Chapter 3

A Model of Mothers' Labor Supply and the Demand for Child Care

3.1 Introduction: What is Microsimulation?

In this chapter I present a behavioral microsimulation model that can be used for the evaluation of policy reforms with respect to (i) changes of the income distribution, (ii) fiscal costs, (iii) labor market reactions of mothers, (iv) the demand for childcare and (v) changes of the households' welfare. Behavioral microsimulation models have been developed and used for the evaluation of different policy reforms both internationally and also in Germany.[1] Examples for policy evaluation studies in the field of labor market and tax policies based on microsimulation in Germany are, among others, Buslei and Steiner (1999), Wagenhals (1998, 2000), Kaltenborn (2001), Bonin et al. (2003) or Fuest et al. (2006). Non-behavioral models that can serve as the basis for distributional analysis of reforms of the tax-transfer system have been applied, among others, by Bach et al. (2003), Corneo (2005b), Maiterth (2004) or Merz and Zwick (2002). There is also a multi-country microsimulation model (EUROMOD) that contains many countries of the European Union, including

[1] Creedy and Duncan (2002) provide a detailed overview of the development of behavioral microsimulation models.

Germany, and allows non-behavioral microsimulation of the different tax-transfer systems. See Lietz and Mantovani (2007) for an overview of EUROMOD and Levy et al. (2007) for an example of non-behavioral family policy evaluation based on EUROMOD.

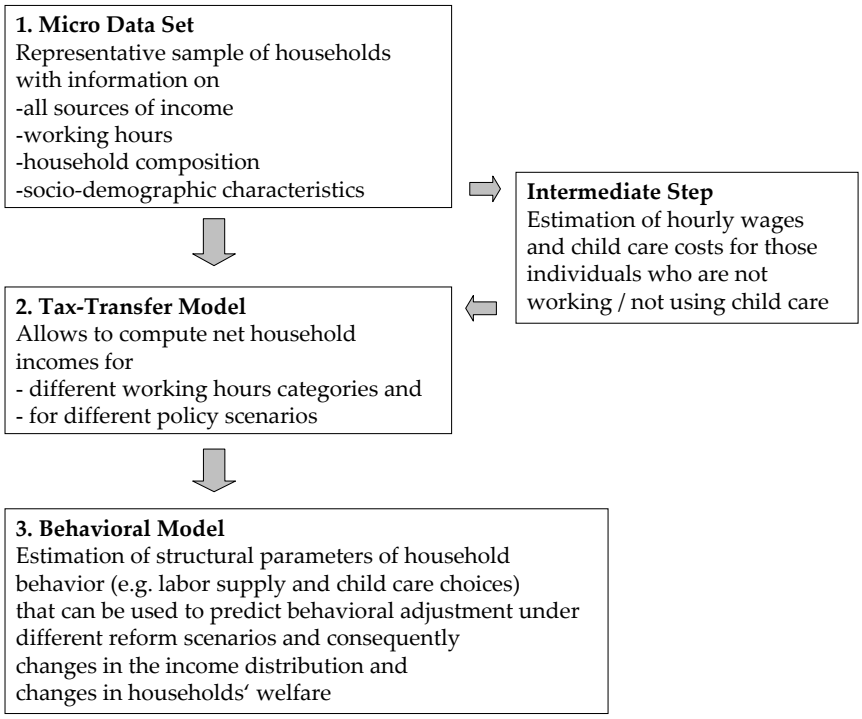
Microsimulation models have become popular because they allow to evaluate potential policy changes from an ex-ante perspective. Important questions such as "How much will a potential reform cost?", "How will households adjust their labor supply?" and "How would the reform change the income distribution?" can be answered on the basis of microsimulation studies.

The model presented in the following extends existing behavioral microsimulation models such that an evaluation of family policy reforms is possible. First, the calculation of net household income under different working hours states based on a detailed model of the German tax-transfer system is extended to include childcare costs. The measure of childcare costs used in this model not only consists of the average parents' fees to existing childcare slots but takes into account that access to these childcare slots is restricted for many families. Second, the behavioral model is extended in the way that mothers' labor supply is estimated jointly with the demand for non-parental childcare. These extensions are important prerequisites to make the model suitable for family policy evaluation, in particular in the field of childcare policy reforms.

