studies in that the decision about whether or not to work and how many hours to work for partnered women is made simultaneously with the decision of whether or not to use child care and how much child care to use. Blau and Robinson, 1988; Blau and Hagy, 1998; and Connelly, 1992 pioneered this approach, but these early papers allowed hours worked and hours demanded of child care to adjust in very small increments anywhere along the positive real line. Our model is closer to that Kornstad and Thoresen, 2007 in that households are constrained in their choice of work hours and hours of child care to a subset of points which correspond to those which are most frequently observed in the data. In all of these models, and in our paper, the household is assumed to maximize its utility, defined over general consumption, (some form of) child development, and leisure of the mother, by choosing the mother's labour supply and hours of formal child care.[4] The father's time allocation is treated as fixed; this is discussed in detail below. Our empirical model is based on the standard

discrete neo-classic labour supply model, which was first developed by Van Soest (1995), extended to include maternal child care as an explicit argument of the household utility function and to define the budget constraint over discrete pairs of working hours and formal child care hours.

We impose the following quantity constraint on the relationship between mother's hours worked and child care hours:

(1) During waking hours, when a child is not being cared for by the father, the child must be taken care of by the mother, a formal child care provider, or an informal child care provider. We treat the father's time taking care of children, working hours and leisure as fixed. While this is somewhat restrictive, it still provides a good approximation of the Australian situation. Women undertake the vast majority of at-home care of children and women's labour supply in general is much more responsive to the presence or absence of children in the household than men's labour supply.

(2) The household may choose to use formal child care regardless of whether the mother is at work or not, but the household only uses free[5], informal child care when the mother is at work. In other words, we assume that informal child care usage is the gap between the mother's working hours and formal child care hours.[6]

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[4] We do not observe child development. In our model, maternal hours spent caring for children is the key input we use as a proxy for child development.

[5] In the data, households only report paying for about 10 per cent of informal child care usage.

[6] In our model implementation, we calculate informal child care as the difference between mother's hours of work and hours spent in formal child care by children rather than use

These two constraints are similar in sprit to those in Duncan et al. (2001) and Kornstad and Thoresen (2007), but we relax the unrealistic restriction in those papers that the number of formal child care hours be equal to or greater than the number of hours worked by the mother. Our paper explicitly recognizes the role of informal child care but restricts that care to be used only for working purposes.

The underlying idea of this assumption is that formal care is an input into child quality and therefore may be used to complement household education of the child even in the absence of a need for child care during periods in which the mother works. Informal child care is inferior to both formal child care and maternal or paternal care and thus for the purposes of caring for children during working hours, the household would choose formal child care first and use informal child care only to make up any shortfall of formal child care relative to working hours.

To make the model tractable, we further assume that, for mothers with both preschool and school–aged children, the primary consideration of the mother when she makes her labour supply and chid care usage decisions is the well-being of the pre-school child(ren). That is, we assume that when school-aged children are present together with pre-school children in the same household, child care of the school-aged children is assumed to mirror that of the preschool children, excluding school hours. For example, if formal hours of child care for

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the reported hours of informal child care. Using reported hours of informal child care would require a more complicated model where households make decisions over three dimensions (labour supply, hours of formal care, and hours of informal care) instead of two. Rather than estimate this more complicated model, we include variables in the

the pre-school child are 40 and the school-age child is in school 30 hours per week (6 hours per day) then we assume that the school-age child is in before- and after-school care for 10 (40-30) hours per week. This is a strong assumption but it is necessary for the model to be tractable. As a sensitivity test, we replace this assumption by assuming that formal child care of school-aged children is fixed and does not enter the utility function. We also estimate the model using the households with preschool children only. The results of the alternative specifications are presented in the Appendix and are not much different from the main results presented below.

To be specific, the household is assumed to maximise the following trans-log utility function by choosing mother's working hours h and average formal child care hours c_f of her preschool children from a set of discrete options:

$$\underset{y,h,c_f}{Max}\ U(v) = v'Av + b'v, \quad v \equiv (\log y, \log l_m, \log c_m)' \tag{1}$$

$$\text{s.t. } y \le \tau(y_0 + wh, X) - \sum_{all\ children} \nu(pc_f, X). \tag{2}$$

y is general consumption net of child care costs which is determined through the budget constraint (2) by asset income and father's income (both captured in y_0), the mother's wage (w) and working hours, and the tax/welfare system which is captured by the function τ and which depends upon household characteristics, X.[7] The function v captures the child care benefit (CCB) scheme

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formal child care demand equation which account for the availability (or lack) of informal care for the household.

[7] In τ, we include Newstart Allowance (NSA), Parenting Payment Partnered (PPP), Family Tax Benefits A and B, together with income tax, Medicare levy, and Low Income Tax Rebate (LITO).

which depends upon child care costs (average price p multiplied by average usage) and household characteristics. l_m is the leisure of the mother which is specified as the difference between her time endowment (T_m) and time spent either working or caring for children

$$l_m = T_m - h - c_m, \tag{3}$$

c_m is the time spent on maternal care which is specified as

$$c_m = \min\{T_c - h, T_c - c_f\}, \tag{4}$$

where T_c is the time during which children need to be cared for either by the mother or through the formal or informal market. Time spent by fathers taking care of children has already been netted out of T_c.

The parameters of the utility function are summarised in A, a symmetric 3×3 parameter matrix with entries A_{ij}, $(i, j = 1,2,3)$, and $b = (b_1, b_2, b_3)'$, a vector with three parameters. b_1 is a constant, but b_2 and b_3 are specified to allow both observed and unobserved individual and household characteristics to affect utility:

$$b_k = \sum_{t=1}^{T_k} \beta_{kt} x_t^k + \varepsilon^{p_k}, \quad (k = 2,3), \tag{5}$$

where $x^k = (x_1^k, ..., x_{T_k}^k)'$ are vectors of exogenous characteristics including age of the mother and the children, number of children in each age group, and other characteristics that describe the family composition such as the presence of extra female adults. In the case of multiple children, maternal child care is measured as the average number of maternal care hours for all preschool children in the household and the impact of the number of children on utility is through b_3.

That is, the number of children affects the marginal utility of maternal care by shifting b_3. Moreover, the potential impact of informal child care is also allowed for by the inclusion of a dummy in b_3 equal to one if $h > c_f$. This dummy controls for which condition in equation (4) determines maternal child care hours and equals one if the family makes recourse to informal child care (as calculated by our residual measure of informal child care usage). The error terms ε^{p_k} may be interpreted as random preferences due to unobserved characteristics.

The choice set for working hours and formal child care hours are defined as

$$h \in \{0, s, 2s, ..., (m-1) * s\}, \tag{6}$$

and

$$c_f \in \{0, r, 2r, ..., (g-1) * r\}, \tag{7}$$

where s and m describe all possible alternatives of working hours, and r and g describe all possible alternatives of formal child care hours. In this paper s is set to 8 hours, m is set to 8, r is set to 10 hours for preschool children to reflect the typical length of child care sessions in this age group, and g is set to 6. Thus, the household chooses from a choice set with $m * g = 48$ working/formal child care hour combinations.

We stress that this set-up allows the household to choose less formal child care hours than the mother's working hours. The gap is assumed to be filled by informal care which is further assumed to have no financial costs for the family. This is an important difference between our model and those of Duncan et al. (2001) and Kornstad and Thoresen (2007).

To the utility of each alternative in the choice set, we add random disturbances μ_j (as in Van Soest,1995), as in the multinomial logit model (Maddala, 1983):

$$U_j = U_j(y_j, l_j, c_{mj}) + \mu_j \quad (j = 0, ..., m * g) \tag{8}$$

where μ_j's are independently and identically distributed with a type I extreme value distribution, and are independent of all x and the other unobservable terms in the model.

The mother chooses alternative j if U_j is the largest among all the alternatives. Conditional upon ε^{p_k}, X, and w, the probability that j is chosen is

$$\Pr[U_j \geq U_{i,} \text{ for all } i] = \frac{\exp(U(y_j, l_{mj,} c_{mj}))}{\sum_{i=1}^{m*g} \exp(U(y_i, l_{mi,} c_{mi}))}. \tag{9}$$

To predict the wage rates of non-workers and workers whose wages are missing in the data and to allow for correlation between wage rates and unobserved utility preferences (ε^{p_k}), a wage equation is simultaneously estimated with (1) and specified as a standard Mincer wage equation:

$$\log w = \pi' z + \varepsilon^w \tag{10}$$

where z is a vector of individual characteristics of the mother. Her education level, co-residence with both parents at the age of 14, and current area of residence are included in the wage equation but not in the utility function and serve the role of exclusion restrictions. π is a vector of parameters to be estimated. ε^w is an unobserved term, assumed to be normally distributed with mean zero, independent of z, but is allowed to be correlated with ε^{p_k}.

