DISCUSSION PAPER SERIES

IZA

IZA DP No. 7007

Labor Supply Heterogeneity and Demand for Child Care of Mothers with Young Children

Patricia Apps
Jan Kabátek
Ray Rees
Arthur van Soest

November 2012

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Labor Supply Heterogeneity and Demand for Child Care of Mothers with Young Children

Patricia Apps
Sydney University Law School and IZA

Jan Kabátek
Tilburg University and Netspar

Ray Rees
CES, University of Munich

Arthur van Soest
Tilburg University, Netspar and IZA

Discussion Paper No. 7007
November 2012

IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

IZA Discussion Paper No. 7007
November 2012

ABSTRACT

Labor Supply Heterogeneity and Demand for Child Care of Mothers with Young Children*

This paper introduces a static structural model of hours of market labor supply, time spent on child care and other domestic work, and bought in child care for married or cohabiting mothers with pre-school age children. The father's behavior is taken as given. The main goal is to analyze the sensitivity of hours of market work, parental child care, other household production and formal child care to the wage rate, the price of child care, taxes, benefits and child care subsidies. To account for the non-convex nature of the budget sets and, possibly, the household technology, a discrete choice model is used. The model is estimated using the HILDA dataset, a rich household survey of the Australian population, which contains detailed information on time use, child care demands and the corresponding prices. Simulations based on the estimates show that the time allocations of women with pre-school children are highly sensitive to changes in wages and the costs of child care. A policy simulation suggests that labor force participation and hours of market work would increase substantially in a fiscal system based solely on individual rather than joint taxation.

JEL Classification: J22, J13, H24

Keywords: time use, income tax, child care subsidies

Corresponding author:

Jan Kabátek
Department of Econometrics and OR
Tilburg University
P.O. Box 90153
5000 LE Tilburg
The Netherlands
E-mail: j.kabatek@uvt.nl

* This research was supported under the Australian Research Council's Discovery Project funding scheme (DP1094021). The authors thank seminar participants at Université Laval, University of Lausanne, University of Mannheim, Netherlands Bureau for Economic Policy Analysis (CPB), Tilburg University, the ESPE Annual Conference, the NATSEM International Child Care, Work, and Family Workshop, the Netspar Pension Day, and the Netspar International Workshop for their valuable comments.

1 Introduction

One of the most striking, and still largely unexplained, facts about female labor supply in the developed countries is its heterogeneity across households, and indeed across countries. In most OECD countries, on average around one third of women work full-time in the labor force, one third do various amounts of part time work, and one third work solely in household production. Very little of the aggregate heterogeneity across all households in any one country is explained by wage rate differences and by the number of children present in the household. Moreover, the correlation between female labor supply and fertility across these countries is strongly positive, even though historically, in any one country, there has been an inverse relationship between them.

Some insight is gained by organizing the data in terms of life cycle phases based on the number and age of children in the household. In the pre-children phase, there is very little difference between male and female labor supply distributions. This changes dramatically when children arrive, and this is when the female labor supply heterogeneity essentially sets in. Though there is a trend of return to the labor force over subsequent phases of the life cycle as the children reach school age and beyond, the basic pattern of heterogeneity persists. Such findings suggest that for the theoretical and empirical analysis of female labor supply it is fruitful to focus on the life cycle phase in which households have young children.

Clearly, the birth of a child implies a fundamental change in the lives of the parents, affecting the couple's preferences, consumption patterns, and the way in which they spend their time. Parents can either specialize in providing child care themselves, or rely on services provided by other care givers such as relatives, friends, and formal institutions. The importance of the availability and the cost of child care services for labor supply of mothers of young children has been confirmed by a host of both theoretical (Apps & Rees, 2009) and empirical studies, including Ribar (1995), Duncan et al. (2001), Blau (2003), Connelly & Kimmel (2003), Doiron & Kalb (2005), Kalenkoski et al. (2005), Kornstad & Thoresen (2007), Baker et al. (2008), and Blundell & Shephard (2011).

The current paper presents a static structural discrete choice model analyzing the time allocation choices of married and cohabiting mothers with preschool aged children. The main advantage of the discrete choice approach is that it can account for the non-convex nature of the household budget sets and, possibly, also of the household technology. Within this model, we analyze the decisions of mothers on hours of market work, time spent on child care and other domestic work, and amount of bought-in child care. The main goal is to assess the sensitivity of choices at the intensive and extensive margin of female labor supply, and to capture underlying substitution patterns between alternative uses of mothers' time.

A similar modeling framework is also employed by Doiron & Kalb (2005), Kornstad & Thoresen (2007), and Blundell & Shephard (2011). We allow for a more flexible household utility function than previous studies (following Van

Soest, 1995 and Van Soest & Stancanelli, 2010) and include both formal child care and informal child care provided by the mother into the household utility function.[1] The key innovation of our approach is however the incorporation of unobserved heterogeneity in the flexible form of latent classes, following Train (2008) and Pacifico (2009). We extend the treatment of unobserved heterogeneity beyond the traditional framework of random coefficient models[2], avoiding restrictive assumptions on the distribution of the population parameters of the utility function. While existing studies often find that the role of unobserved heterogeneity is limited, this may well be due to a too restrictive assumption on the distribution of the unobserved heterogeneity components. We find that our flexible way of incorporating unobserved heterogeneity leads to very different labor supply elasticities from those of a model without heterogeneity.

The model is estimated using the HILDA dataset, a household survey of the Australian population which contains detailed information on time use, child care demands and the corresponding prices. Simulations based on our estimates show that hours of market work and the formal child care demands of mothers with pre-school children are highly sensitive to changes in net wages and the costs of bought-in child care. A policy simulation suggests that labor force participation and hours of market work would increase substantially in a fiscal system based solely on individual rather than joint taxation.

The paper is organized as follows. In the next section we set out the underlying household model. In Section 3 we present the econometric specification of the model that we take to the data. Section 4 discusses the data used for the estimations and Section 5 presents and discusses the estimation results. Section 6 presents the results of the simulations. Section 7 concludes.

2 The Model

We present the model of household choice in a static framework, ignoring the fact that this is just one phase in the household's overall life cycle. This seems a strong limitation, since *a priori* we expect that decisions made in this phase, especially on female labor supply, could be influenced by intertemporal factors, such as the anticipated loss of human capital resulting from reducing current market labor supply and the effects of this on future wage rates and employment possibilities. Thus a woman may continue working in this phase, despite a low or even negative current wage net of tax, social security payments and child care costs, as an investment in her long-term career prospects. Since lack of data precludes incorporation of these issues in the econometric work, we cannot

[1] In prior work, only formal care has been incorporated into the utility function. This has been done either directly, with the hours of child care being an argument of the utility function (Ribar, 1995), or indirectly by subtracting the child care costs from disposable household income (Doiron & Kalb, 2005; Kornstad & Thoresen, 2007). In our model we employ the direct approach, so that formal and informal child care can be imperfect substitutes with different effects on household utility.

[2] Applications using this approach include Ribar (1995), Doiron & Kalb (2005) and Van Soest & Stancanelli (2010).

capture them fully in the following model. However, we do attempt to capture them in a reduced form sense, since the marginal utility of market work *vis á vis* leisure or domestic work will tend to be increased by the existence of such factors. We also take the number of children in the household as exogenously fixed, and so do not model the fertility decision.

Household $h = 1, 2, ...H$, chooses:

- its consumptions of a market good x_{ih}, with $i = 1, 2, .., n$ denoting the individuals within the household;
- the mother's leisure consumption l_{2h};
- consumption of a composite household good y_h, comprising child care as well as other forms of household production;
- the second earner's time inputs into production of this household good, t^y_{2h};
- purchases of the market child care good m^c_h.

Consumption is a composite market good with price 1, the mother's gross wage rate is w_{2h}, and the price of the market child care good is p^c_h. Note that, as the data suggest, we allow this price to vary across households.[3] Throughout, we take the father's leisure $\hat{l}_{1h}$ and time allocation $\hat{t}^y_{1h}$ as exogenously given. Therefore, given the time endowment constraint, his market labor supply $L_{1h} = \hat{L}_{1h}$ is also taken as exogenously fixed. The sum of the primary and second earners' gross incomes from market supply, $\sum_i w_{ih} L_{ih}$ is denoted by $I_h(w_{1h}, w_{2h})$. The two adults in the household have utility functions $u_{ih}(x_{ih}, y_h, l_{ih})$, $i = 1, 2$, and the children's utilities are $u_{ih}(x_{ih}, y_h)$, $i = 3, .., n$. Thus child care and other household outputs are modeled as a household public good.

The household is assumed to maximize a household welfare function, concave in utilities,

$$W_h = \Psi_h(u_{1h}(.), ..., u_{nh}(.); \mathbf{e}_h) \ h = 1, 2, ...H \tag{1}$$

where $\mathbf{e}_h$ is a vector of exogenously given "environmental" or "distributional" factors which can be interpreted as determining the household's preferences over the utility profiles of its members.[4] This function is based upon some household choice process which need not be further specified, and is intended to capture such things as love and caring for each other, as well as more conventional attributes of social welfare functions such as ethical views of fairness.

The household's budget constraint can be written as

$$\sum_i x_{ih} + p^c_h m^c_h \leq I_h(w_{1h}, w_{2h}) - T(I_h(w_{1h}, w_{2h}), p^c_h m^c_h; n, ..) \ h = 1, 2, ...H \tag{2}$$

[3] Every variable or function with subscript h can vary across households. Each of these is therefore in principle a contributor to across-household heterogeneity in choices.