Behavioral microsimulation models consist of three parts, as is graphically shown in Figure 3.1. First, a representative micro data set is needed that contains all relevant information on household structure, income from different sources, working hours, and socio-demographic characteristics. The second part consists of a tax-transfer model that computes net household incomes for each household in the data set on the basis of information on gross incomes. With this model, it is possible to compute net household incomes not only under the current legislation but also for different hypothetical tax-benefit regimes. Aggregating these so-called "morning-

after" effects yields the potential fiscal costs or revenues of the simulated reform. The third part, finally, is an empirically estimated behavioral model - in this case, a model of mothers' labor supply and the demand for childcare. On the basis of the estimated parameters of this model and the changes in disposable income, behavioral changes that would result from simulated reforms can be predicted. These behavioral changes in turn lead to changes in disposable income, as well as to changes in the fiscal budget.

Figure 3.1: Three Parts of a Behavioral Microsimulation Model



Source: Own depiction.

On the basis of post-reform income, that changes not only due to modifications of the parameters of the tax-transfer system but also due to behavioral adjustment, it is possible to perform a distributional analysis in order to identify "winners" and "losers" of policy reforms. However, if such an analysis is based on market incomes only, the potential losses in utility due to an increase in market work that

leads to less time for leisure or other non-market activities such as childcare are not taken into account. A comprehensive study of the change in households' well-being therefore has to be based on money metrics of utility changes such as the compensating variation.

3.2 Data

The microsimulation model used in the following bases on data from the German Socio-Economic Panel (SOEP). The SOEP is a longitudinal survey based on a representative sample of private households in Germany with detailed information on household incomes, working hours and household structure. The SOEP, which is provided by the German Institute of Economic Research (DIW Berlin), started in 1984 and contains information on more than 23,000 individuals in 12,500 households in the year 2002. Weighting factors allow to aggregate the sample to the total population living in private households.[2] Every year, key questions such as those on household composition, education and qualifications, labor market experience, earnings and income, housing and health are asked. Moreover, there are topical modules that change every year. In the year 2002, one of these topics was childcare. This wave not only includes information on childcare utilization, which is asked every year, but also on childcare expenditures.

For the same year, data on the availability of formal childcare on the level of all 440 German counties are available.[3] These data can be matched to the individual data using the county classification numbers that are provided in the SOEP. As will be explained below, this regional information together with the individual information on private expenditures for childcare will be used in the estimation of childcare costs that households face at different working hours categories. Since these data are only available for 2002, I decided to use the 2001 to 2003 waves of the SOEP

[2]For detailed information on the SOEP, see SOEP-Group (2001) and Wagner et al. (2006).

[3]These data are made available by the Deutsches Jugendinstitut DJI in Munich. I would like to thank Hiltrud Bayer for the timely provision of these data.

for the estimation of the model, since the local availability of childcare slots can be assumed to be similar in the year before and after the actual observation.

The sample used for the following analysis includes married or cohabiting couples and single mothers with at least one child aged up to six years and not yet enrolled in school. Two-parent families in which the father is working less than full-time are excluded. The reason to drop two-parent families with a non full-time working father is to keep the model simple: For mothers with a full-time working partner as well for as single mothers, regular childcare by the father during working hours is not available.[4] Households with self-employed mothers, mothers who are still in education or training or are severely disabled are also excluded from the sample. This gives a sample size of 1495 households, of which 548 are observed in one wave, 411 are observed in two waves and 536 are observed in three waves. In total, this adds up to 2978 observations.

Basic descriptive statistics, such as the distribution of households across working hours and childcare categories that will be used in the following analysis are summarized in Table 3.1. As this table shows, 54% of all mothers are not working. This share increases to 67% among the mothers with a child under three years, while it only amounts to 40% in the group of mothers whose youngest child is three to six years old.

Overall, 49% of all mothers with children up to six years are using some sort of paid childcare for their youngest child. Among mothers whose youngest child is below three years, this share is lower and amounts to 24%. 10% of the mothers report to be working although they are not using paid childcare for their youngest child. Thus, they have to have access to some sort of unpaid non-parental childcare. Not surprisingly, the average age of the youngest child is higher among families in which the mother is working. Younger children are less likely to have a working

[4]In the data set that will be used for the empirical analysis, two-parent families with a not full-time working father make up 10 percent of all families whose youngest child is less than 7 years.

mother and to be in paid childcare. Moreover, as the number of children increases, mothers are less likely to be working or using paid childcare for their youngest child.

As can be seen from this table, the distribution across working hours and childcare categories is very similar among single mothers as compared to the whole sample. The only exception is that marginal employment is less prevalent among single mothers compared to the whole sample, which can be explained by the work incentives for this group, that will be described below (see Figure 3.6). More descriptive information on the sample, such as the distribution of household income and childcare costs will be presented in the following sections.