As in similar models (for example, Gong and Van Soest, 2002), unobserved fixed benefit of not working (FB) is added to the income at zero hours of work. Thus the utility of all alternatives at zero hours of work are replaced by $U(y_0 + FB, l_{m0,}, c_m)$. FB is specified as

$$FB = \delta' t \tag{11}$$

where t is a vector of exogenous variables and δ is a vector of parameters. Positive fixed benefits increase the probability of not working by increasing the utility of non-participation. They can be interpreted equally as fixed costs associated with working.

2.2 Estimation

If all the wages were observed and without random preferences, the model could be estimated by maximum likelihood with the likelihood contribution given by Equation (9). With unobserved wages, the wage Equation (10) also needs to be estimated. This is done simultaneously with the joint labour supply-child care model. With the presence of unobserved preferences in leisure and maternal child care, maximum likelihood estimation would require evaluation of the three-dimensional integral defined over the distribution of the error terms ε^w, ε^{p_2}, and ε^{p_3}. Numerical integration in more than two dimensions can be difficult to solve.

In this paper, we use Simulated Maximum Likelihood (SML) to avoid this multi-dimensional numerical integration. Denoting the probability of working h_j

hours and using c_j hours of formal child care conditional on ε^{p_2}, ε^{p_3}, and wage rate[8] by

$$\Pr[h = h_j, c_f = c_j \mid w, \varepsilon^{p_2}, \varepsilon^{p_3}] \ (j = 1, ..., m\text{-}g), \tag{12}$$

The exact likelihood contribution for someone observed to work h_0 and use c_0 hours of formal child care with observed gross wage rate w_0 is then given by

$$L = \iint \Pr[h = h_0, c_f = c_0 \mid w_0, \varepsilon^{p_2}, \varepsilon^{p_3}] f_1(\varepsilon^{p_2} \mid w_0) f_2(\varepsilon^{p_3} \mid w_0) \mathrm{d}\varepsilon^{p_2} \mathrm{d}\varepsilon^{p_3} f(w_0), \tag{13}$$

Or, if the wage rate is not observed, the exact likelihood contribution is

$$L = \iiint \Pr[h = h_0, c_f = c_0 \mid w, \varepsilon^{p_2}, \varepsilon^{p_3}] f_1(\varepsilon^{p_2} \mid w) f_2(\varepsilon^{p_3} \mid w) f(w) \mathrm{d}\varepsilon^{p_2} \mathrm{d}\varepsilon^{p_3} \mathrm{d}w, \tag{14}$$

where $f_k(\cdot \mid w)$ (k=1,2) are the conditional density functions of ε^{p_k} given w, and $f(\mathrm{w})$ is the density of the wage rate (or of ε^w). The three error terms ε^w, ε^{p_2}, and ε^{p_3} are specified to follow a joint normal distribution of which the parameters are to be estimated:

$$\begin{pmatrix} \varepsilon^w \\ \varepsilon^{p_2} \\ \varepsilon^{p_3} \end{pmatrix} \sim \mathrm{N}(0, \Sigma), \text{ where } \Sigma = \begin{pmatrix} \sigma_w^2 & 0 & 0 \\ \sigma_{wp_2} & \sigma_{p_2}^2 & 0 \\ \sigma_{wp_3} & 0 & \sigma_{p_3}^2 \end{pmatrix} \tag{15}$$

The numerical multi-dimensional integral is approximated by a simulated mean: for each individual, we take R draws from the distribution of the error terms (ε^w, ε^{p_2}, and ε^{p_3}) and compute the average of the R likelihood values conditional on these draws. The integral Equation (13) is thus approximated by

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[8] Throughout, we condition on earnings of the husband, other non-labour income, child care price, and other exogenous explanatory variables x, z, and t. These are suppressed in our notation.

$$L = \frac{1}{R}\sum_{r=1}^{R} \Pr[h = h_0, c_f = c_0 \mid w_0, \varepsilon_r^{p_2}, \varepsilon_r^{p_3}] f(w_0),$$

And Equation (14) is replaced by

$$L = \frac{1}{R}\sum_{r=1}^{R} \Pr[h = h_0, c_f = c_0 \mid w_r, \varepsilon_r^{p_2}, \varepsilon_r^{p_3}],$$

where $\log w_r = \pi' z + \varepsilon_r^w$ and $(\varepsilon_r^w,\ \varepsilon_r^{p_2},\ \varepsilon_r^{p_3})$ $(r = 1,...,R)$ are based upon draws from the distribution of $(\varepsilon^w,\ \varepsilon^{p_2},\ \varepsilon^{p_3})$.

The draws are taken from Halton sequences using the procedure described in Train (2003). The estimator resulting from random independent draws is inconsistent for fixed R, but will be consistent as R tends to infinity with the number of observations of the sample.[9] Many studies (see e.g., Morokoff and Caflisch, 1995, Sloan and Wozniakowski, 1998, Bhat, 2001, Train, 2003, Sandor and Train, 2004) show that using 'quasi-random' draws which are designed to provide better coverage than independent draws, simulation can be more efficient in terms of reduced simulation errors for a given number of draws. In particular, Bhat (2001), Train, (2003), and Sandor and Train (2004) all tested Halton sequences for mixed logit models and found their use to be vastly superior to random, independent draws.

2.3 Simulations and the calculation of the net price elasticity

Labour supply and child care demand behaviour of the households may be described by their corresponding elasticities. Due to the complexity of the

[9] If $\sqrt{n}/R \to 0$ and with independent drawings across observations, the method is asymptotically equivalent to maximum likelihood (see Lee, 1992, or Gourieroux and Monfort, 1993 for references).

model, simulations are needed to derive elasticities and to estimate policy effects. When calculating the elasticities, hours of work and child care are calculated as `expected hours', that is computed as a probability weighted sum of hours over all possible values which hours can take. Wage, gross child care price, and income elasticities for each observation are derived by increasing all wage rates, gross child care price, or other incomes by 1 per cent and calculating the per centage change of average hours or the employment rate. The net child care price elasticity is calculated as the ratio between the gross price elasticity and the per centage change in the net child care price corresponding to a 1 per cent change in the gross child care price. From these, we calculate the average elasticities for the whole sample and for selected subsamples of interest. The standard errors of these average elasticities are obtained using Monte Carlo methods by repeating the simulation 100 times with parameter estimates of the model drawn from their estimated distributions.

Simulations could also be used to estimate the effects on labour supply, child care demand, income distribution, and public expenditure of future policy changes as long as those changes can be incorporated into the budget constraint.

3. DATA

3.1.1 Data source and sample

Data used for the main analysis are drawn from waves five, six, and seven of the `in-confidence' version of the Household, Income and Labour Dynamics in Australia Survey (HILDA) which cover the period 2005 - 2007. The HILDA Survey is an annual panel survey of Australian households which was begun in

2001.[10] There are approximately 7,000 households and 13,000 individuals who respond in each wave. The choice of data is based upon the following three considerations. First, and most importantly, the HILDA data from wave five onwards collected child care usage data separately by child and separately for employment and non-employment related reasons. In the first four waves, data was more aggregated within the household. Secondly, we choose to pool across three waves of data to achieve a sufficiently large sample size. This is important in the construction of our local average child care price. We use median child care prices within Labour Force Survey Regions (LFSR) as defined by the Australian Bureau of Statistics (ABS).[11] In order to construct this local average price we need a reasonable number of observations in each LFSR. Pooling across these three waves achieves sufficient sample size to estimate a median for each LFSR. Lastly, child care policies in Australia were roughly constant over this period. In particular, there were no major changes to the Child Care Benefit scheme during this period. The Child Care Tax Rebate (CCTR), now called Child Care Rebate, was announced at the beginning of the sample period. However, the way in which the rebate was originally structured through the tax system meant that families did not receive the rebate, in the form of a lump sum payment, until two years after making the expense. Given this time lag and the lump-sum nature of the payment, we assume that this program did not affect people's decisions during our sample period. A final consideration which favours this choice of sample period is that the Australian Bureau of Statistics (ABS) created a child care price index, which we use to make the price comparable across waves. This index is only available from 2005.