[4] In principle, the distributional factors could also include the wage rates, but this will not be allowed for in the empirical model.

where $T(.)$ is a tax/benefit function which may contain as arguments demographic variables as well as gross incomes and expenditure on bought-in child care.[5]

The technology of household production is expressed by the production function

$$y_h = g_h(\hat{t}^y_{1h}, t^y_{2h}) \; h = 1, 2, ...H \tag{3}$$

and there is a time constraint

$$l_{2h} + t^y_{2h} + L_{2h} = T \tag{4}$$

where T is a given time endowment. Because we will be adopting a discrete optimization approach, directly comparing values of the household welfare function at all choice opportunities (see Van Soest, 1995), we do not need to impose conditions of convexity or even differentiability on the function in (3). Thus the household can be thought of as choosing the variables m^c_h, l_{2h} and t^y_{2h} that determine consumptions, market labor supplies and income *via* the constraints (2)-(4) in such a way as to yield a global maximum of the function $\Psi_h(.)$. We can obtain a reduced form of this function by substituting from (2) - (4) into (1) to obtain a utility function that depends on the choice variables l_{2h}, t^y_{2h} and m^c_h as well as net household income. This then forms the basis for the empirical model specification.

3 Econometric Model Specification

We base the econometric specification[6] on three choice variables: hours of mother's market work, hours of mother's housework and hours of bought-in child care. In order to employ discrete choice methods, we restrict these variables to take one of five possible numerical values, which we can characterize as "low", "low-medium", "medium", "high-medium" and "high". This yields a grid of $5^3 = 125$ possible discrete choice points from which the households can choose the optimal allocation. The only restriction which we impose on the household-specific choice sets is that we exclude alternatives which would imply formal childcare costs that would exceed family income - this applies mainly to the high-intensity formal care choices among households with the lowest disposable incomes.[7] For the purpose of our model we specify the vector[8] $\mu = [l_2, t^y_2, m^c, Y]$, with the leisure variable, l_2, derived as the residual of the

[5] For example there may be tax offsets for expenditure on market child care.

[6] For detailed discussion and applications of the discrete approach adopted here see, for example, van Soest (1995), van Soest, Das and Gong (2002) and Pacifico (2009).

[7] It should be noted that in other empirical works, additional household-specific restrictions prove to be necessary to account for infeasibility of certain choices. Kornstad & Thoresen (2007) selectively constrain choice sets of households to account for high degree of rationing in Norwegian day care centers. However, we do not find rationing to be a substantial issue in the context of Australian child care centres, since most of the families in our dataset report not to have problems with finding good quality child care (and getting this care for the hours needed).

[8] Since this formulation applies to each household we drop the household subscript for convenience.

daily time constraint (24 hours) after subtracting market work and household hours.

The fourth variable, Y, is net household income, calculated as gross income net of taxes, family tax benefits and expenditure on child care. Gross income is the sum of each partner's earnings and the family's non-labor income. The husband's earnings and non-labor income are treated as exogenous.[9] The mother's gross earnings are calculated as the product of her gross wage rate and her choice of market hours. The unobserved wages are predicted by a Heckman selection model (Heckman, 1979), with the exclusion restrictions being number of children in the household, and a sum of husband's income and family non-wage income.[10] Expenditure on child care is calculated as the product of a predicted child care price and the household's choice of child care hours. Predicted child care prices are used in order to account for families who do not use formal child care (and therefore do not report a corresponding price). Following Connelly (1992), we predict the prices using another Heckman selection model with the exclusion restrictions being number of adults in the household (other than the spouses), and residential distance from grandparents. Sample selection criteria and regression results for both selection models are presented in the Appendix.

Since household income does not include the value of household production it does not depend on the time t_2^y spent on household production. There are therefore 25 possible values of net household income for each household, corresponding to all combinations of five choices of L_{2h} and five choices of m_h^c.

3.1 Basic Model

We first present the model without unobserved heterogeneity. We take a reduced form of the household welfare function introduced in the previous section, specified as a flexible quadratic function

$$\Psi(\mu) = \mu' \mathbf{A} \mu + \mathbf{b}' \mu \tag{5}$$

where $\mathbf{A}$ is a symmetric 4×4 coefficient matrix, and $\mathbf{b}$ is a 4-component vector. The first three components of $\mathbf{b}$, corresponding to the time use variables l_2, t_2^y, m^c, are defined as

$$b_j = \sum_{k=1}^{K} \beta_{kj} X_k, \; j = 1, .., 3 \tag{6}$$

where the X_k denote respectively a constant term and variables representing observed household characteristics such as wife's age; wife's age squared; number of pre-school age children; number of school-age children; and hours of informal child care provided by relatives, friends or the husband. These represent

[9]The exogeneity of husband's income is a strong assumption, however as we will show on the data, vast majority of Australian men are working full-time irrespective of the labor income of their wives. For that reason, we consider the exogeneity assumption justifiable.

[10]Similar income-based exclusion restrictions are used by, *e.g.,* Blundell et al. (2007b) and Sorensen (1992).

sources of observed heterogeneity. The elements of the matrix $\mathbf{A}$ as well as the component b_4 are assumed the same for all households[11].

The household welfare function in reduced form does not explicitly separate the parameters of household production, the utility functions of the household members, or the household process which combines the utilities of the members. This should be kept in mind when interpreting the parameters. For example, the partial derivative of $\Psi(.)$ with respect to l_2 is the marginal change in household welfare when the other components of μ - t_2^y, m^c and Y - are held constant, that is, when an hour of market work is replaced by an hour of domestic work without changing income. This captures the (positive) effect of additional home production as well as the potential (positive or negative) effect of a higher or lower preference for domestic rather than market work, not accounting for the value of home production or the wage for market work. Differences in b_1 across households may therefore either reflect differences in productivity in household production or differences in preferences, or both. Conceptually, these are of course two quite distinct sources of heterogeneity, but they cannot be separately identified in the available data (since we do not observe the output of household production).

We introduce randomness in the value of the household welfare function at each possible choice point (l_2, t_2^y, m^c, Y) by specifying:

$$\Psi_r = \Psi(.) + \varepsilon_r, \ r = 1, 2, .., 125 \tag{7}$$

We can rationalize these errors as being due to optimization errors or to unobserved alternative specific characteristics that make each alternative more or less attractive than predicted by the systematic part. They can be due to factors that make a specific alternative more (less) attractive because of high (low) productivity or other, possibly preference-related, factors. The ε_r are assumed to be independent of each other and identically distributed and to follow the Type 1 Extreme Value Distribution. This implies that the conditional probability that point r^* is chosen as the optimal point is

$$P[\Psi_{r^*} > \Psi_r, \ \forall r \neq r^* \mid \mu, \mathbf{A}, \mathbf{b}] = \frac{\exp \Psi(\mu_{r^*}, \mathbf{A}, \mathbf{b})}{\sum_{r=1}^{125} \exp \Psi(\mu_r, \mathbf{A}, \mathbf{b})} \tag{8}$$

Finally, to guarantee that household welfare always increases with household income (an assumption which is needed for economic interpretation of the estimates) we penalize the likelihood when necessary by adding points inside the budget frontier as additional choices (that are never chosen by the household).

3.2 Unobserved Heterogeneity

It is likely that different households within the selected sample of families with young children have different unobserved attributes, for example in human and

[11] The linear coefficient of b_4 is left without any interactions to reduce the computational complexity of the problem. We do not regard this adjustment to be very restrictive, given that the utility function is identified up to a monotonic transformation only.

physical capital, which may impact on domestic productivity, measured, for example, by child outcomes. There may also be unobserved variation in the quality of market child care. Unobserved heterogeneity, whether in domestic productivity, in market child care or in preferences, is captured by the specification of error terms ε_r in the model as interdependent across alternatives. This contrasts with the basic model in which the errors are alternative-specific, which implies independence of irrelevant alternatives.

Several alternative approaches have been developed to allow for unobserved heterogeneity in the context of discrete choice labor supply models, with the most prominent method being the parametric random coefficients model (see Van Soest, 1995, or Keane & Moffitt, 1998). However this model has been criticized for the very restrictive assumptions imposed on the distribution of stochastic terms (see Burda et al., 2008; Train, 2008; Pacifico, 2009). The distributions are predominantly assumed to be multivariate normal or log-normal, which implies that the corresponding density of parameter values is unimodal, that is, it has one peak characterizing the most frequent household welfare function.

The restrictiveness of the unimodality assumption is well documented in Burda et al. (2008) who show that the standard random coefficients models perform poorly when the distribution of unobserved heterogeneity has multiple modes. This multimodality is not well captured by the standard models, rendering the resulting preference ordering too uniform.

Such identification is of particular importance for our analysis, because previous theoretical work (Apps & Rees, 2009) suggests that multimodal parameter distributions might well be present in the context of female labor supply. We therefore model the unobserved heterogeneity in a very flexible way allowing for non-standard distributions of the latent parameters. We adopt the latent class approach, which assumes that the population consists of a small number of different homogeneous populations (or classes) $K_c, c = 1, ..., C$, characterized by welfare functions with parameters $\mathbf{A}_c, \mathbf{b}_c$ (see Train, 2008). Given the probability $P(h \in K_c)$ that a household $h = 1, ..., H$ is in the class $K_c, c = 1, ..., C$, and writing the probability that point r^* is chosen by this household as

$$P[\Psi_{r^*} > \Psi_r,\ \forall r \neq r^* \mid \mu, \mathbf{A}_c, \mathbf{b}_c, \mathbf{X}] = \frac{\exp \Psi(\mu_{r^*}, \mathbf{A}_c, \mathbf{b}_c, \mathbf{X})}{\sum_{r=1}^{125} \exp \Psi(\mu_r, \mathbf{A}_c, \mathbf{b}_c, \mathbf{X})} \tag{9}$$

the unconditional probability that alternative r^* is chosen by household h is

$$\sum_{c=1}^{C} P(h \in K_c) \times P[\Psi_{r^*} > \Psi_r,\ \forall r \neq r^* \mid \mu, \mathbf{A}_c, \mathbf{b}_c, \mathbf{X}]\ ,\ c = 1, ..., C \tag{10}$$

Allowing for multiple latent classes makes the model more difficult to estimate, with the traditional maximum likelihood optimization methods often failing to converge. Train (2008) and Pacifico (2009) show that in such cases we can take advantage of the well-known EM algorithm. This estimation procedure is considerably faster and more stable than the traditional methods, which makes it feasible to estimate flexible models even with a large number of latent classes.