Table 3.1: Descriptive Statistics

Choice Categories		Frequency			
working hours of the mother	child care hours of the youngest child	All Households		Single mothers	
		Absolute Number	Share (in %)	Absolute Number	Share (in %)
0	0	1223	41	114	39
marginal (8)	0	104	4	7	2
part-time (20)	0	108	4	8	3
full-time (37)	0	45	2	10	3
0	part-time (20)	328	11	31	11
marginal (8)	part-time (20)	285	10	18	6
part-time (20)	part-time (20)	429	14	35	12
full-time (37)	part-time (20)	61	2	9	3
0	full-time (37)	46	2	17	6
marginal (8)	full-time (37)	4	< 1	0	0
part-time (20)	full-time (37)	87	3	16	5
full-time (37)	full-time (37)	258	9	31	11
Sum		2978	100	296	100

Choice Categories		Frequency			
working hours of the mother	child care hours of the youngest child	Families with youngest child < 3 years		Families with youngest child aged 3-6	
0	0	978	64	245	17
marginal (8)	0	76	5	28	2
part-time (20)	0	71	5	37	3
full-time (37)	0	23	2	22	2
0	part-time (20)	28	2	300	21
marginal (8)	part-time (20)	124	8	161	11
part-time (20)	part-time (20)	114	7	315	22
full-time (37)	part-time (20)	13	1	48	3
0	full-time (37)	12	1	34	2
marginal (8)	full-time (37)	1	< 1	3	< 1
part-time (20)	full-time (37)	21	1	66	5
full-time (37)	full-time (37)	71	5	187	13
Sum		1532	100	1446	100

Choice Categories		Average over all households		
working hours	child care hours	Age of youngest child	Number of children under 6	Total number of children in the household
0	0	1.5	1.4	2.0
marginal (8)	0	1.8	1.3	1.8
part-time (20)	0	2.2	1.2	1.7
full-time (37)	0	2.5	1.1	1.8
0	part-time (20)	3.9	1.1	2.0
marginal (8)	part-time (20)	2.8	1.2	1.9
part-time (20)	part-time (20)	3.4	1.1	1.7
full-time (37)	part-time (20)	3.4	1.1	1.6
0	full-time (37)	3.3	1.2	1.4
marginal (8)	full-time (37)	4.2	1.0	0.7
part-time (20)	full-time (37)	3.4	1.1	1.3
full-time (37)	full-time (37)	3.4	1.1	1.6
Overall average		2.5	1.3	1.9

Source: SOEP, waves 2001 - 2003.

3.3 The Tax Benefit Model

The tax-benefit model is a crucial part of any microsimulation model, allowing to calculate net incomes for every household for any choice of working hours. Moreover, by changing parameters of the tax-benefit system, the model can be used to calculate net incomes not only for the current legislation but also for many possible reform alternatives.

The tax-benefit model used in this analysis is the Tax-Transfer Simulation Model STSM.[5] This model contains the main features of the German tax and transfer system. The calculation of taxable income is based on information on earnings from dependent employment, income from capital, property rents and other income. For most households, earnings from dependent employment is the most important source of income. These earnings are calculated by multiplying gross hourly wages by the respective working hours in each category. For non-working individuals, wages are estimated on the basis of a Heckman (1979) type selection-correction model.[6]

Gross household income is the sum of all income components of all household members. Taxable income is calculated by deducting child allowances and other expenses from gross household income. The income tax is computed by applying the income tax formula to the individual incomes of unmarried spouses; for married spouses, income is taxed jointly, with an income splitting factor of 2. Income tax and social security contributions are deducted from gross income, and social transfers such as child benefits, child-rearing benefits, unemployment compensation, housing benefits and social assistance are added to calculate net household income. Note that STSM uses retrospective information of income components in order to compute net household incomes for a given year. Thus, the incomes computed on basis of the SOEP waves 2001-2003 are in fact incomes for the years 2000-2002.

Net household income, that is market income after taxes and transfers, however,

[5] A detailed documentation of STSM can be found in Steiner et al. (2005).
[6] Estimation results of the wage estimation are documented in Steiner et al. (2005).

does not depict the budget constraint of families with young children comprehensively. Many German families do not have access to unpaid childcare options, and the mothers' market work activities are associated with expenses for suitable care of their children.[7] Thus, I will argue in the following that childcare costs have to be deducted from *net household income* in order to get *disposable household income* which actually reflects the budget constraint of families with young children. The next section shows how childcare costs can be measured in a setting of potential access restrictions to formal childcare.