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[10] See Watson and Wooden (2002) for more details.

[11] Labour Force Survey Regions are described in ABS (2005)

We focus on the labour supply of partnered mothers with at least one preschool child and the demand for formal child care in these households. We eliminate all households without preschool children. We eliminate mothers who are retired, are full-time students, are self-employed or work in family businesses. After discarding observations with missing values for any variables used in our model, the sample consists of 2,023 mothers with at least one preschool child.

We leave out households without pre-school children, including some households with school-aged children. Our rationale for this is that the labour supply and child care issues faced by those households may be quite different from those with preschool children. Importantly, school-age children are older and go to school for around 30 hours per week, which makes their need for both maternal and non-maternal child care much less than that of younger children. This sample of households with pre-school children, for these reasons, will be a more homogeneous sample which should reduce the influence of unobserved preferences on observed outcomes. This sample homogeneity should therefore provide a reduction in bias.

We present sample statistics in the second column of Table 1. In the third column of Table 1, we present the sample statistics for a sub-sample of 1,159 mothers of pre-school children in households in which there are no school-aged child present. This sub-sample is used for sensitivity analysis as described below. From the second column of Table 1, about 43 per cent of households with preschool children use formal child care. Hours spent in child care for the preschool children are about 18 hours per week. About 56 per cent of the mothers were employed and the average working mother works 25 hours per week at an hourly wage of $25 (at the June 2005 price level). The characteristics

of the mothers in the sub-sample are broadly similar to that of the whole sample except they are younger and slightly better educated.

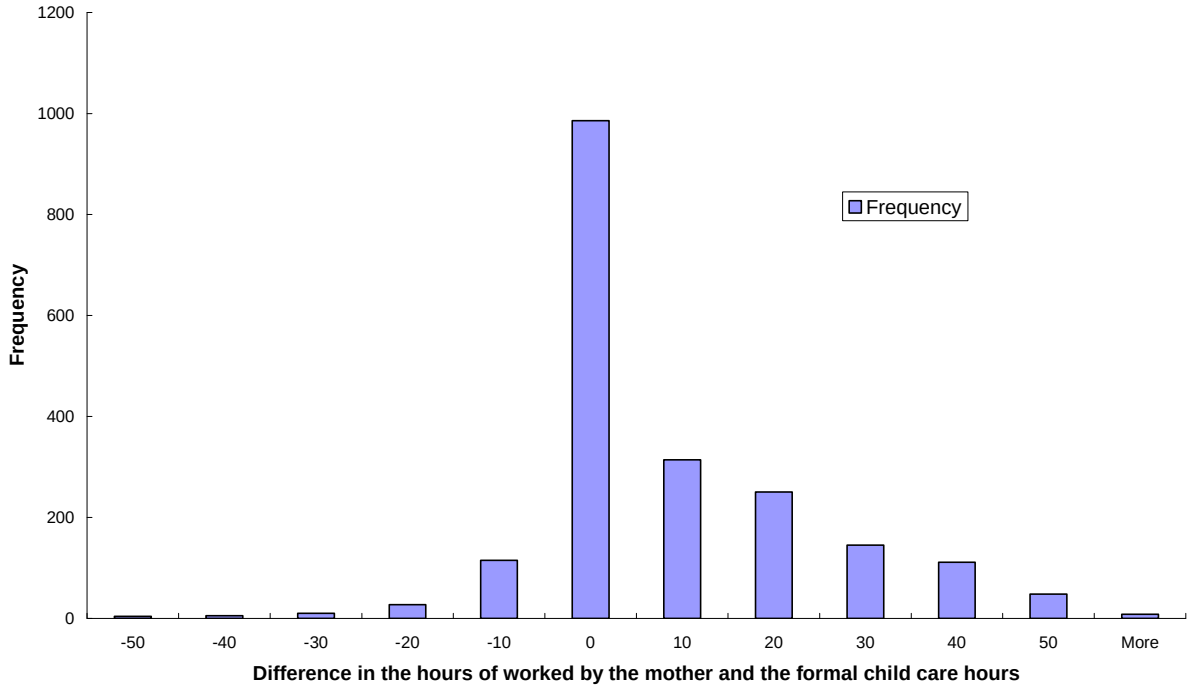
Many households use more formal child care than the mother's hours of work. To see how mother's working hours and formal child care hours are related, Figure 1 presents the distribution of the difference between the two. Figure 1 shows that in about 21 per cent of households with preschool children, the average reported hours of formal child care per pre-school child are more than the mothers' reported hours of work. This indicates that the quantity constraint (that formal child care hours are greater than or equal to hours worked by the mother) imposed by Duncan et al. (2001) and Kornstad and Thoresen (2007) is probably too restrictive.

Table 1. Sample statistics

Variables	Whole sample	Sub-sample with pre-school children only
Hours worked per week by the working mothers	24.791 (13.67)	25.600 (13.52)
Labour force participation rate of the mothers	0.563	0.598
Average hours of child care (per child) of children using formal care	18.774(12.86)	19.025 (13.16)
Proportion of families using formal care	0.426	0.451
Wage rate of the mother (at June 2005 price)	25.311 (22.51)	26.591 (22.12)
Unearned private income of the couple and earnings of the father	1237.864 (1241.97)	1305.138(1288.76)
Mean median child care prices (at June 2005 price)	4.669 (0.92)	4.727 (0.98)
Age of the mother	32.850(5.87)	31.753 (5.81)
Dummy, mother received higher edu.	0.340	0.413
Dummy, mother received vocational edu.	0.248	0.242
Dummy, mother finished Year 12 only	0.206	0.205
Dummy, mother did not finish Year 12	0.206	0.140
Dummy, father received higher edu.	0.274	0.297
Dummy, father received vocational edu.	0.419	0.399
Dummy, father finished Year 12 only	0.141	0.162
Dummy, father did not finish Year 12	0.166	0.142
The mother was not with both parents at the age of 14	0.216	0.217
The mother was not born but educated in Australia	0.135	0.146
The mother was neither born nor educated in Australia	0.052	0.055
The mother speaks a language other than English	0.118	0.111
The mother is an Aboriginal and Torres islander	0.020	0.017
The mother and the father were not born but educated in Australia	0.191	0.201
Neither the mother nor the father born or educated in Australia	0.097	0.082
No. of children aged 0 to 4	1.347 (0.57)	1.442 (0.58)
No. of children aged 5 to 12	.597 (0.84)	-
No. of children aged 13 to 15	.094 (0.34)	0.053 (0.25)
Age of the youngest child	1.536(1.46)	1.092 (1.24)
Dummy, presence of extra female adult	0.031	0.026
Dummy, presence of children older than 12	0.866	0.775
Mean age of the children in the studied group	1.904 (1.36)	1.537 (1.24)
NSW	0.279	0.270
VIC	0.248	0.255
QLD	0.230	0.244
SA	0.076	0.068
WA	0.104	0.107
TAS	0.030	0.023
NT	0.007	0.008
ACT	0.026	0.026
% of child care staff w/t exp. (state avg.)	15.7% (4.4%)	15.7% (4.4%)
% of child care staff w/t qual. (state avg.)	66.9% (5.0%)	66.9% (5.0%)
Obs. (number of partnered mothers)	2,023	1,159

Note: Standard deviations are in the parentheses.

Figure 1. Difference between hours worked by mothers and average child care hours of preschool children



3.1.2 Child care price

Gong et al. (2010) show that measurement error in the child care price can have large affects on results in labour supply and child care demand models. In this paper, we follow their method to construct an improved hourly child care price. In the `in-confidence' version of HILDA, only child care costs net of `regular child care benefits' are available. However, with information on child care usage by each child, gross family income, child and family characteristics, and eligibility rules for Child Care Benefits, we are able to construct a more accurate gross hourly child care price for different age ranges of children. For more details on construction of the price, see Gong et al., (2010).

Gong et al. (2010) use the average median price for *all* age groups of children in a Labour Force Survey Region (LFSR). Here, we use the median gross price *specific* to preschool children in a LFSR. The price effects and elasticities

reported in Gong et al. (2010) are the effect of changing the average market price in the LFSR. Changing the average market price in their paper effectively means changing *all* prices for all age groups of children. The price changes analysed here are the price changes for one group of children only. Consequently, the price elasticities in this paper are smaller than those in Gong et al. (2010), which is to be expected.

4. RESULTS

4.1 Estimation results

The SML results are based upon 30 draws per household. We present the parameter estimates of the utility function in Table 2.