4 Data

4.1 Survey Data and Sample Selection Criteria

We estimate the models presented in the previous section on data from the Household, Income and Labor Dynamics in Australia (HILDA) Survey. The survey provides data on a wide range of socioeconomic variables for a representative sample (17,000 respondents) of the Australian population, who have been followed annually since the year 2001. Particularly relevant to this study are the data on time use and the detailed information on the cost and utilization of formal and informal child care.

Mothers with pre-school aged children represent only a small fraction of each HILDA sample. To increase sample size we construct a pooled cross-section using the four consecutive waves of HILDA from 2005 to 2008. From each wave we select partnered mothers with pre-school children. We exclude couples in which a partner is disabled, retired, or a full-time student, the husband is unemployed or the family lives in a multi-family household. We also exclude records which report incomplete or implausible survey responses.[12]

The final sample contains 1465 records. Descriptive statistics for the dependent variables and the socioeconomic and demographic characteristics entering as independent variables in X are reported in Table 1. For the purpose of comparisons by gender, the table includes descriptive statistics for male wage rates, labor supplies and time allocations to housework and home child care.

Table 1 about here

4.2 Socio-Economic and Demographic Characteristics and Time Use

On average, parents of pre-school children are in their early thirties, with the father around two years older than the mother. Married couples represent 83 per cent of the sample. Only 56 per cent of mothers in the sample are employed and, as we would expect, market hours distributions differ dramatically by gender, as shown graphically in Figure 1. The result is a gap of over 30 hours per week between average female and male labor supplies. The vast majority of men work full-time (more than 35 hours per week[13]) while women have a distribution of market hours that is relatively uniform, apart from a large spike at zero hours. There are 83 women who report working more than 18 hours a day for seven days a week.[14] We scale these hours to satisfy a time constraint of working at

[12]These mostly included households with missing data on the relevant time use variables.

[13]"Full-time employment" is defined by the Australian Bureau of Statistics (ABS) as 35 hours or more per week.

[14]The time use data are collected by questionnaire and reported as weekly time uses. Unlike diary data, questionnaire data are typically subject to larger reporting errors, and as a result the sum of individual time allocations to the various activities often fails to satisfy the time constraint.

most 18 hours per day, retaining the relative time allocations in the original data.

Figure 1 about here

Figure 2 compares hours of housework by gender. Housework is defined to include the allocation of time to child care as well as to errands and domestic chores. As we would expect, hours of housework are higher for females than for males, as shown in Figure 3, and their leisure hours[15] are more dispersed, with substantially higher frequencies at the lower levels of weekly leisure time. It is clear that for this group of households with young children, the total work burden is on average larger for mothers than for fathers.

Figures 2 and 3 about here

4.3 Child Care

We differentiate between "formal care" which is provided by recognized institutions, such as kindergartens and care centers, and "informal care" provided by the husband, grandparents or other relatives, and friends. There are two reasons for this distinction. First, formal child care differs from informal child care in that it is recognized as incurring costs by the Australian fiscal authorities, and the family is eligible for reimbursement of a considerable part of these costs. Second, the price data on informal care is rather unreliable. The price of formal child care is reported for all children in registered care. In contrast, informal child care is often provided with no charge, or at a price that implies an unobserved subsidy from the carer. The lack of more detailed information about the costs of informal child care makes any effort to impute corresponding prices infeasible. Therefore, we consider the choice of formal care only, treating informal care as exogenously given.[16] Informal care enters the utility function through X in (7), measured in hours, without a specified price.

Formal care is used by 43% of the families, while the use of informal child care is almost universal (only 9 families report that they used no form of informal child care). The distributions of the weekly hours of child care are presented in Figure 4. The profiles for both types of care are relatively similar, although the formal care distribution does not go far above 60 hours per week. This reflects the fact that formal care centers are closed on weekends.

Figure 4 about here

[15] Leisure is computed as the remainder of the daily time endowment after subtracting market work and housework hours, which may be adjusted to satisfy the total time constraint. The 42-hours threshold is a consequence of this computation.

[16] An economic rationale for this would be that informal child care is quantity-rationed and has a lower cost than formal child care, the price of which determines demand for child care at the margin.

4.4 Labor and Non-Labor Incomes

Annual labor incomes are derived from reported weekly gross salaries from all jobs. The annual non-labor income of the couple is computed as the sum of each partner's business income, investment income, private domestic pensions and overseas pensions. Figure 5 presents distributions of male and female labor incomes and household non-labor income. According to these data, around 45% of mothers have zero labor income, while 54% of families in the sample have zero non-wage income. The distribution of non-labor income for the subsample of families with non-negative incomes is skewed towards zero. At the same time several outliers report very large incomes from business and investments.

Figure 5 about here

These income data are used to derive the set of 25 family incomes, net of the taxes and benefits and cost of child care, associated with the discrete time use choices. All incomes are deflated to 2005, the selected base year, using the Australian consumer price index.

4.5 Family Income Taxes and Child Care Subsidies

We calculate net household income as gross income net of tax liabilities under the Personal Income Tax (PIT), Low Income Tax Offset (LITO) and Medicare Levy (ML)[17] and net of cash transfers under Family Tax Benefit Part A (FTB-A) and Family Tax Benefit Part B (FTB-B). These are the key tax policy instruments setting the parameters of the Australian family income tax system. The calculation of the net price of formal child care takes account of the two main subsidies for child care, Child Care Benefit (CCB) and the Child Care Rebate (CCR).

The tax base for the PIT and LITO is individual income, and therefore the marginal and average rates on the income of each partner are independent. In contrast, the tax base of the ML is partly joint income, due to the withdrawal of exemption limits on family income. Tax rates therefore become partly interdependent, with higher rates for a second earner over some range of "primary income".[18] Cash transfers under FTB-A are also withdrawn on family income. In the discussion to follow we show how these policy instruments raise tax rates on mothers as second earners by effectively replacing the individual tax base of the PIT and LITO with that of joint income, for the vast majority of families with dependent children. We also show how the LITO undermines the strict progressivity of the PIT. For the purpose of illustration, we take the rates applying in the 2007-08 financial year[19] and present results for a family with two children under 13 years, with the younger child under 5 years.

[17]Despite its title, the ML is entirely an income tax. It is not tied to funding any aspect of the health system.

[18]"Primary income" here refers to the income of the partner with the higher income.

[19]While the rate scale and brackets of the PIT and the LIT0 vary across the four waves of the HILDA data we are using, the structure is essentially the same in each financial year.

4.5.1 Personal Income Tax and LITO

The marginal rate scale of the 2007-08 PIT is strictly progressive, beginning with a zero rated threshold of $6,000, followed by rates of 15%, 30% and 40% up to an income of $150,000, and thereafter a top rate of 45%. However, when the LITO is added, strict progressivity is lost. In 2007-08 the LITO provided a tax credit of $750, phased out at 4 cents in the dollar on individual incomes above $30,000. The net effect is a new, and less transparent, rate scale with a zero rated threshold of $11,000 and a higher rate of 34 cents in the dollar on incomes from $30,001 to $48,750, as illustrated in Figure 6. The figure plots marginal and average tax rate profiles with respect to individual taxable income. Because the marginal tax rates of partners are independent, both partners face the same marginal and average rates at any given level of income.

Figure 6 about here

The LITO was first introduced in 1993 and has been increased gradually over successive government budgets, with the effect of raising the "middle" marginal tax rate of the PIT scale across an ever widening band of middle incomes. While expanding the LITO, the government simultaneously lowered tax rates at higher income levels over a period of significant revenue gains resulting from bracket creep (tax brackets of the PIT scale are not indexed). For example, over the period 2004-05 to 2007-08, the top marginal tax rate fell by 2 percentage points, while the income threshold for the top rate rose from $70,000 to $150,000 pa. Very few working mothers gain from these tax cuts because few earn incomes at these levels.

4.5.2 Medicare Levy, FTB-A and FTB-B

The ML raises marginal tax rates by 1.5 percentage points for taxpayers with incomes above specified thresholds for exemption categories or reductions.[20] For the two-parent family the exemption threshold income is based on family income and varies with the number of children. In 2007-08 the family income limit for a full reduction for a two-parent family was $29,207, plus $2,682 for each dependent child or student. The exemption is withdrawn at a rate of 8.5 cents in the dollar above this limit, which has the effect of introducing a new marginal tax rate of 44 cents in the dollar across income bands that are well below average earnings. Thus the ML achieves a further shift away from the strictly progressive rate scale of the PIT and, at the same time, by defining the threshold for the exemption on family income, shifts the tax base towards joint income.

Family Tax Benefits have a more profound effect of the same kind. FTB-A provides a cash transfer for each dependent child, with the size of the transfer varying with the age of the child. The "Maximum Rate" of FTB-A in 2007-08

[20] There is also a surcharge for individuals and families on higher incomes who do not have private patient hospital cover - calculated at an additional 1 per cent of taxable income.

for a child under 13 years was \$4,460.30. This maximum payment is withdrawn at 20 cents in the dollar on a family income over \$41,318 up to the "Base Rate" of \$1,890.70 pa. The Base Rate is withdrawn at 30 cents in the dollar at a higher family income threshold that depends on the number of dependent children, e.g., for a family with two dependent children, the income threshold for the Base Rate is \$95,192.

FTB-B provides a payment of \$3,584.30 pa for a family with a child under 5 years.[21] The payment is withdrawn at a rate of 20 cents in the dollar on a second income above \$4,380. It can therefore be classified as a gender based tax[22] with, paradoxically, the higher rate applying to the income of the mother as second earner.[23]

Figure 7 compares graphically the resulting profiles of marginal tax rates with respect to primary income for a single-income family and for the second earner in a two-income family in which both partners earn the same incomes.[24] FTB payments are for two children under 13, with one under 5 years.

Figure 7 about here

The graph highlights two important effects of the Family Tax Benefit system and ML. First, they raise marginal rates across bands of second income up to the family income threshold at which the payments are fully withdrawn. Secondly, they introduce a marginal rate scale with the highest rates applying across relatively low and average incomes. For example, the marginal tax rate on a mother's earnings in a family with a primary earner on an average income can rise to over 70 cents in the dollar.