3.4 Childcare Costs in the Presence of Rationing

In the previous literature on labor supply of mothers in Germany, the prevalent measure of childcare costs has been the expenses reported by families who are actually using childcare or official statistics about average parents' fees for childcare slots (see, for example, Merkle (1994)). However, using these concepts, childcare costs are only measured for households who are actually using childcare. For households facing access restrictions to childcare slots, this measure is not appropriate. There are several studies who mention that in addition to childcare costs (as defined above) also availability of childcare plays a role in mothers' employment decision (Merkle (1994)), although these studies do not quantify this effect. On the other hand, there are several studies for Germany that analyze the effect of local availability of childcare on mothers' employment (Kreyenfeld and Hank (2000) and Spiess and Buechel (2002)).

In order to assess both dimensions, parents' fees as well as accessability of childcare, at the same time, I use a measure of childcare costs ("expected costs of childcare") that explicitly takes into account rationing of childcare slots in facilities. I

[7] As the analysis of the SOEP data presented in Table 2.5 shows, childcare is almost exclusively the mothers' responsibility. On average, fathers are in charge of childcare about 17 hours per week, including weekends.

will assume that rationing occurs only with respect to subsidized childcare, not with childcare on the "private market", i.e. childcare by nannies or babysitters. This follows the argument that at some (potentially very high) price, each family could find a person who would look after the children. Expected costs of childcare are thus calculated as weighted average of parents' fees to subsidized slots and the price of privately organized care. The weights refer to the probability of being rationed with respect to subsidized care.

Formally, expected costs of childcare, ec, consist of the parents' fee for a subsidized childcare slot, c^s, and a market (non-subsidized) price for childcare charged by a nanny, c^{ns}, weighted by the probability to have access to a subsidized childcare slot, π, and being rationed, $(1-\pi)$, respectively:

$$ec = c^s \cdot \pi + c^{ns} \cdot (1-\pi) \tag{3.1}$$

Micro data sets such as the SOEP include information on parents' fees for subsidized slots. Using this information, average parents' fees can be estimated and predicted according to certain characteristics such as the age of the child and household income (see section 3.4.3). The price of private care can typically not be estimated on the basis of micro-data since there are very few observations reporting to use private childcare. Searching internet platforms like www.tagesmutter.de, however, revealed that the national average price of private childcare was around 5 Euro per child per hour in 2003.[8] More challenging, however, is to find out the individual probability of getting a subsidized slot. Beblo et al. (2005) have assumed that this probability can be set equal to the local availability rate of subsidized childcare. However, this implies that parents of all children in Germany actually demand childcare, which does not seem to be plausible. For a more accurate measure of the probability that a child is rationed with respect to childcare, it has to be estimated on the basis of information from survey data.

[8] See Beblo et al. (2005).

3.4.1 The Probability of Being Rationed with Respect to Subsidized Childcare

Estimation of the probability that a child is rationed with respect to center-based childcare requires that the demand for and the supply of childcare can be estimated. The problem of estimating the demand for childcare on the basis of survey data, however, is that in the presence of access restrictions to childcare, the observed utilitzation cannot be interpreted as demand. In most data sets that are available there is only information about the childcare status of the child, i.e. it is known if a child is in a childcare facility or not. If a child is not in a childcare facility, this can be the case because (i) the parents do not want the child to be in a childcare facility, or (ii) because the parents applied for a childcare slot but were not chosen from the queue. This implies that the observed variable "childcare status" is in fact the joint outcome of two unobserved variables, namely the demand for childcare and the supply of a childcare slot. In order to calculate the probability that a child is restricted in the access to subsidized childcare, a model has to be estimated that allows to predict the probability that a child is not offered a childcare slot ($supply = 0$), although the parents want the child to be cared for in a facility ($demand = 1$). On the basis of partial observability models, demand and supply for a restricted good can be estimated, even if only the joint outcome of the two unobserved variables demand and supply is observed.[9]

Formally, the model can be stated as follows: The latent variable demand for childcare $D*$ depends on child and household characteristics, collected in the row vector X_D, and a stochastic part ε_D,

[9]Previous studies that have analyzed the demand for childcare (such as Spiess (1998)) have not considered the problem that the childcare status observed in survey data cannot be interpreted as the demand for childcare. An alternative strategy for identifying the demand for childcare in the presence of rationing is used in a study for Switzerland based on the "revealed preferences" approach; see Banfi et al. (2006).