The parameters A_{ij} and b_i determine the shape of the utility function but their exact meanings are hard to interpret. The signs of the parameters in b determine the direction in which characteristics affect preferences. A positive β_{2k} implies a positive effect of x_k on the marginal utility of leisure. However, unlike in a standard discrete labour supply model where leisure is specified as the residual of labour supply from the mother's total endowment, it cannot be interpreted readily as a negative effect on labour supply in this model. In this model, leisure is the residual of labour supply and maternal care so that a positive effect on leisure can be a negative effect on either labour supply or maternal care, or both. Similarly, a positive β_{3k} implies a positive effect of x_k on maternal care, which is the residual of total non-maternal child care. Again, it can be a negative effect on either labour supply or formal child care, or both, due to the fact that total non-maternal care is either formal child care or the mother's labour supply.

From the estimates, what can be seen is that, like in the standard models, the variables describing family structure and the mother's characteristics all play important roles in determining preferences. The number of children, age of the mother, and the mother's immigration background (as indicated by speaking a language other than English) all have significant effects on preferences. However, the direction and magnitude of the impacts of the variables on labour supply or maternal care can not be ascertained directly from the parameter values, but rather need to be calculated through simulation.

The parameters in the fixed benefit equation can be linked more directly to the labour force participation of the mother—a positive parameter indicates that the corresponding variable has a positive effect on the benefits of not working and thus a negative impact on participation. For example, the older the youngest child, the lower the fixed benefit of not working is for the mother with pre-school children so that the more likely she is to participate in the labour force. The number of school-aged children also plays a significant role in this fixed benefit--more young children (including school-aged) leads to a higher fixed benefit of staying home and a lower participation.

It is worth noting that unobserved preferences for maternal care play a significant role as well and they are positively correlated with the unobserved heterogeneity the wage equation. The variance of the unobserved preference for leisure is imprecisely estimated, though.

Table 2. Simulated maximum likelihood estimates - parameters of the utility function

Variables		
y^2 (A_{11})	-0.158[-1.34]	
l^2 (A_{22})	-1.472**[-4.53]	
c_m^2 (A_{33})	0.273**[2.96]	
yl (A_{12})	-0.016[-0.16]	
yc_m (A_{13})	-0.005[-0.06]	
lc_m (A_{23})	-0.542**[-5.28]	
b_1	5.079**[6.31]	
$b's$	b_2	b_3
Constant	-0.854[-0.66]	2.952[1.55]
Age of the mother	0.333**[2.20]	0.397**[2.90]
The mother speaks a language other than English	-0.925**[-2.67]	0.004[0.02]
The mother is an Aboriginal and Torres islander	-1.365[-1.33]	1.372[1.29]
The mother was not born but educated in Australia	0.025[0.08]	
The mother was neither born nor educated in Australia	-0.012[-0.03]	
Age of the youngest child	0.406**[5.62]	0.048[0.25]
No. of children aged 0 to 4	0.857**[5.08]	0.331[1.44]
No. of children aged 5 to 12	-0.184*[-1.76]	0.078[0.91]
No. of children aged 13 to 15	0.248[1.17]	-0.646**[-2.80]
Presence of extra female adult	0.135[0.31]	0.468[1.05]
Father received higher edu.	-0.219[-0.78]	-0.154[-0.68]
Father received vocational edu.	-0.038[-0.15]	0.027[0.13]
Father did not finished Year 12	-0.176[-0.60]	-0.126[-0.51]
The mother and the father were not born but educated in Australia		-0.006[-0.04]
Neither the mother nor the father born or educated in Australia		-0.458**[-2.00]
Presence of children older than 12		0.172[1.45]
Mean age of pre-school children		-0.180[-0.92]
% of child care staff w/t exp. (state avg.)		-0.039**[-1.96]
% of child care staff w/t qual. (state avg.)		-0.009[-0.39]
Variance of the unobserved preference for leisure (σ_p^2)	0.014[0.05]	0.160**[3.62]
Cov. of the unobserved preference for leisure with wage (σ_{wp})	0.038 [0.93]	0.149**[6.05]
Fixed benefit equation		
constant	1.168**[7.25]	
Age of the mother	-0.207**[-5.17]	
The mother speaks a language other than English	0.230**[2.95]	
The mother is an Aboriginal and Torres islander	-0.075[-0.44]	
The mother was not born but educated in Australia	0.051[0.84]	
The mother was neither born nor educated in Australia	0.148*[1.79]	
Age of the youngest child	-0.081**[-4.79]	
No. of children aged 0 to 4	0.017[0.46]	
No. of children aged 5 to 12	0.101**[3.48]	
No. of children aged 13 to 15	0.280**[3.72]	
presence of extra female adult	0.003[0.03]	
Father received higher edu.	-0.010[-0.16]	
Father received vocational edu.	-0.043[-0.73]	
Father did not finished Year 12	0.076[1.09]	
Dummy, wave 6	0.026[0.72]	
Dummy, wave 7	0.058[1.56]	
Likelihood	-3347.96	
Obs.	2,023	

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

The parameter estimates for the wage equation are presented in Table 3. The parameter estimates are in line with a standard Mincer equation for Australia (see Breusch and Gray, 2004; Leigh, 2008; and Breunig et al., 2008 for a few examples). For example, higher education brings a wage premium of about 45 per cent for mothers of preschool children, relative to their counterparts who only finished Year 12 and women who speak a language other than English earn less than those who do not.

Table 3. Simulated maximum likelihood estimates –wage equation

Variables	Mothers of the preschool children
Constant	1.994**[7.53]
Age of the mother	0.476**[3.02]
Age-squared of the mother	-0.049**[-2.07]
Mother received higher edu.	0.445**[14.91]
Mother received vocational edu.	0.118**[3.82]
Mother did not finished Year 12	-0.091**[-2.57]
The mother speaks a language other than English	-0.097**[-2.46]
The mother is an Aboriginal and Torres islander	-0.016[-0.11]
The mother was not with both parents at the age of 14	-0.026[-0.97]
Balance of NSW	-0.136**[-3.65]
Melbourne	-0.137**[-4.29]
Balance of VIC	-0.113**[-2.65]
Brisbane	-0.123**[-3.29]
Balance of QLD	-0.122**[-3.21]
Adelaide	-0.048[-0.89]
Balance of SA	-0.254**[-2.87]
Perth	-0.171**[-3.49]
Balance of WA	-0.203**[-3.38]
Tasmania	-0.224**[-2.33]
Northern Territory	-0.095[-0.50]
ACT	-0.068[-1.30]
The mother was not born but educated in Australia	-0.040[-1.34]
The mother was neither born nor educated in Australia	-0.147**[-3.04]
Variance of the wage (σ_w^2)	0.151**[63.62]

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

4.2 Simulation results

Table 4 presents average elasticities of labour supply and child care demand with respect to wage, income, gross child care price and net child care price for the full sample. In Table 5, elasticity estimates for some selected subsamples of interest are presented.

4.2.1 Labour supply elasticities

First of all, it is worth noting that the estimates of wage and income elasticities of labour supply in Table 4 are in line with the literature (see for example, Breunig, et al., 2008). For mothers with preschool children, the average wage elasticities of hours worked and employment are 0.427 and 0.274 (significant at the 5 per cent level) and the income elasticities of hours worked and employment are -0.092 (significant at the 10 per cent level) and -0.048, respectively.

Secondly, the average labour supply elasticities of both gross and net child care price are statistically significant and negative. The average gross child care price elasticities of hours of work and employment for the mothers are -0.106 and -0.070, respectively, which means that for a one per cent increase in the gross child care price, on average, mother's hours of work would decrease by about 0.11 per cent and their employment rate would decrease by 0.07 per cent.

The net price elasticities of hours of work and employment of the mothers with preschool children are -0.096 and -0.059, respectively. As expected, they are slightly smaller than the gross price elasticities due to the means-testing of CCB.

Table 4. Elasticities of the whole sample

With respect to	**Labour supply elasticity**		**Child care demand elasticity**	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price	-0.106** (0.03)	-0.070** (0.02)	-0.294** (0.05)	-0.166** (0.03)
Net child care price	-0.096** (0.03)	-0.059** (0.01)	-0.246** (0.04)	-0.132** (0.02)
Wage	0.427** (0.08)	0.274** (0.05)	0.281** (0.06)	0.176** (0.03)
Income	-0.092* (0.05)	-0.048 (0.04)	-0.036 (0.04)	-0.036* (0.02)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

4.2.2 Relationship to previous results

These findings confirm those of Gong et al. (2010) that there is a negative and statistically significant labour supply response of partnered women to increased child care costs. The estimates reported in Table 4 and those reported by Gong

et al. (2010) are not statistically different than one another. However, Gong et al. (2010) report a higher point estimate of the gross price elasticity of employment of -0.29.