If we treat primary income as fixed and calculate the additional tax a family pays when the mother goes out to work, we obtain an average tax rate profile that includes rates of over 40 per cent, as shown in Figure 7. Consistent with joint taxation, average tax rates on the two-income family are much higher than the rates on the single-income family at any given level of primary income, until the payments are fully withdrawn. Under a tax system of this kind, the low level of female hours reported in the preceding section is hardly surprising.

4.5.3 Child Care Benefit and Child Care Rebate

Child Care Benefit depends (among other things) on the ages of children, number of children, type of child care and the hours of child care used. The benefit is phased out with rising family income according to the age of the child and the number of children receiving child care.

---

[21] For a family with the youngest child aged 5 to 15 or full-time student aged 16 to 18, the payment is \$2,595.15 per year.

[22] See Alesina, Ichino and Karabarbounis (2007).

[23] Note that with selective taxation of this kind, partners in the two-income family no longer face the same marginal tax rates.

[24] Note that the marginal tax rate profile for the primary income earner in the two-income household is the same as that shown for the second earner apart from higher rates at very low levels of second income due to FTB-B.

The Child Care Rebate reimburses families for their claimed child care expenses. It can cover up to 50% of the net child care expenses (that is, after subtracting CCB). The CCR rate is not income-tested, but it has an upper cap on the amount of expenses which can be reimbursed. For the year 2008, this cap was $4,354 per year.

5 Results

We first present the results for the baseline homogeneous specification presented in subsection 3.1, and then discuss those for the extended model dealing with unobserved heterogeneity, as detailed in subsection 3.2.

5.1 Baseline Model: No Heterogeneity

The estimated parameters of the baseline model are reported in Table 2. If the homogeneity assumption were found to be valid, the results would be consistent and more efficient than the latent class model. The coefficients indicate that several of the interaction terms yield intuitively plausible results. Increases in the number of pre-school aged children present in the household raise the marginal utility of formal child care, and therefore strengthen the demand for it. On the other hand, increases in the (assumed exogenous) availability of informal child care weaken it. The same is true for the time allocation to housework.

Table 2 about here

The estimated marginal utilities of the choice variables, the components of the vector μ, are central to our analysis, but their evaluation is more complex than consideration of the simple regression coefficients in isolation, since they involve the total effects of a change in one of these variables working through the entire matrix $\mathbf{A}$ and vector $\mathbf{b}$. They are also household-specific, since the utilities $\Psi(\mu)$ depend on the household's socio-demographic characteristics, $\mathbf{X}$, as well as the values of its choice variables. Therefore we present the marginal utilities in two ways: first, by averaging them across the sample of households; and secondly, by presenting the proportion of households that are measured as having negative marginal utilities for each given choice variable. It is also useful to identify separately the average marginal utility of each choice variable for the subset of households which buy formal child care. The results are presented in Table 3.

Table 3 about here

As expected, marginal utilities of income, domestic child care and housework/leisure are on average positive, with only very small fractions of households having negative values at their computed optimal choice values. On the other hand, around 90% of households are reported as having negative marginal utilities of formal child care at their optimal choice levels. This is of course not a problem for those households which choose to consume zero amounts of market child care, but the last column of the table shows that those households consuming positive amounts also on average have negative marginal utilities, which is clearly inconsistent with it having a positive price.

This counter-intuitive result can be potentially attributed to unobserved heterogeneity. An important observation in this respect is that our sample contains a substantial share (57%) of households which do not use any formal child care. Such sample composition can prove problematic for the homogeneous model if the decision about formal child care utilization is influenced by unobserved differences in mothers' housework productivity. The model will try to explain this relation in terms of the variables included in the utility function, assigning strong disutility to formal child care. Failure to account for unobserved heterogeneity will cause the coefficients of child care to be biased, making it seemingly unattractive even for the active users. Therefore, it is indeed advisable to extend our analysis further and attempt to control for the unobserved heterogeneity in a flexible form.

5.2 Allowing for Unobserved Heterogeneity: the Latent Class Model

A key step in the EM estimation procedure is the initial selection of the number of latent classes. This decision involves a trade-off. On the one hand, the higher the number of heterogeneous groups, the better is the fit of the model, as we account for unobserved heterogeneity in a more flexible form. On the other hand, more stratified models are bound to be estimated less precisely, as the number of unknown parameters rises proportionally to the number of allowed latent classes. The determination of the optimal number of classes is therefore crucial for maintaining correct inference of our model.

Following Train (2008), we compare the models with varying classification choices on the basis of their Schwarz-Bayesian information criteria (BIC)

$$BIC = -2\log(L) + k\log(n) \tag{11}$$

where L is the likelihood, k is the number of free parameters in the model and n is the number of observations in our sample. The multiple-class models yield the following statistics:

Table 4 about here

As we see, the 8-class model attains the lowest BIC, and should therefore be considered as the most reliable specification for further analysis.

Before discussing results corresponding to the model with 8 classes we examine whether our models can actually fit the data. This is done by predicting individual time use allocations and comparing their aggregated distribution to its empirically observed counterpart. Figure 8 presents this comparison both for the baseline model and for the model with 8 latent classes.

Figure 8 about here

As expected, the 8-class model replicates the empirical distributions very well, attaining almost identical shares of intensity levels among all three time use choices. The homogeneous model performs much worse and essentially fails to capture the distribution of market work hours. In particular, the model underestimates the share of women not working in the market, and overestimates the share of women with low-intensity part-time jobs. The distributions of the other two choice variables are replicated well even by the homogeneous model, though the latent class model still provides more precise approximations.

We refrain from presenting the regression coefficients corresponding to the 8-class model because the class-level stratification makes their interpretation practically infeasible. However, one statistic which remains readily interpretable is the share of the population with negative marginal utilities.

Table 5 about here

The only share which exhibits a substantial change compared to the baseline specification (cf. Table 3) is the one corresponding to formal child care. The proportion of mothers exhibiting disutility from additional child care drops by 30 percentage points, attaining 53% in total and 31% when we restrict ourselves to mothers who are actively using formal child care.[25] This is a considerable improvement compared to the homogeneous specification.

The relative performance of the models with varying numbers of latent classes is further tested through a series of simulations in the next section. The aim of these simulations is to predict how people respond to selected changes within their economic environment. By predicting (and comparing) the behavioral responses for different model specifications, we can draw inferences about the importance of class-level heterogeneity, and assess the validity of the homogeneity assumption.

6 Microsimulations

We evaluate the following changes: first, we simulate two basic adjustments to the aggregate price level - a 10% increase in the net wages of mothers, and a 10% increase in the net prices of formal child care (Section 6.1). Second, we carry out a policy simulation in the spirit of Apps & Rees (2009), building on their critique of FTB and other joint-income fiscal measures (as discussed in the previous section). We propose an alternative system of taxes and benefits

[25] The latter is obtained by taking weighted means over all classes, where the weights are the class probabilities given the observed choice.

which aims to be less distortionary in respect of female labor supply than the current one, and we estimate its impact on household choices within the sample of households.

6.1 Changing Net Wages of Mothers and Net Child Care Prices

The impact of the price changes is measured in terms of aggregate elasticities: we compute the percentage changes in total hours of market work, total hours of domestic work, and total hours of bought-in child care with respect to changes in the net hourly wage rates of all women in our sample, or all net prices of child care. The other variables are kept constant (including, for example, the male partner's wage rates). Changing net rather than gross wages has the advantage of circumventing secondary effects caused by changes in the effective tax rates: increasing net wages by 10% results in 10% higher disposable incomes from mother's market work across all households.

The resulting income changes are proportional to the net earnings of mothers and therefore those in the labor market earn more ceteris paribus, while the non-participants retain their original disposable incomes. Since the 10% increase in the wage makes participation more attractive, we can expect an increase both in the market hours of employed mothers and in the participation of those working solely at home. Similarly, an increase in net child care prices results in an income reduction that is proportional to the cost of bought-in child care, and we can also expect an effect on the decisions of both users and non-users.

We compute the ratios of percentage changes in the relevant time use and care variables to the percentage changes in the underlying policy instruments (wages and prices) which are 10 percent, by construction. Computation of the aggregate elasticities is carried out in the following way. We first derive the benchmark time use allocations (using the same wages and prices that are used for estimation). This is done by averaging individual choice probabilities predicted by our logit model, and multiplying the results by the hours of time use activities corresponding to the given choice. This provides us with a simulation of average time use hours, based on the estimated model. Ideally these simulated values should be close to their empirically observed counterparts. For the 8-class model, the simulated daily averages are 1.2 hours for formal child care, 2.5 hours for work, and 10 hours for housework. The corresponding observed mean values in the data (after replacing each observed value by the mean of its category to account for the discretization) are 1.2, 2.7 and 10.1, respectively. This shows that the model is able to reproduce the means in the data.

The computation of average hours after the wage or price increase is very similar to the pre-reform case. The only difference is that for the prediction of choice probabilities we adjust disposable income for each alternative in the choice set. This changes the utility values for some of the choice alternatives and not for others, and, as a consequence, also changes the probabilities of all the choices. Using the new probabilities we recompute average hours. Finally, we compute the percentage deviations in the new averages compared to the benchmark. Since all changes are 10%, these percentage changes can be interpreted as 10 times the corresponding elasticities. The resulting elasticities for models with varying numbers of classes are provided in Table 6.[26]

Table 6 about here

The first panel gives the responses to an increase of all mothers' net wage rates. The first thing to note is the big difference between the homogeneous (one class) model and the models with unobserved heterogeneity (two or more latent classes). When we allow for unobserved heterogeneity, the predicted responses fall substantially, and remain relatively stable among models with different numbers of classes. These results demonstrate the importance of controlling for unobserved heterogeneity in our analysis.

Standard errors are on average rising as we allow for further classes, making some of the effects less significant for heavily stratified models. This reflects the fact that these models are more flexible and therefore require more data for accurate estimation. Nevertheless, in certain cases we also observe that the standard errors fall as we move to the more stratified models. We attribute this effect to the increased goodness of fit of the latter specifications. Given the results of the BIC selection procedure discussed in the previous section, the following discussion of simulation outcomes will focus on the 8-class model.