$$D* = X_D\beta_D + \varepsilon_D \tag{3.2}$$

where β_D is a column vector of coefficients. It will be assumed that parents will have realized demand if $D*$ is above a certain threshold, which is normalized to zero,

$$D = 1 \text{ if } D* > 0 \tag{3.3}$$

Therefore, the probability that parents demand institutional childcare can be stated as

$$Pr(D = 1) = Pr(\varepsilon_D > -X_D\beta_D) \tag{3.4}$$

Further, it is assumed that parents are selected from the queue according to some household, child and regional characteristics X_S, a vector of coefficients β_S and a stochastic error term ε_S, formally

$$S* = X_S\beta_S + \varepsilon_S \tag{3.5}$$

As in the case of the observed demand, there will be supply of a childcare slot for a certain child if $S*$ is above zero,

$$S = 1 \text{ if } S* > 0 \tag{3.6}$$

Thus, the probability of having access to a childcare slot is

$$Pr(S = 1) = Pr(\varepsilon_S > -X_S\beta_S) \tag{3.7}$$

As already mentioned above, only the joint outcome of the two variables D and S, namely childcare utilization C, is observed. The probability that childcare is used can be thus stated as

$$Pr(C = 1) = Pr(S = 1 \cap D = 1) = Pr(D = 1) \cdot Pr(S = 1|D = 1) \tag{3.8}$$

Poirier (1980) proposed to estimate the parameters of β_D and β_S in a bivariate probit model that is identified under the normality assumption if each equation

excludes at least one exogenous variable appearing in the other equation. The likelihood function of this model is given as

$$L = \Pi[\Phi_2(X_D\beta_D, X_S\beta_S; \rho)]^C \cdot [1 - \Phi_2(X_D\beta_D, X_S\beta_S; \rho)]^{1-C} \tag{3.9}$$

where Φ_2 denotes the bivariate normal cumulative distribution function. This model was used for estimating demand and supply of childcare slots in the UK by Chevalier and Viitanen (2004).

In the German case some children are not rationed with respect to childcare services. Children who have already been in a childcare facility the year before do not have to queue again for a slot in the current year. Due to the panel structure of the SOEP data, information on last year's childcare status is available. Furthermore, I will assume that all children who live in a county where availability of childcare slots is near to hundred percent in their age group are also part of the unrestricted sample. Drawing on this information, I will follow the idea of Abowd and Farber (1982) and divide the sample into two parts, namely the unrestricted observations and the possibly restricted observations. For the unrestricted part, the observed variable "childcare utilization" can be explained by demand-side variables only. The likelihood function thus changes to

$$\begin{aligned} L &= \Pi_{NR=1}\Phi(X_D\beta_D)^C[1 - \Phi(X_D\beta_D)]^{1-C} \cdot \\ &\quad \Pi_{NR=0}[\Phi(X_D\beta_D) \cdot \Phi(X_S\beta_S)]^C \cdot 1 - [\Phi(X_D\beta_D) \cdot \Phi(X_S\beta_S)]^{1-C} \end{aligned} \tag{3.10}$$

where $NR = 1$ denotes the unrestricted sample and $NR = 0$ denotes the possibly restricted sample. In this model suggested by Abowd and Farber (1982), identification of the parameters is based on the assumption that the coefficients of the demand equation, β_D are the same for the restricted and the unrestricted part of the sample. However, this model does not allow for a correlation of unobservable characteristics between the demand for and supply of childcare. Since it seems plausible to

assume that unobserved characteristics of the demand and the supply equation are correlated, I suggest a more flexible specification, such as

$$\begin{aligned} L &= \Pi_{NR=1}\Phi(X_D\beta_D)^C[1-\Phi(X_D\beta_D)]^{1-C}\cdot \\ &\quad \Pi_{NR=0}[\Phi_2(X_D\beta_D, X_S\beta_S;\rho)]^C\cdot[1-\Phi_2(X_D\beta_D, X_S\beta_S;\rho)]^{1-C} \end{aligned} \tag{3.11}$$

In contrast to Poirier's model, identification is based on exclusion restrictions[10] as well as the estimation of a univariate probit for the unrestricted part of the sample. As in Abowd and Farber's model, the underlying assumption is that the coefficients of the demand variables are the same in both parts of the sample. As a robustness check, I have split the sample and estimated a partial observability model in the style of Poirier (1980) only for the possibly restricted part of the sample. While the predicted rationing probabilities of both models are not significantly different from each other, in the model estimated on the basis of the likelihood function in equation 3.11 convergence is achieved markedly faster.