So which is the `right' number? It turns out that the elasticity estimates are different for a variety of reasons. There is one clear reason why the elasticity estimates in this paper should be smaller than those reported in Gong et al. (2010). There are also three other reasons why the estimated elasticities might be different, but the direction of the difference is not clear.

The biggest difference between the two papers is in the estimation approach. In this paper, we directly specify the utility function and the household budget constraint. In Gong, et al. (2010), a linear approximation of labour supply function that is consistent with the utility maximization process is estimated.[12] Secondly, the two papers use different samples. This paper uses a sample of households which have at least one preschool child whereas Gong, et al. (2010) use all households with children under the age of 13. Thirdly, the estimates reported in this paper are the 'average elasticity', which is the average of the elasticity across all observations. In Gong et al., the 'elasticity of the average' is reported, which is the elasticity calculated at the sample average. While it is clear that these differences should result in different elasticity estimates, we have no a priori beliefs about whether this should make elasticity estimates larger or smaller.

[12] Gong et al. (2010) contains a lengthy discussion of the contrast between the `direct' approach of this paper and the `indirect' approach of that paper.

One reason why one might expect smaller elasticities in this paper is that they are calculated with respect to a change in the child care price for preschool children. In Gong et al. (2010), elasticities are reported with respect to a change in average child care price which means that *all* child care prices are changing, not just those for preschool children. This difference is expected to lead to smaller estimates in this paper than in Gong et al. (2010). To confirm this point, we calculated gross child care price elasticities specific to preschool children using the results from Gong et al. (2010). The employment elasticity of child care price of preschool children is estimated to be about -0.15 with a 95 per cent confidence interval of [-0.30, 0.00]. Indeed, this is much smaller than the estimate of -0.29 for the elasticity with respect to average (all) prices.

4.2.3 Child care demand elasticities

As expected, child care demand is negatively impacted by its own price. From Table 4, the average net child care price elasticity of child care hours is about -0.243; for a one per cent increase in the net child care price, child care hours decrease, on average, by about 0.24 per cent. The elasticity of child care use with respect to its own price is -0.166, which means that a one per cent increase in the net child care price would lead to 0.17 per cent decrease in child care use.

The results in Table 4 show that both child care demand and labour supply elasticities with respect to wage are positive and with respect to child care price they are both negative. The two cross-price elasticities have the same sign as the own price elasticities (wage elasticity of labour supply and child care price elasticity of child care) which implies that labour supply and child care are complements.

As mentioned above, the assumption that child care of school-aged children mirrors that of preschool children is quite strong. The results of an alternative specification, in which child care for school-aged children is assumed to be fixed and does not enter the utility function, are presented in Tables A.1.2 and A.1.3 of the Appendix. The simulated elasticities are quite similar to the original specification.

4.2.4 Elasticities of subsamples

In Table 5, elasticities for a few subsamples are presented. The sample is partitioned according to education and wage levels of both partners, non-labour income of the mothers, and the number of children in the household. The differences in the elasticity estimates for the various subsamples illustrate that labour supply response differs by demographic group.

The results show that labour supply of women with higher wages or in households with higher income levels is slightly less responsive to child care price than those with lower wages or from households with lower income. For example, the average employment elasticity of net child care price for women with wages above the median is -0.05, while for those whose wages are below the median, it is -0.07.[13] Comparing women above and below median non-labour income, with high and low education, or with husbands with high and low education produces similar results. This is not surprising, as education, wage, and household income are all strongly correlated. Lower responsiveness from women with higher wages and income may be partly because child care costs are a smaller part of the household budget for these women.

Similar to the results for labour supply elasticities, child care price elasticity is also slightly smaller for women with higher wage/education or with a higher educated husband (or higher non-labour income) than those with lower wage/education or with lower educated husbands (non-labour income).

Child care price elasticities also differ by family type. In households with multiple children, labour supply elasticities of child care price are larger than those in single child households. In multiple children households, child care costs form a larger part of the budget and the effect of the same child care price change in magnitude is therefore larger.

[13] We can reject that these differences are zero at the 5 per cent level using the bootstrapped confidence intervals.

Table 5. Elasticities for selected sub-samples

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price of preschool children				
By mother's education				
With tertiary education	-0.094**(0.03)	-0.061**(0.01)	-0.283**(0.04)	-0.161**(0.03)
Without tertiary education	-0.125**(0.04)	-0.083**(0.02)	-0.310**(0.05)	-0.174**(0.03)
By father's education				
With tertiary education	-0.095** (0.03)	-0.062** (0.01)	-0.279** (0.04)	-0.158** (0.03)
Without tertiary education	-0.132** (0.04)	-0.089** (0.02)	-0.328** (0.05)	-0.185** (0.03)
By number of children				
One pre-school child	-0.079** (0.02)	-0.052** (0.01)	-0.225** (0.03)	-0.130** (0.02)
Multiple pre-school children	-0.158** (0.05)	-0.105** (0.03)	-0.427** (0.07)	-0.236** (0.04)
By mother's wage				
Above median	-0.083**(0.02)	-0.053**(0.01)	-0.270**(0.04)	-0.152**(0.03)
Below median	-0.130**(0.04)	-0.087**(0.02)	-0.318**(0.05)	-0.180**(0.03)
By mother's non-labour income				
Above median	-0.077**(0.02)	-0.050**(0.01)	-0.236**(0.04)	-0.138**(0.02)
Below median	-0.136**(0.04)	-0.090**(0.02)	-0.353**(0.05)	-0.194**(0.03)
Net child care price				
By mother's education				
With tertiary education	-0.088** (0.02)	-0.054** (0.01)	-0.243** (0.04)	-0.130** (0.02)
Without tertiary education	-0.106** (0.03)	-0.066** (0.02)	-0.250** (0.04)	-0.133** (0.02)
By father's education				
With tertiary education	-0.089** (0.02)	-0.054** (0.01)	-0.240** (0.04)	-0.128** (0.02)
Without tertiary education	-0.110** (0.03)	-0.071** (0.02)	-0.260** (0.04)	-0.139** (0.02)
By number of children				
One pre-school child	-0.077** (0.02)	-0.047** (0.01)	-0.206** (0.03)	-0.112** (0.02)
Multiple pre-school children	-0.131** (0.04)	-0.082** (0.02)	-0.332** (0.05)	-0.169** (0.03)
By mother's wage				
Above median	-0.080**(0.02)	-0.051**(0.01)	-0.258**(0.05)	-0.127**(0.02)
Below median	-0.109**(0.03)	-0.069**(0.02)	-0.252**(0.05)	-0.145**(0.03)
By mother's non-labour income				
Above median	-0.080**(0.02)	-0.051**(0.01)	-0.242**(0.05)	-0.143**(0.03)
Below median	-0.109**(0.03)	-0.073**(0.02)	-0.353**(0.05)	-0.194**(0.03)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