In the case of the net wage increase, we observe time use shifts which correspond to intuition. A 10% increase of all net wage rates results in a (significant) 4.3% rise in average working hours, implying a positive uncompensated own labor supply elasticity of 0.43 for this group of mothers with young children. This is well in line with the large literature on female labor supply. The positive substitution effect (the price of leisure increases) dominates the negative income effect. Moreover, the 10% wage increase leads to a (significant) 4.2% increase in hours of bought-in child care (a "cross" elasticity of 0.42). First, the higher demand on time due to increasing hours of market work leads to substitution of own child care by bought-in child care. Second, higher earnings lead to higher family income, increasing the demand for formal child care if this is a normal good.

The housework elasticity proves to be significantly negative, at -0.08. The negative sign implies that higher wages lead the mothers to work less in the household. However, the actual change of housework hours is not large enough to compensate for the increase of hours of market work, implying that mothers also reduce the time spent on leisure in order to do more market work.[27]

[26] Standard errors on the elasticities were computed through 199 Monte Carlo simulations, recomputing the percentage changes with simulated sets of preference coefficients **A** and **b**. The coefficients were drawn through Cholesky decomposition of an underlying covariance matrix, which was derived using a ML procedure proposed by Ruud (1991), correcting for variance of the aggregate class shares and covariance structure between different class-level parameterizations.

[27] In absolute terms, the wage increase induces the average mother to spend about 0.55 hours per week more on market work, 0.40 hours less on housework, and 0.15 hours less on leisure.

Turning to the impact of the rise in child care prices in the second panel, it is not surprising that the highest elasticity is that of formal child care itself. With a 10% rise in child care prices, the demand for formal child care falls significantly, by 4.2%. This in turn causes mothers to work less in the market - market hours drop significantly, by 0.8%, as they have to substitute their own time for bought-in services.[28] Accordingly, the hours of housework increase by 0.2%, replacing almost all of the forgone time formerly spent on market work.[29]

6.2 Policy Simulation: Alternative System of Taxes and Benefits

6.2.1 Overview of the Reform

As discussed earlier, the shift towards joint taxation with the means testing of FTB-A and the ML on family income can be expected to have substantial disincentive effects on female labor supply. We analyze this by simulating the effects of switching to an individual based income tax with universal payments.[30] We construct the reform by eliminating the ML and making the payments under FTB-A universal. A key feature of the reform is the removal of the excessively high effective marginal rates on the incomes of the majority of mothers under the existing system.

To fund the increase in benefit payments we introduce a proportional increase in all marginal tax rates of the PIT & LITO (see Section 4.5.1). Assuming no behavioral responses, we calculate that an increase in tax rates of 26.76% would be required for revenue neutrality. On the basis of this figure, we multiply each rate of the income tax by 1.2676, making the resulting personal income tax more progressive than the original. Figure 8 presents the differences in the net tax positions of the households in our sample induced by the reform (assuming no behavioral responses). The differentials are ordered by the corresponding pre-reform net household incomes, so that we can see how the tax burden shifts over different income groups.

Figure 9 about here

The scatter plot shows that the increased progressivity of the post-reform tax system shifts the tax burden towards higher incomes, while improving the position of middle-income families. (By construction, this redistribution is revenue neutral so the changes for all families in the sample add up to zero.)

Table 7 about here

[28] This elasticity is well in line with that of Gong and Breunig (2011) but smaller than that in Gong et al. (2011).

[29] On average mothers spend about 0.10 hours per week longer on housework and reduce their market work by 0.10 hours and bought-in child care by 0.05 hours.

[30] As proposed in Apps and Rees (2009).

Table 7 summarizes the behavioral changes in the time allocations induced by the reform. As for the previous simulations, we observe a large discrepancy between the changes predicted by the homogeneous model and those predicted by the models with more than one latent class, with the results of the latter proving relatively stable across different specifications. Again this implies that accounting for unobserved heterogeneity is important not only to improve the fit of the model but also from a substantive point of view.

We again focus on the outcomes for the 8-class specification. We observe that the reform would lead to a 3.11% increase in average hours of work (about 0.43 hours per week, using the average hours in Table 1), a 1.75% increase in average hours of formal child care (0.15 hours per week), and a 0.63% decrease in the average hours of housework (about 0.45 hours per week). All these effects are statistically significant. For the average woman in the sample, not phasing out FTB is more important than the increase in the marginal tax rate in making market work more attractive. This explains why market work hours increase and, as a consequence, domestic work falls and demand for bought-in child care increases.

6.2.2 Heterogeneity of the Behavioral Responses

The behavioral effects induced by the reform appear to be highly heterogeneous across population groups and latent classes. Closer analysis of our results reveals positive effects at the extensive margin of female labor supply, with the predicted participation rate rising by 4.4% (to about 58%). On the other hand, these effects are mitigated by responses at the intensive margin, with some employed mothers choosing to work fewer hours under the reform. Average hours of market work (conditional on being employed) fall by 1.3%, with individual responses showing considerable variation. In fact, expected hours of market work increase for 69% of all women in the sample. The 1.3% decline in the aggregate work at the intensive margin is driven by the response of mothers on higher wages and in full-time employment (represented by the scatter points in the right lower part of Figure 8). Clearly these women are not among the prospective beneficiaries of the reform because the extra FTB payments are not sufficient to compensate them for their higher tax burdens. Facing lower net incomes they substitute away from market work towards non-market time uses

Such behavioral heterogeneity is crucial for successful targeting of policy reforms, as it helps us to identify the potential impact on different subsamples of the population. It is also interesting from the perspective of economic modeling, as we can compare the relative performance of homogeneous and latent-class models. In order to do so, we split the sample into two groups according to actual employment status, and compute the elasticities separately for the two groups, using both the homogeneous model and the latent class model with eight classes. Using the homogeneous specification, the effects prove to be almost identical for both groups, as this model captures only a small part of the differences in productivity and preferences between the groups. According to the eight class model results, the simulated increase of aggregate working hours is much stronger for non-employed mothers, with the absolute increase of market work hours being 28% larger. As for the change of formal child care hours, the non-employed mothers exhibit a rather modest increase in absolute terms (70% lower than employed mothers), but in relative terms their bought-in child care rises more than for employed women (the initial level of formal child care utilization is substantially lower for non-employed mothers).

The failure to capture heterogeneity in responses of the homogeneous model is further illustrated by the fact that this model cannot replicate observed differences in reported time use allocations between the two groups, overestimating work and formal child care allocations of non-employed mothers and underestimating them for employed mothers. On the other hand, the 8-class model produces almost identical time use patterns as observed in the data. For these reasons, it is hard to maintain that the homogeneous model would be able to provide reliable predictions of the responses to proposed policy changes.

6.2.3 Net Fiscal Effect of the Reform

We also analyze the net revenue effect of the FTB reform taking account for behavioral changes predicted by our 8-class model. Changes in time allocations can affect government revenue through two distinct channels: by raising (reducing) their work intensity the mothers are also raising (reducing) income tax revenues, and by buying in longer (shorter) child care hours the families get larger (smaller) child care benefits.

The key result in this context is that the government marginally improves its net fiscal position. Income tax revenue from mothers rises by only 0.5%, which seems low compared to the 3.1% increase in aggregate working hours. The reason is the heterogeneity in responses discussed above: mothers with higher wages tend to reduce their hours of market work, and the progressive nature of the income tax system makes the fall in tax revenues from this group relatively large, substantially offsetting the additional revenue from low and middle income households. More specifically, mothers who increase their market hours (69% of the sample) are predicted to pay an average of $151 more in annual income taxes (a 5.6% increase) whereas those who reduce their hours reduce their income tax liabilities by a predicted average of $261 per annum (a 2.3% reduction). The net result is an aggregate tax impact of the reform of 25$ per household (which translates into the aforementioned 0.5%).

The situation is very similar for the child care benefits, which increase only slightly in aggregate: on average, a household gets an additional $2 (0.1% of the initial payments), which is small compared to the 1.75% change of formal child care hours. Analogously to the income tax effects, this outcome reflects the heterogeneity in behavioral responses.[31] Combining the two effects, we estimate

[31] In our sample, 65% of the mothers are predicted to raise their hours of bought-in child care (typically the mothers who increase their hours of market work). Once again, a key role is played by the mothers with higher wages, who reduce their market work hours but also their utilization of formal child care. The relatively large reduction of their claimed benefits is large enough to offset most of the increased benefit claims from other households.

that on average households will contribute an additional $23 to government tax revenue, an increase that represents 0.2% of their original contribution.

6.3 Robustness Checks

In order to assess the stability of our results, we run a series of sensitivity checks, altering the econometric specification of our model in the following ways.

To achieve a more flexible specification, we divide the time use variables into a finer grid (6^3) of discrete choices, allowing for greater degree of discretion in the household-level decision making. We also experiment with the composition of time use variables, reducing the mother's housework decision to a single maternal child care choice.[32] Another extension augments the model by a fixed disutility of working estimated as an additional parameter of the utility function.[33] Furthermore, to account for potential misreporting in the individual household accounts, we estimate a model with wages and child care prices imputed by our model.

Table 8 about here

The elasticities presented in Table 8 confirm that changes in the econometric specification are likely to change the nominal values of our results. However their relative sizes and signs remain similar to those of the original model, with most of the values remaining in the 95% confidence interval of the corresponding baseline elasticities.

The stability of the elasticities is interesting in the context of the model containing maternal child care decisions, as it suggests that changes in the hours of housework are proportionate, irrespective of the distinction between child care-related and other household activities. Women who engage in the labor market will therefore work less in the household, delegating part of their chores either to the husband, or buying in the services from the market.

We also check the validity of standard errors corresponding to the measured elasticities without changing the specification of the model itself, controlling for general heteroskedasticity and household-specific clustering. In both cases the newly derived standard errors preserve the significance levels attained by the benchmark approach, suggesting that the heteroskedasticity is not likely to distort our estimates.

[32] That way, we can examine direct substitution effects between informal and formal child care. However, such adjustment comes at the cost of making the residual time allocation more difficult to interpret, as it contains both leisure time and housework unrelated to child care.

[33] There is no clear consensus with respect to which form the working indicator should take on. Blundell et al. (2007a) put the employment dummy into the budget constraint, so that it represents fixed monetary costs of working. Donald & Hamermesh (2009) interact the dummy with time use variables entering the utility function, referring to the corresponding parameters as shifters of time use efficiency. We choose to add the employment dummy into the individual utility function in a non-interacted form, which allows us to model fixed disutility from work without substantially increasing the computational burden.

7 Conclusions

In this paper we have analyzed the time allocation decisions of mothers with preschool children, with emphasis on their labor supply choices. We have focused on the identification and analysis of unobserved heterogeneity, which has its origins in across-household variations in productivity and preferences and which has proven to play a dominant role in the decision making of mothers in our data. The heterogeneity in unobserved productivities and tastes among the identified latent groups undermines the usefulness of the homogeneous model with no unobserved heterogeneity. The parameters fail to capture the true effects of factors driving household decision making, and hence simulations based on the baseline homogeneous model specification can be expected to give misleading results.

To control for unobserved heterogeneity, we estimated a series of latent-class multinomial logit models, taking the 8-class model to be the best parameterization. This model was found to perform optimally, balancing goodness of fit on the one hand against parsimony on the other. To assess the responsiveness of our sample to changes in the tax system and in child care prices, we conducted a series of policy reform simulations, increasing net wages of mothers and net child care prices in the first two reforms, and altering the joint-income structure of the existing system in the third reform.

The first two micro simulations based upon our estimates show that mothers are responsive both to the changes in wages and child care prices. This result suggests that market work and formal child care tend to be complements, and respond significantly to wage and price changes. The results also indicate that significant changes in labor supply and child care demand can remain unidentified when the unobserved heterogeneity is left untreated, thus significantly distorting the size of predicted changes in female labor supply.

In the third simulation, we show that the tax measures that withdraw benefits on the basis of joint income are likely to prove adverse to the labor supply decisions of working mothers, and that the tax system can be made more favorable for employed mothers by switching to a fully individual based system. In such a setting, women are predicted to increase their labor supply and to utilize more formal child care. These responses also raise additional tax revenue which could be used to lower tax rates and therefore achieve efficiency gains.

The gains from the reforms we have simulated arise from changing the structure of effective marginal tax rates under the Australian "quasi-joint" family tax system. Running a similar policy simulation on data for countries with full joint taxation may yield considerably stronger behavioral responses.

A number of improvements and extensions are of course possible. First, our analysis would benefit from exploiting the panel structure of the HILDA data set, controlling for time-stable individual effects. Secondly, although we consider the current method of treating unobserved heterogeneity to perform well, it could be worthwhile to assess the stability of our results by using alternative ways of controlling for unobserved heterogeneity, such as the random coefficient mixed logit model, or the approaches utilizing Bayesian nonparametric methods.

References

Alesina, A., Ichino, A., Karabarbounis, L., 2007. Gender Based Taxation and the Division of Family Chores. IZA Discussion Papers 3233. Institute for the Study of Labor (IZA).

Apps, P., Rees, R., 2009. Public Economics and the Household. Cambridge University Press, Cambridge.

Baker, M., Gruber, J., Milligan, K., 2008. Universal Child Care, Maternal Labor Supply, and Family Well-Being. Journal of Political Economy 116, 709–745.

Blau, D., 2003. Child Care Subsidy Programs, in: Means-Tested Transfer Programs in the United States. National Bureau of Economic Research, Inc. NBER Chapters, pp. 443–516.

Blundell, R., Gosling, A., Ichimura, H., Meghir, C., 2007a. Changes in the Distribution of Male and Female Wages Accounting for Employment Composition Using Bounds. Econometrica 75, 323–363.

Blundell, R., MaCurdy, T., Meghir, C., 2007b. Labor Supply Models: Unobserved Heterogeneity, Nonparticipation and Dynamics, in: Heckman, J., Leamer, E. (Eds.), Handbook of Econometrics. Elsevier. volume 6 of *Handbook of Econometrics*. chapter 69.

Blundell, R., Shephard, A., 2011. Employment, Hours of Work and the Optimal Taxation of Low Income Families. IZA Discussion Papers 5745. Institute for the Study of Labor (IZA).

Burda, M., Harding, M., Hausman, J., 2008. A Bayesian Mixed Logit-Probit Model for Multinomial Choice. Journal of Econometrics 147, 232–246.

Connelly, R., 1992. The Effect of Child Care Costs on Married Women's Labor Force Participation. The Review of Economics and Statistics 74, 83–90.

Connelly, R., Kimmel, J., 2003. Marital Status and Full-time/Part-time Work Status in Child Care Choices. Applied Economics 35, 761–777.

Doiron, D., Kalb, G., 2005. Demands for Child Care and Household Labour Supply in Australia. The Economic Record 81, 215–236.

Donald, S.G., Hamermesh, D.S., 2009. A Structural Model of the Fixed Time Costs of Market Work. Economics Letters 104, 125–128.

Duncan, A., Paull, G., Taylor, J., 2001. Mothers' Employment and the Use of Childcare in the UK. IFS Working Papers W01/23. Institute for Fiscal Studies.

Gong, X., Breunig, R., 2011. Estimating Net Child Care Price Elasticities of Partnered Women With Pre-School Children Using a Discrete Structural Labour Supply-Child Care Model. CEPR Discussion Papers 653. Centre for Economic Policy Research, Research School of Economics, Australian National University.

Gong, X., Breunig, R., King, A., 2011. Partnered Womens Labour Supply and Child Care Costs in Australia: Measurement Error and the Child Care Price. CEPR Discussion Papers 652. Centre for Economic Policy Research, Research School of Economics, Australian National University.

Heckman, J., 1979. Sample Selection Bias as a Specification Error. Econometrica 129, 153–161.

Kalenkoski, C.M., Ribar, D.C., Stratton, L.S., 2005. Parental Child Care in Single-Parent, Cohabiting, and Married-Couple Families: Time-Diary Evidence from the United Kingdom. American Economic Review 95, 194–198.

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

Kimmel, J., Connelly, R., 2007. Mothers' Time Choices: Caregiving, Leisure, Home Production, and Paid Work. The Journal of Human Resources 42, 643–681.

Kornstad, T., Thoresen, T., 2007. A Discrete Choice Model for Labor Supply and Childcare. Journal of Population Economics 20, 781–803.

Pacifico, D., 2009. On The Role of Unobserved Preference Heterogeneity in Discrete Choice Models of Labor Supply. Working Paper 1995. Univ. Modena.

Ribar, D.C., 1995. A Structural Model of Child Care and the Labor Supply of Married Women. Journal of Labor Economics 13, 558–97.

Ruud, P., 1991. Extensions of Estimation Methods Using the EM Algorithm. Journal of Econometrics 49, 305–341.

Sorensen, E., 1993. Continuous Female Workers: How Different Are They from Other Women? Eastern Economic Journal 19, 15–32.

Train, K., 2008. EM Algorithms for Nonparametric Estimation of Mixing Distributions. Journal of Choice Modelling 1, 40–69.

Train, K., 2009. Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge.

Van Soest, A., 1995. Structural Models of Family Labor Supply: A Discrete Choice Approach. Journal of Human Resources 30, 63–88.

Van Soest, A., Das, M., Gong, X., 2002. A Structural Labour Supply Model with Flexible Preferences. Journal of Econometrics 107, 345–374.

Van Soest, A., Stancanelli, E., 2010. Does Income Taxation Affect Partners Household Chores? IZA Discussion Papers 5038. Institute for the Study of Labor (IZA).

Figures and Tables

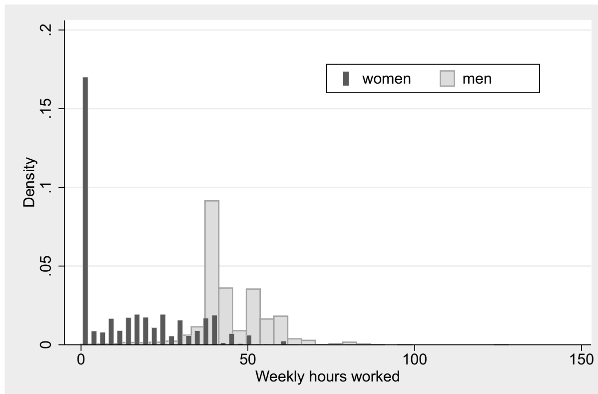

Figure 1: Distribution of Weekly Hours of Market Work in Families with Preschool Children

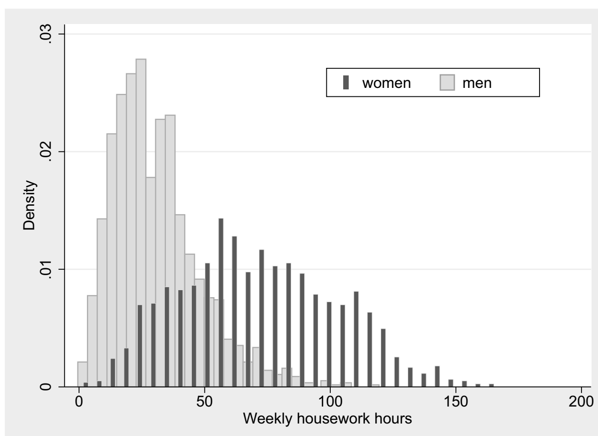

Figure 2: Distribution of Weekly Hours Spent on Housework in Families with Preschool Children