Table 5 continued. Elasticities for selected sub-samples

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Wage				
By mother's education				
With tertiary education	0.449** (0.08)	0.286** (0.05)	0.310** (0.07)	0.195** (0.04)
Without tertiary education	0.396** (0.07)	0.256** (0.04)	0.238** (0.06)	0.148** (0.03)
By father's education				
With tertiary education	0.409** (0.07)	0.258** (0.04)	0.274** (0.06)	0.171** (0.03)
Without tertiary education	0.467** (0.09)	0.309** (0.06)	0.295** (0.07)	0.186** (0.04)
By number of children				
One pre-school child	0.426** (0.08)	0.270** (0.04)	0.305** (0.07)	0.196** (0.04)
Multiple pre-school children	0.429** (0.08)	0.282** (0.05)	0.234** (0.05)	0.137** (0.03)
By mother's wage				
Above median	0.425**(0.07)	0.265**(0.04)	0.292**(0.06)	0.180**(0.03)
Below median	0.429**(0.08)	0.283**(0.05)	0.269**(0.06)	0.171**(0.04)
By mother's non-labour income				
Above median	0.366**(0.07)	0.234**(0.04)	0.247**(0.05)	0.154**(0.03)
Below median	0.488**(0.09)	0.314**(0.05)	0.314**(0.07)	0.197**(0.04)
Income				
By mother's education				
With tertiary education	-0.118** (0.06)	-0.066 (0.04)	-0.050 (0.04)	-0.041 (0.03)
Without tertiary education	-0.055* (0.03)	-0.022 (0.02)	-0.017 (0.04)	-0.019 (0.02)
By father's education				
With tertiary education	-0.112*(0.06)	-0.064 (0.04)	-0.047 (0.04)	-0.040 (0.03)
Without tertiary education	-0.046 (0.04)	-0.012 (0.03)	-0.014 (0.03)	-0.014 (0.02)
By number of children				
One pre-school child	-0.093* (0.05)	-0.045 (0.04)	-0.041 (0.04)	-0.033 (0.02)
Multiple pre-school children	-0.089* (0.05)	-0.054 (0.05)	-0.027 (0.04)	-0.031 (0.02)
By mother's wage				
Above median	-0.129**(0.06)	-0.075*(0.04)	-0.052(0.04)	-0.043(0.03)
Below median	-0.055(0.04)	-0.021(0.04)	-0.021(0.03)	-0.021(0.02)
By mother's non-labour income				
Above median	-0.165**(0.08)	-0.108(0.06)	-0.064(0.06)	-0.055(0.04)
Below median	-0.019(0.02)	0.012(0.02)	-0.009(0.02)	-0.009(0.01)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

5. CONCLUSIONS

In this paper, we construct and estimate a model of labour supply and child care demand for partnered women with preschool children. The model is an extension of the standard discrete structural labour supply model which explicitly includes child care as a separate argument of the utility function. This model enables us to analyse labour supply and child care demand simultaneously. This approach probably corresponds more closely to how households actually make decisions about work and child care. We introduce an important methodological innovation in this paper in that we impose a

quantity constraint that the number of total child care hours (formal and informal) is required to be at least as large as the number of hours worked by the mother. Unobserved heterogeneity in time allocation preferences is included and is allowed to be correlated with unobservable factors which influence wages. The model is estimated using Simulated Maximum Likelihood with data drawn from the fifth to seventh waves (covering the period 2005 - 2007) of the 'in-confidence' version of the Household, Income, and Living Dynamics in Australia (HILDA) Survey.

Utility function, child care demand, and wage equation estimates are used to simulate estimates of the gross and net child care price elasticities for partnered women with children. The framework can also be used to estimate the effects on labour supply, child care, income distributions, and public expenditure of possible future policy changes.

We find statistically significant gross and net child care price elasticities of labour supply for partnered women with young children. In particular the net child care price elasticity of hours of work and employment are about -0.10 and -0.06, respectively. Although these point estimates are slightly different than those in Gong et al. (2010), they re-confirm that the labour supply behaviour of partnered women with young children does respond to the price of child care.

We explore how different demographic groups may respond differently to child care price changes. Labour supply and child care demand responses to child care price changes are highest amongst women with lower wages, lower household income, and lower education. This suggests that targeted child care subsidies may be slightly more effective for low wage earners and/or women in low income households if the aim is to encourage female labour supply.

Our results correspond to much of the previous literature. The wage equations we estimate are similar to other estimates from Australia, the child care demand curve is downward sloping, and labour supply and child care are complements. Furthermore, the results appear to be robust to changes in model specification.

Here we focus only on partnered mothers with preschool children and we treat father's work and child care decisions as being given. This provides two future extensions which could be considered: the analysis could be extended to households with only school-aged children (and without preschool children) and to single-parent households and the behaviour of fathers in couple-headed households could be included in the model. Both extensions involve additional model complexity but could potentially enrich the results of this paper.

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APPENDIX

A.1 ESTIMATES OF AN ALTERNATIVE SPECIFICATION

The following tables present the results of an alternative model specification where child care of the school-aged children is assumed to be fixed and does not enter the utility function explicitly.

Table A.1.1. Simulated maximum likelihood estimates of the alternative model specification - parameters of the utility function

Variables		
y^2 (A_{11})	-0.165[-1.41]	
l^2 (A_{22})	-1.460**[-4.52]	
c_m^2 (A_{33})	0.278**[3.01]	
yl (A_{12})	-0.027[-0.26]	
yc_m (A_{13})	-0.009[-0.10]	
lc_m (A_{23})	-0.514**[-5.03]	
b_1	5.074**[6.22]	
$b's$		
	b_2	b_3
Constant	-0.895[-0.69]	2.910[1.53]
Age of the mother	0.346**[2.29]	0.398**[2.90]
The mother speaks a language other than English	-0.938**[-2.72]	-0.001[0.00]
The mother is an Aboriginal and Torres islander	-1.371**[-1.34]	1.355[1.25]
The mother was not born but educated in Australia	0.039[0.13]	
The mother was neither born nor educated in Australia	0.001[0.00]	
Age of the youngest child	0.399**[5.53]	0.047[0.25]
No. of children aged 0 to 4	0.867**[5.16]	0.346[1.50]
No. of children aged 5 to 12	-0.212**[-2.01]	0.110[1.28]
No. of children aged 13 to 15	0.285[1.34]	-0.650**[-2.83]
Presence of extra female adult	0.140[0.31]	0.456[1.02]
Father received higher edu.	-0.220[-0.79]	-0.150[-0.66]
Father received vocational edu.	-0.034[-0.13]	0.028[0.14]
Father did not finished Year 12	-0.191[-0.65]	-0.132[-0.53]
The mother and the father were not born but educated in Australia		-0.020[-0.14]
Neither the mother nor the father born or educated in Australia		-0.459**[-2.01]
Presence of children older than 12		0.163[1.38]
Mean age of pre-school children		-0.176[-0.90]
% of child care staff w/t exp. (state avg.)		-0.038*[-1.95]
% of child care staff w/t qual. (state avg.)		-0.009[-0.37]
Variance of the unobserved preference for leisure ($\sigma^2_{p_2}$)	0.013[0.05]	0.159**[3.11]
Cov. of the unobserved preference for leisure with wage (σ_{wp_2})	0.037[0.91]	0.147**[5.98]
Fixed benefit equation		
constant	1.222**[7.26]	
Age of the mother	-0.218**[-5.22]	
The mother speaks a language other than English	0.239**[2.96]	
The mother is an Aboriginal and Torres islander	-0.067[-0.38]	
The mother was not born but educated in Australia	0.053[0.84]	
The mother was neither born nor educated in Australia	0.154*[1.80]	
Age of the youngest child	-0.083**[-4.75]	
No. of children aged 0 to 4	0.014[0.35]	
No. of children aged 5 to 12	0.108**[3.56]	
No. of children aged 13 to 15	0.288**[3.67]	
presence of extra female adult	0.004[0.04]	
Father received higher edu.	-0.009[-0.13]	
Father received vocational edu.	-0.045[-0.74]	
Father did not finished Year 12	0.079[1.10]	
Dummy, wave 6	0.027[0.72]	
Dummy, wave 7	0.059[1.54]	
Likelihood	-3350.86	
Obs.	2,023	

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

Table A.1.2. Simulated maximum likelihood estimates of the alternative model specification –wage equation

Variables	Mothers of the preschool children
Constant	1.992**[7.52]
Age of the mother	0.477**[3.02]
Age-squared of the mother	-0.049**[-2.08]
Mother received higher edu.	0.449**[15.01]
Mother received vocational edu.	0.121**[3.92]
Mother did not finished Year 12	-0.089**[-2.51]
The mother speaks a language other than English	-0.097**[-2.46]
The mother is an Aboriginal and Torres islander	-0.014[-0.10]
The mother was not with both parents at the age of 14	-0.027[-1.00]
Balance of NSW	-0.138**[-3.69]
Melbourne	-0.139**[-4.34]
Balance of VIC	-0.114**[-2.67]
Brisbane	-0.125**[-3.34]
Balance of QLD	-0.123**[-3.21]
Adelaide	-0.049[-0.91]
Balance of SA	-0.256**[-2.91]
Perth	-0.172**[-3.50]
Balance of WA	-0.207**[-3.45]
Tasmania	-0.223**[-2.31]
Northern Territory	-0.094[-0.50]
ACT	-0.068[-1.30]
The mother was not born but educated in Australia	-0.039[-1.28]
The mother was neither born nor educated in Australia	-0.147**[-3.04]
Variance of the wage (σ_w^2)	0.151**[63.66]

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

Table A.1.3. Elasticities of the whole sample (the alternative model specification)

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price	-0.105** (0.03)	-0.069** (0.02)	-0.282** (0.05)	-0.160** (0.03)
Net child care price	-0.079** (0.02)	-0.052** (0.01)	-0.221** (0.04)	-0.126** (0.02)
Wage	0.417** (0.09)	0.268** (0.05)	0.275** (0.06)	0.172** (0.04)
Income	-0.087 (0.05)	-0.045 (0.04)	-0.038 (0.04)	-0.032 (0.02)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

Table A.1.4. Elasticities for selected sub-samples (the alternative model specification)

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price of preschool children				
By mother's education				
With tertiary education	-0.092** (0.03)	-0.060** (0.01)	-0.272** (0.04)	-0.155** (0.03)
Without tertiary education	-0.123**(0.04)	-0.081**(0.02)	-0.297**(0.05)	-0.167**(0.03)
By father's education				
With tertiary education	-0.092** (0.03)	-0.060** (0.01)	-0.272**(0.04)	-0.155**(0.03)
Without tertiary education	-0.130** (0.04)	-0.088** (0.02)	-0.315**(0.05)	-0.178**(0.03)
By number of children				
One pre-school child	-0.079** (0.02)	-0.051** (0.01)	-0.216** (0.03)	-0.125** (0.02)
Multiple pre-school children	-0.155**(0.05)	-0.102** (0.03)	-0.409** (0.07)	-0.228** (0.04)
By mother's wage				
Above median	-0.081**(0.02)	-0.052**(0.01)	-0.259**(0.04)	-0.146**(0.03)
Below median	-0.128**(0.04)	-0.085**(0.02)	-0.305**(0.05)	-0.174**(0.03)
By mother's non-labour income				
Above median	-0.076**(0.02)	-0.049**(0.01)	-0.225**(0.04)	-0.133**(0.02)
Below median	-0.134**(0.04)	-0.089**(0.02)	-0.339*8(0.05)	-0.187*8(0.03)
Net child care price				
By mother's education				
With tertiary education	-0.079** (0.02)	-0.048** (0.01)	-0.213** (0.03)	-0.115** (0.02)
Without tertiary education	-0.091**(0.03)	-0.056**(0.01)	-0.210**(0.04)	-0.111**(0.02)
By father's education				
With tertiary education	-0.078**(0.02)	-0.047** (0.01)	-0.206**(0.34)	-0.111**(0.02)
Without tertiary education	-0.097** (0.03)	-0.061** (0.02)	-0.223**(0.04)	-0.119**(0.02)
By number of children				
One pre-school child	-0.064** (0.02)	-0.039** (0.01)	-0.168** (0.03)	-0.092** (0.02)
Multiple pre-school children	-0.121** (0.04)	-0.075** (0.02)	-0.294** (0.05)	-0.154** (0.03)
By mother's wage				
Above median	-0.067**(0.02)	-0.043**(0.01)	-0.218**(0.04)	-0.124**(0.02)
Below median	-0.092**(0.03)	-0.061**(0.01)	-0.223**(0.04)	-0.128**(0.02)
By mother's non-labour income				
Above median	-0.069**(0.02)	-0.044**(0.01)	-0.205**(0.04)	-0.121**(0.02)
Below median	-0.090**(0.02)	-0.060**(0.01)	-0.236**(0.04)	-0.131**(0.02)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

Table A.1.4 continued. Elasticities for selected sub-samples (the alternative model specification)

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Wage				
By mother's education				
With tertiary education	0.439** (0.09)	0.280** (0.05)	0.303** (0.07)	0.191** (0.04)
Without tertiary education	0.387**(0.08)	0.250**(0.05)	0.235**(0.06)	0.146**(0.03)
By father's education				
With tertiary education	0.400**(0.08)	0.252**(0.05)	0.268** (0.06)	0.168** (0.03)
Without tertiary education	0.458** (0.10)	0.303** (0.06)	0.291**(0.07)	0.183**(0.04)
By number of children				
One pre-school child	0.417** (0.08)	0.265** (0.05)	0.300** (0.07)	0.193** (0.04)
Multiple pre-school children	0.418** (0.09)	0.274** (0.06)	0.228**(0.05)	0.134**(0.03)
By mother's wage				
Above median	0.415**(0.08)	0.259**(0.05)	0.286**(0.06)	0.177**(0.03)
Below median	0.420**(0.09)	0.277**(0.05)	0.265**(0.07)	0.168**(0.04)
By mother's non-labour income				
Above median	0.356**(0.07)	0.227**(0.04)	0.240**(0.05)	0.150**(0.03)
Below median	0.479**(0.10)	0.308**(0.06)	0.310**(0.07)	0.195**(0.04)
Income				
By mother's education				
With tertiary education	-0.113** (0.06)	-0.063** (0.04)	-0.052 (0.04)	-0.041 (0.03)
Without tertiary education	-0.051 (0.04)	-0.019(0.03)	-0.019 (0.03)	-0.019(0.02)
By father's education				
With tertiary education	-0.107*(0.06)	-0.060(0.04)	-0.049(0.04)	-0.041(0.03)
Without tertiary education	-0.042(0.04)	-0.009(0.03)	-0.014(0.03)	-0.013(0.02)
By number of children				
One pre-school child	-0.089* (0.05)	-0.042 (0.04)	-0.043 (0.04)	-0.033 (0.02)
Multiple pre-school children	-0.084* (0.05)	-0.050 (0.04)	-0.028 (0.04)	-0.032 (0.02)
By mother's wage				
Above median	-0.125**(0.06)	-0.071*(0.04)	-0.055(0.04)	-0.044(0.03)
Below median	-0.050(0.04)	-0.018(0.03)	-0.021(0.03)	-0.020(0.02)
By mother's non-labour income				
Above median	-0.159**(0.08)	-0.104**(0.06)	-0.069(0.05)	-0.057(0.04)
Below median	-0.015(0.02)	0.014(0.02)	-0.007(0.02)	-0.007(0.01)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

A.2 ESTIMATES USING THE SUB-SAMPLE OF MOTHERS WITH PRE-SCHOOL CHILDREN ONLY

The following tables present the results using the sub-sample of mothers with pre-school only where the child care issue of the school-aged children does not exist.

Table A.2.1. Simulated maximum likelihood estimates for the sub-sample - parameters of the utility function

Variables		
y^2 (A_{11})	-0.278**[-2.40]	
l^2 (A_{22})	-1.714**[-3.91]	
c_m^2 (A_{33})	0.069[0.54]	
yl (A_{12})	-0.066[-0.45]	
yc_m (A_{13})	-0.120[-1.09]	
lc_m (A_{23})	-0.525**[-3.81]	
b_1	6.186**[8.38]	
$b's$	b_2	b_3
Constant	-0.761[-0.41]	4.995**[2.02]
Age of the mother	0.412**[2.03]	0.283*[1.70]
The mother speaks a language other than English	-0.814*[-1.75]	-0.064[-0.20]
The mother is an Aboriginal and Torres islander	-0.895[-0.87]	2.854**[2.43]
The mother was not born but educated in Australia	0.113[0.29]	
The mother was neither born nor educated in Australia	0.055[0.10]	
Age of the youngest child	0.451**[4.07]	0.068[0.29]
No. of children aged 0 to 4	0.837**[3.67]	0.399[1.47]
No. of children aged 5 to 12		
No. of children aged 13 to 15	-0.213[-0.57]	-0.314[-0.86]
Presence of extra female adult	0.830[1.16]	0.724[1.25]
Father received higher edu.	-0.306[-0.77]	-0.132[-0.53]
Father received vocational edu.	-0.090[-0.26]	-0.128[-0.45]
Father did not finished Year 12	-0.011[-0.03]	-0.128[-0.48]
The mother and the father were not born but educated in Australia		0.061[0.32]
Neither the mother nor the father born or educated in Australia		-0.686**[-2.42]
Presence of children older than 12		0.015[0.10]
Mean age of pre-school children		-0.279[-1.15]
% of child care staff w/t exp. (state avg.)		-0.042*[-1.64]
% of child care staff w/t qual. (state avg.)		-0.007[-0.25]
Variance of the unobserved preference for leisure ($\sigma^2_{p_2}$)	0.012[0.06]	0.118**[2.03]
Cov. of the unobserved preference for leisure with wage (σ_{wp_2})	0.041[0.63]	0.132**[4.05]
Fixed benefit equation		
constant	1.424**[5.55]	
Age of the mother	-0.266**[-4.10]	
The mother speaks a language other than English	0.193[1.46]	
The mother is an Aboriginal and Torres islander	-0.477**[-2.20]	
The mother was not born but educated in Australia	0.104[1.08]	
The mother was neither born nor educated in Australia	0.279**[2.17]	
Age of the youngest child	-0.084**[-3.06]	
No. of children aged 0 to 4	0.021[0.37]	
No. of children aged 5 to 12		
No. of children aged 13 to 15	0.404**[2.63]	
presence of extra female adult	-0.242[1.53]	
Father received higher edu.	0.025[-0.25]	
Father received vocational edu.	-0.058[-0.65]	
Father did not finished Year 12	0.157[1.42]	
Dummy, wave 6	0.030[0.51]	
Dummy, wave 7	0.051[0.86]	
Likelihood	-1,979.49	
Obs.	1,159	