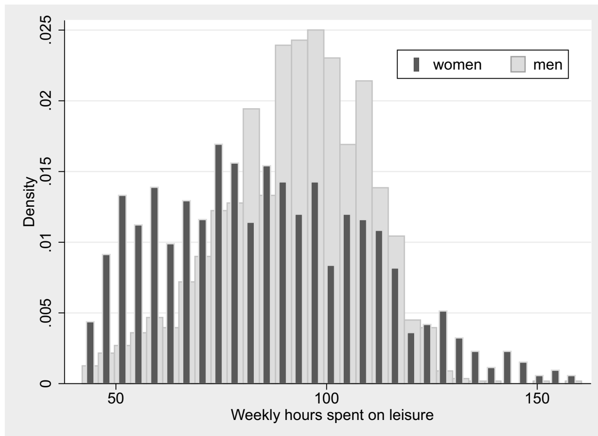

Figure 3: Distribution of Weekly Hours Spent on Leisure in Families with Preschool Children

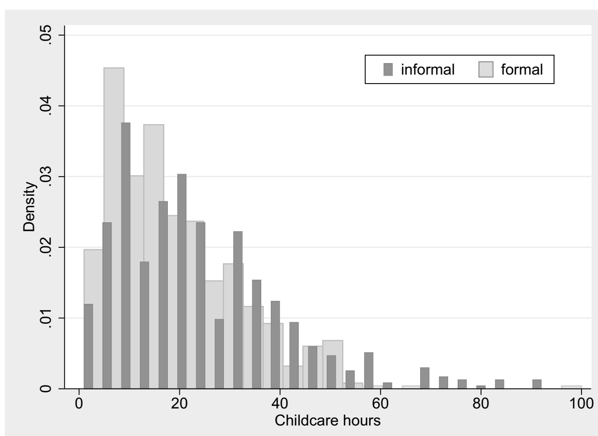

Figure 4: Distribution of Weekly Hours of Informal and Formal Child Care, Families with Preschool Children Using Child Care

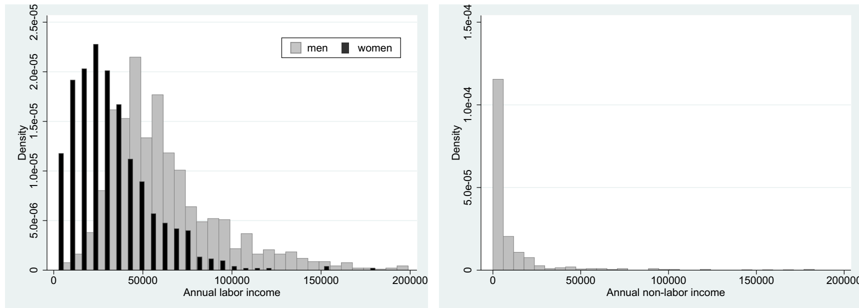

Figure 5: Annual Labor and Non-Labor Gross Incomes of Families with Preschool Children, 2008, AUD

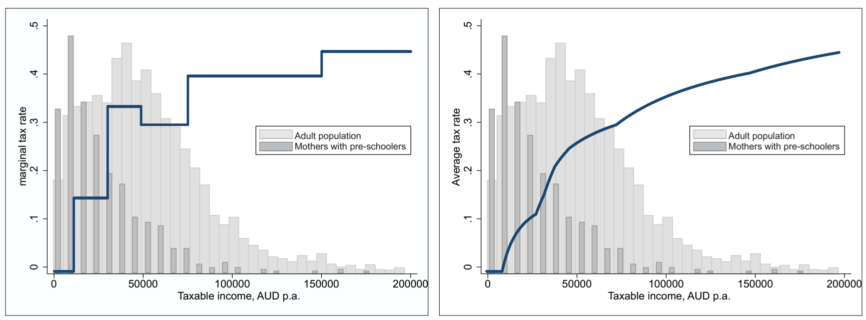

Figure 6: Marginal and Average Income Tax Rates, 2007-08, and Annual Incomes, 2008

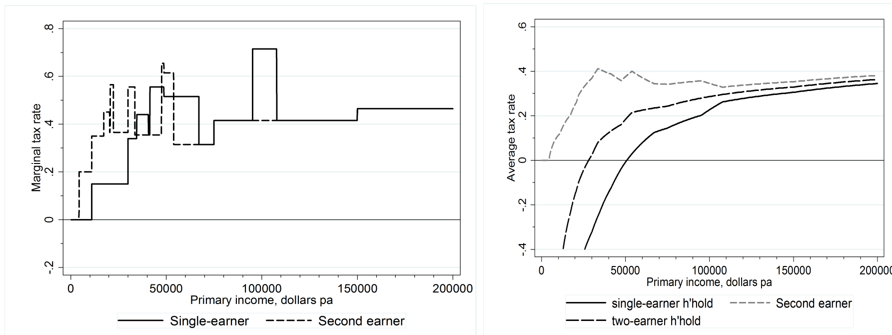

Figure 7: Effective Marginal and Average Tax Rates (Including Income Taxes and Family Payments) by Primary Income, 2007-08

Table 1: Summary Statistics, Sample of Couples with Preschool Children

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Age - women	32.9	5.6	16	48
Age - men	34.9	6.3	18	58
Marital status (dummy)	0.82	0.4	0	1
Employment status - women (dummy)	0.55	0.5	0	1
Employment status - men (dummy)	1	0	1	1
Number of children, aged 0-4	1.39	0.6	1	4
Number of children, aged 5-9	0.47	0.7	0	4
Number of children, total	2.01	0.96	1	6
Market work - women, weekly hours	13.9	15.8	0	80
Market work - men, weekly hours	44.5	11.3	0	128
Informal child care - women, weekly hours	41.2	25.8	0	128
Informal child care - men, weekly hours	16.4	11.6	0	80
Informal child care - other relatives & friends, weekly hours	6.9	13.6	0	120
Housework (excl. child care) - women, weekly hours	30.4	18.0	0	133.3
Housework (excl. child care) - men, weekly hours	14.7	10.9	0	80
Leisure - women, weekly hours	82.3	27.6	0	160
Leisure - men, weekly hours	91.9	18.01	10	150.5
Formal child care, weekly hours	8.3	12.8	0	100
Formal child care price, in AUD, hourly	8.7	3.5	1.583	23.8
Annual wage - men, in AUD	63373	35736	5136	357216
Annual wage - women, in AUD	18514	23570	0	182256
Annual non-labor family income, in AUD	6617	31778	0	683974
Number of observations		1465		

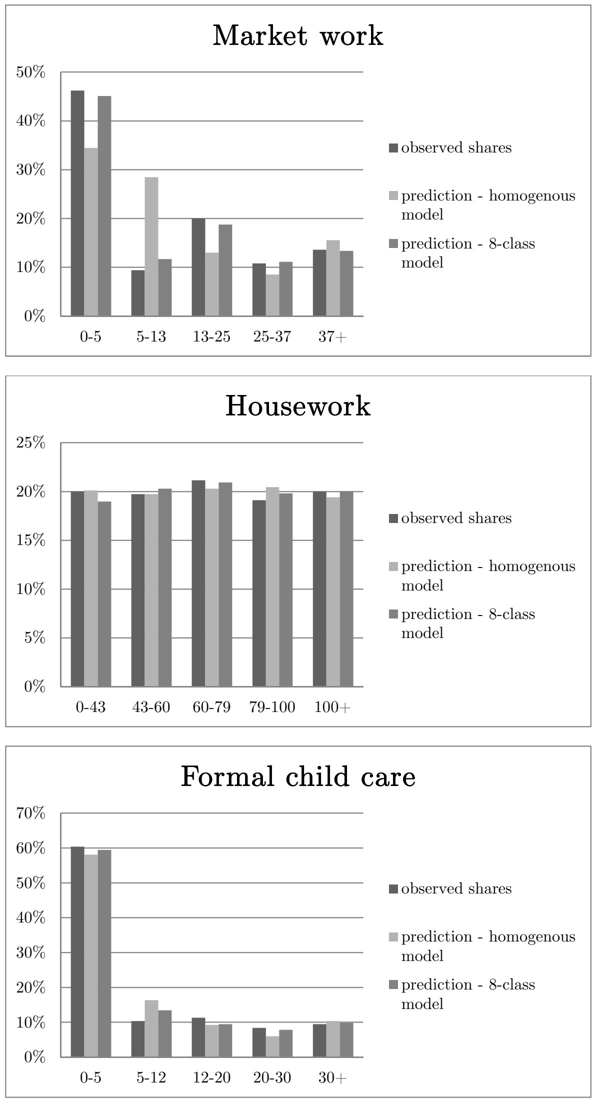

Figure 8: Distribution of Time Use Variables into Intensity Levels, Observed and Predicted Shares

Table 2: Regression Results for the Baseline Homogeneous Model

Matrix A		Vector b	
Income	.199 (.092)**	Formal care*log(age)	-.613 (3.63)
Formal care	2.23 (6.20)	Formal care*log(age)^2	.130 (.529)
Housework	4.71 (3.42)	Formal care*married	-.031 (.057)
Leisure	7.59 (3.52)**	Formal care*No. dependent children	-.127 (.037)***
Formal care^2	.128 (.014)***	Formal care*children aged 0-4	.329 (.056)***
Housework^2	.066 (.005)***	Formal care*children aged 5-9	.093 (.049)*
Leisure^2	.022 (.006)***	Formal care*informal care	-.009 (.001)***
Income*formal care	.011 (.004)**	Housework*log(age)	-4.07 (2.01)**
Income*housework	.019 (.002)***	Housework*log(age)^2	.607 (.294)**
Income*leisure	.020 (.002)***	Housework*married	.026 (.032)
Formal care*housework	-.066 (.004)***	Housework*No. dependent children	-.112 (.020)***
Formal care*leisure	-.064 (.005)***	Housework*children aged 0-4	.336 (.032)***
Housework*leisure	-.050 (.005)***	Housework*children aged 5-9	.148 (.027)***
		Housework*informal care	-.008 (.001)***
		Leisure*log(age)	-4.87 (2.07)**
		Leisure*log(age)^2	.685 (.305)**
		Leisure*married	.012 (.034)
		Leisure*No. dependent children	-.053 (.023)**
		Leisure*children aged 0-4	.231 (.034)***
		Leisure*children aged 5-9	.114 (.031)***
		Leisure*informal care	-.009 (.001)***
n			1465
Log-likelihood			-6076.44

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.