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

Table A.2.2. Simulated maximum likelihood estimates for the sub-sample –wage equation

Variables	Mothers of the preschool children
Constant	2.405**[6.19]
Age of the mother	0.186[0.79]
Age-squared of the mother	0.002[0.06]
Mother received higher edu.	0.429**[10.67]
Mother received vocational edu.	0.155**[3.68]
Mother did not finished Year 12	-0.088[-1.58]
The mother speaks a language other than English	-0.093[-1.61]
The mother is an Aboriginal and Torres islander	-0.084[-0.46]
The mother was not with both parents at the age of 14	-0.103**[-2.38]
Balance of NSW	-0.052[-0.98]
Melbourne	-0.123**[-2.66]
Balance of VIC	-0.059[-0.98]
Brisbane	-0.093*[-1.79]
Balance of QLD	-0.147**[-2.53]
Adelaide	-0.142**[-2.06]
Balance of SA	-0.144[-1.21]
Perth	-0.198**[-2.58]
Balance of WA	-0.361**[-2.88]
Tasmania	-0.162[-0.88]
Northern Territory	-0.167[-0.76]
ACT	-0.151**[-2.11]
The mother was not born but educated in Australia	0.023[0.54]
The mother was neither born nor educated in Australia	-0.009[-0.15]
Variance of the wage (σ_w^2)	0.150**[45.85]

t-values are in the brackets. * Significant at 10% level. ** Significant at 5% level.

Table A.2.3. Elasticities of the mothers with pre-school children only

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price	-0.107** (0.03)	-0.072** (0.02)	-0.284** (0.07)	-0.159** (0.03)
Net child care price	-0.081** (0.03)	-0.054** (0.02)	-0.223** (0.03)	-0.126** (0.02)
Wage	0.432** (0.11)	0.278** (0.07)	0.304** (0.06)	0.189** (0.04)
Income	-0.029 (0.05)	0.002 (0.03)	-0.012 (0.04)	0.001 (0.03)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

Table A.2.4. Elasticities for selected sub-samples of the mothers with pre-school children only

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Gross child care price of preschool children				
By mother's education				
With tertiary education	-0.094** (0.03)	-0.063** (0.02)	-0.271** (0.06)	-0.152** (0.03)
Without tertiary education	-0.131**(0.04)	-0.088**(0.03)	-0.310**(0.08)	-0.171**(0.04)
By father's education				
With tertiary education	-0.095**(0.03)	-0.062** (0.02)	-0.271** (0.06)	-0.151** (0.03)
Without tertiary education	-0.135** (0.05)	-0.093** (0.03)	-0.314** (0.07)	-0.177** (0.04)
By number of children				
One pre-school child	-0.077** (0.02)	-0.052** (0.01)	-0.211**(0.05)	-0.122**(0.02)
Multiple pre-school children	-0.147** (0.05)	-0.097** (0.03)	-0.382**(0.10)	-0.208**(0.04)
By mother's wage				
Above median	-0.081**(0.03)	-0.053**(0.02)	-0.255**(0.06)	-0.142**(0.03)
Below median	-0.133**(0.04)	-0.090**(0.03)	-0.314**(0.07)	-0.175**(0.04)
By mother's non-labour income				
Above median	-0.079**(0.03)	-0.051**(0.02)	-0.223**(0.06)	-0.129**(0.03)
Below median	-0.135**(0.04)	-0.092**(0.03)	-0.345**(0.08)	-0.188**(0.04)
Net child care price				
By mother's education				
With tertiary education	-0.076** (0.02)	-0.051** (0.01)	-0.223** (0.06)	-0.126** (0.03)
Without tertiary education	-0.091**(0.03)	-0.061**(0.02)	-0.224**(0.06)	-0.124**(0.03)
By father's education				
With tertiary education	-0.075** (0.02)	-0.049** (0.01)	-0.221** (0.06)	-0.124** (0.03)
Without tertiary education	-0.095** (0.03)	-0.066** (0.02)	-0.228** (0.06)	-0.130** (0.03)
By number of children				
One pre-school child	-0.060** (0.02)	-0.040** (0.01)	-0.167**(0.02)	-0.097**(0.01)
Multiple pre-school children	-0.110**(0.04)	-0.073** (0.02)	-0.299**(0.09)	-0.164**(0.04)
By mother's wage				
Above median	-0.068**(0.02)	-0.045**(0.01)	-0.216**(0.06)	-0.121**(0.03)
Below median	-0.095**(0.03)	-0.064**(0.02)	-0.231**(0.06)	-0.130**(0.03)
By mother's non-labour income				
Above median	-0.071**(0.02)	-0.046**(0.01)	-0.203**(0.06)	-0.117**(0.03)
Below median	-0.092**(0.03)	-0.063**(0.02)	-0.244**(0.06)	-0.134**(0.03)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.

Table A.2.4 continued. Elasticities for selected sub-samples of the mothers with pre-school children only

With respect to	Labour supply elasticity		Child care demand elasticity	
	Hours	*employment*	*Hours of formal care*	*Use of formal care*
Wage				
By mother's education				
With tertiary education	0.437** (0.11)	0.281** (0.07)	0.322** (0.07)	0.207** (0.04)
Without tertiary education	0.421**(0.11)	0.274**(0.07)	0.270**(0.06)	0.167**(0.03)
By father's education				
With tertiary education	0.401** (0.09)	0.253** (0.06)	0.293**(0.06)	0.128**(0.04)
Without tertiary education	0.502** (0.13)	0.336** (0.09)	0.330** (0.07)	0.207** (0.04)
By number of children				
One pre-school child	0.440** (0.10)	0.285** (0.07)	0.342**(0.07)	0.223**(0.04)
Multiple pre-school children	0.420**(0.11)	0.269**(0.08)	0.253** (0.05)	0.144** (0.03)
By mother's wage				
Above median	0.412**(0.10)	0.258**(0.07)	0.308**(0.06)	0.189**(0.04)
Below median	0.451**(0.11)	0.298**(0.08)	0.300**(0.07)	0.189**(0.04)
By mother's non-labour income				
Above median	0.352**(0.09)	0.221**(0.06)	0.255**(0.05)	0.158**(0.03)
Below median	0.511**(0.13)	0.336**(0.09)	0.353**(0.08)	0.221**(0.04)
Income				
By mother's education				
With tertiary education	-0.051 (0.05)	-0.014 (0.04)	0.002 (0.04)	-0.005 (0.03)
Without tertiary education	0.013 (0.04)	0.034(0.03)	0.031 (0.04)	0.012(0.03)
By father's education				
With tertiary education	-0.055 (0.06)	-0.021 (0.04)	-0.003 (0.04)	-0.011 (0.03)
Without tertiary education	0.032(0.03)	0.055 (0.03)	0.045 (0.03)	-0.028 (0.02)
By number of children				
One pre-school child	-0.043(0.05)	-0.003(0.04)	0.000(0.04)	-0.003(0.03)
Multiple pre-school children	-0.010(0.04)	0.010(0.03)	0.028(0.04)	0.006(0.02)
By mother's wage				
Above median	-0.075(0.06)	-0.036(0.04)	-0.013(0.04)	-0.017(0.03)
Below median	0.017(0.04)	0.040(0.03)	0.037(0.036)	0.018(0.03)
By mother's non-labour income				
Above median	-0.069(0.07)	-0.040(0.05)	0.003(0.05)	-0.010(0.04)
Below median	0.012(0.03)	0.045**(0.02)	0.021(0.03)	0.012(0.02)

Standard errors are in the parentheses. ** Significant at 5 % level. * Significant at 10% level.