	Average Marginal Utility		**Negative Fraction**	
	Full Sample	Child Care Users	Full Sample	Child Care Users
Income	1.06	1.04	0	0
Formal care	-0.69	-0.05	0.83	0.58
Housework	0.63	0.26	0.17	0.37
Leisure	0.64	0.33	0.24	0.28

Table 3: Average Marginal Utilities of the Main Regressors and Fraction of the Population Sample with Negative Marginal Utilities, Homogeneous Model

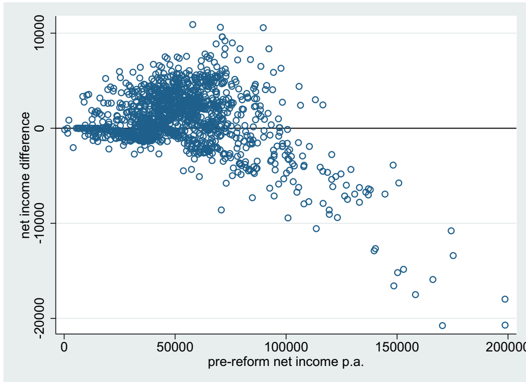

Figure 9: Post-Reform Differences in the Net Tax Positions of the Families, Ordered by Pre-Reform Net Household Incomes

No. of Classes	Log-Likelihood	BIC
1	-6076.44	12415.31
2	-4921.44	10367.73
3	-4676.13	10139.53
4	-4226.96	9503.61
5	-3963.88	9239.88
6	-3748.64	9071.83
7	-3584.41	9005.79
8	**-3319.71**	**8738.83**
9	-3236.49	8823.87

Table 4: Bayesian Information Criteria for Multi-Class Models

	Whole Sample	Child Care Users
Income	0	0
Formal care	0.53	0.31
Housework	0.24	0.41
Leisure	0.23	0.38

Table 5: Fraction of the Population Sample with Negative Marginal Utilities of the Main Regressors, Model with 8 Latent Classes

Mothers' Net Wage Increased by 10%

No. of classes	1	2	3	4	5	6	7	8	9
Formal care hrs.	1.01	0.58	0.58	0.58	0.59	0.50	0.51	0.42	0.49
	(0.051)**	(0.042)***	(0.096)***	(0.101) ***	(0.070)***	(0.078)***	(0.095)***	(0.065)***	(0.097)***
Market work hrs.	1.35	0.77	0.65	0.48	0.65	0.62	0.52	0.43	0.68
	(0.043)***	(0.034)***	(0.084)***	(0.088)***	(0.067)***	(0.126)***	(0.134)***	(0.086)**	(0.149)***
Housework hrs.	-0.23	-0.10	-.10	-0.06	-0.10	-0.07	-0.10	-0.08	-0.09
	(0.012)***	(0.011)***	(0.020)***	(0.016)***	(0.018)***	(0.015)***	(0.023)***	(0.015)***	(0.023)***

Net Child Care Price Increased by 10%

No. of classes	1	2	3	4	5	6	7	8	9
Formal care hrs.	-0.51	-0.51	-0.48	-0.52	-0.47	-0.45	-0.50	-0.42	-0.38
	(0.017)***	(0.02)***	(0.031)***	(0.043)***	(0.033)***	(0.079)***	(0.06)***	(0.081)***	(0.06)***
Market work hrs.	-0.17	-0.11	-0.15	-0.10	-0.12	-0.10	-0.11	-0.08	-0.11
	(0.01)***	(0.011)***	(0.018)***	(0.026)***	(0.02)***	(0.023)***	(0.027)**	(0.021)***	(0.027)***
Housework hrs.	0.03	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01
	(0.003)***	(0.004)***	(0.006)***	(0.005)**	(0.007)***	(0.008)***	(0.008)***	(0.008)***	(0.008)***

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.

Table 6: Elasticities of Time Use Allocations with Respect to Changes in Net Wages and Net Child Care Prices

No. of classes	1	2	3	4	5	6	7	8	9
Formal care hrs.	3.90%	2.77%	2.77%	3.52%	3.78%	1.57%	2.24%	1.75%	2.74%
	(0.243)***	(0.234)***	(0.648)***	(0.634)***	(0.54)***	(0.422)***	(0.511)**	(0.38)***	(0.564)***
Market work hrs.	6.49%	4.43%	3.54%	4.16%	3.96%	2.99%	2.77%	3.11%	3.41%
	(0.337)***	(0.262)***	(0.627)***	(0.616) ***	(0.62)***	(0.83)***	(0.885)**	(0.684)***	(0.915)***
Housework hrs.	-1.11%	-0.6%	-0.57%	-0.63%	-0.39%	-0.38%	-0.66%	-0.63%	-0.61%
	(0.091)***	(0.076)***	(0.155)***	(0.113)***	(0.144)***	(0.136)***	(0.191)**	(0.133)***	(0.152)***

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.

Table 7: Percentage Changes in Time Allocations after FTB Reform

Mothers' Net Wage Increased by 10%

	Original Model	6 Brackets	Maternal Care	Fixed Disutility	Imputed
Formal care hrs.	0.42 $(0.065)^{***}$	0.51	0.43	0.42	0.36
Market work hrs.	0.43 $(0.086)^{**}$	0.61	0.57	0.57	0.47
Housework hrs.	-0.08 $(0.015)^{***}$	-0.12	-0.07	-0.09	-0.06

Net Child Care Prices Increased by 10%

	Original Model	6 Brackets	Maternal Care	Fixed Disutility	Imputed
Formal care hrs.	-0.42 $(0.081)^{***}$	-0.45	-0.44	-0.35	-0.40
Market work hrs.	-0.08 $(0.021)^{***}$	-0.11	-0.09	-0.11	-0.10
Housework hrs.	0.02 $(0.008)^{***}$	0.02	0.01	0.01	0.01

FTB Reform - Percentage Changes

	Original Model	6 Brackets	Maternal Care	Fixed Disutility	Imputed
Formal care hrs.	1.75% $(0.380)^{***}$	1.94%	2.29%	2.68%	1.92%
Market work hrs.	3.11% $(0.684)^{***}$	3.18%	3.01%	4.26%	3.25%
Housework hrs.	-0.61% $(0.133)^{***}$	-0.77%	-0.37%	-0.96%	-0.58%

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.

Table 8: Robustness Check - Elasticities and Reform Responses Derived by Alternative Model Specifications with 8 Latent Classes

Appendix - Heckman Selection Models

Here we present details of the Heckman selection models which were used to predict missing wages and childcare prices. In the wage regressions we use a sample of married and cohabiting women complying with the following selection criteria: we exclude women who are either older than 55, full-time students or disabled. The exclusion restrictions used in the participation equation are non-wage income, and number of children.

In the case of child care price regressions we further reduce the sample to contain only women with pre-school children. This reduced sample is still larger than the dataset used in our discrete choice model, because the time-use questionnaire was collected only for a randomized subsample. The exclusion restrictions used in the child care participation equation are number of adults in the household (excluding the spouses), and residential distance from grandparents (the base group represents families without grandparents).

Table 9: Mothers' Wage Estimation, Heckman Selection Model. The Dependent Variable Is Gross Hourly Wage.

	Participation Equation	Wage Equation
Constant	-.027 (.307)	3.984 (7.380)
Married	-.048 (.039)	1.057 (.925)
Urbanization index	.100 (.028)***	1.086 (.730)
Non-english ethnicity	-.287 (.046)***	-4.351 (1.176)***
Mother's age	.033 (.015)**	.265 (.366)
Mother's age squared	-.0009 (.0002)***	-.006 (.005)
Mother's tenure	.032 (.004)***	.404 (.113)***
Mother's tenure squared	.0005 (.0001)***	.0001 (.003)
Other household income (log)	-.100 (.012)***	
No. of children aged 0-4	-.574 (.024)***	
No. of children aged 5-9	-.226 (.025)***	
No. of children aged 10-14	-.149 (.026)***	
No. of children aged 15-18	.019 (.032)	
Inverse Mills Ratio		13.121 (1.994)***
Obs.	9324	9324

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.
Additional controls include regional, educational and yearly dummies.

Table 10: Childcare Price Estimation, Heckman Selection Model. The Dependent Variable Is Gross Hourly Price of Formal Childcare.

	Participation Equation	Price Equation
Const.	-2.645 (.968)***	8.090 (6.187)
Mother's gross hourly wage	.003 (.0009)***	-.008 (.008)
Other household income (log)	-.010 (.030)	.049 (.121)
Married	-.050 (.094)	.409 (.414)
Urbanization index	.096 (.068)	.354 (.288)
Non-english ethnicity	-.197 (.125)	-.195 (.586)
Mother's age	.069 (.055)	.001 (.273)
Mother's age squared	-.0003 (.0008)	-.0002 (.004)
No. of children aged 0-4	.174 (.059)***	-.276 (.294)
No. of children aged 5-9	-.084 (.051)*	-.130 (.229)
No. of children aged 10-14	-.274 (.087)***	-.981 (.471)**
No. of children aged 15-18	-.277 (.143)*	-1.683 (.652)***
No. of other adults in the household	.015 (.131)	
Distance to grandparents: Same household	-.730 (.376)*	
Distance to grandparents: Less than 1 km	-.408 (.147)***	
Distance to grandparents: 1 to 4 kms	-.243 (.144)*	
Distance to grandparents: 5 to 9 kms	-.091 (.135)	
Distance to grandparents: 10 to 19 kms	-.086 (.138)	
Distance to grandparents: 20 to 49 kms	-.297 (.153)*	
Distance to grandparents: 50 to 99 kms	-.025 (.210)	
Distance to grandparents: 100 to 499 kms	-.068 (.166)	
Distance to grandparents: 500 kms or more	-.030 (.154)	
Distance to grandparents: Overseas	-.413 (.218)*	
Inverse Mills Ratio		.932 (1.498)
Obs.	1725	1725

Standard errors in the parentheses, significance levels: 90*, 95**, 99***.
Additional controls include regional, educational and yearly dummies.