The variables used in both the demand (X_D) and the supply equation (X_S), are the age of the child, the mother's marital status and number of siblings in childcare facilities. Mother's nationality is also included in both equations, since both, demand patterns as well as the ability to overcome the access restrictions to subsidized childcare may differ between Germans and non-German citizens.

The variables that are included in the demand equation only are, among others, mother's education. This is measured by two dummy-variables indicating high-school degree and university degree. The variable indicating university degree is also interacted with a dummy variable indicating that the child is under the age of three, since high skill mothers may wish to enter the labor market earlier and therefore demand a childcare slot earlier than lower skilled mothers. A dummy variable indicating frequent church attendance of the mother is also used as a variable

[10]Note that the exclusion restrictions are only necessary to identify the parameter ρ.

that possibly captures attitudes towards non-parental childcare.[11] In addition to these mother's characteristics and income variables, some variables on household composition are also included in the estimation of the demand equation, such as number of siblings in certain age groups and the presence of another adult household member besides the parents.

In the supply equation, the number of childcare slots per 100 children available at the county level is used as additional explanatory variable. This variable is available for each of the 440 counties and for three different age groups, namely for children under the age of three, for children aged between three years and school age and for children above six years. These data can be matched to the SOEP households using the county classification number. Furthermore, data on the spatial structure of the countries are matched to individual data using variables from the INKAR data set provided by the Federal Office for Building and Regional Planning *(Bundesamt fuer Bauwesen und Raumordnung)*.[12] In this data set, all 440 German counties are classified into 1 out of 9 spatial structure types, depending on populaton density and distance to the next urban center.

Chevalier and Viitanen (2004) use the average price for a childcare facility at the regional level as an additional variable for identification of the demand equation. For the case of Germany, however, this variable cannot be used. Official data on prices at the regional level do not exist since facilities are not required to report the fees they charge. However, even if data on parents' fees were available, it would not be possible to include them as explanatory variable in the estimation of the demand equation due to endogeneity problems: The parents' fees depend on the family's income, which is determined by employment of both parents. As has been argued before, mothers' labor force participation is endogenous. Thus, in the German context, the "price" variable cannot be included.

[11] This variable has been used in previous studies on the demand for childcare in the US (see Joesch and Hiedemann (2002)) in order to capture values and beliefs about appropriate ways to care for children.

[12] For more information on this data set, see Bundesamt fuer Bauwesen und Raumordnung (2002).

Unfortunately, the data on the local availability of childcare are available only for the year 2002. Since I will need the individual rationing probabilities for three years (2001 to 2003) I estimate the model on data from 2002 and predict the probabilities using the estimated coefficients and the children's characteristics for the year before and the year after. Table 3.2 provides detailed information on sample size, definitions and descriptive statistics on the variables used in the estimated model.

Note that the dependent variable, "child in childcare" is defined as 1 if a child is attending any sort of subsidized childcare. If a child is cared for by a private nanny, for example, the dependent variable is coded as 0. One restriction of the model employed here is that it does not allow to distinguish between part-time and full-time care. However, one might argue that rationing might be higher with respect to full-time care than to part-time care since availability of full-time care is considerably lower. In principal, it is possible to estimate a model differentiating between full-time and part-time care and allowing for different levels of rationing. Instead of a bivariate probit such as suggested in equation 3.11, one could estimate such a model using an ordered probit or a multinomial logit. Both specifications were estimated, however the parameters of the demand and supply equation could not be identified with the data at hand. The reason is that the differentiation between full-time and part-time care leads to very small number of observations within each category of the dependent variable for the group of children under three years.

Table 3.3 presents the coefficients of the estimated model. All coefficients - if significant - have the expected sign. The demand for childcare is lower for children aged less than 4 years compared to the reference group (children aged 4 to 6 years) and school-aged children. More educated mothers demand more childcare for their children, although the coefficient for "mother holding a university degree" is significant only for children under three years. This result is not surprising since childcare utilization for children older than three years is common in Germany even for children with non-working mothers (see section 2.2). Neither the mother's nationality

Table 3.2: Descriptive Statistics of the data used for the estimation of demand and supply of center-based childcare

Variable Name	Mean	Standard Deviation
mother holds high school degree	0.24	–
mother holds university degree	0.11	–
mother visits church frequently	0.23	–
other adult apart from parents living in the household	0.07	–
mother has German nationality	0.85	–
father is living in the same household	0.91	–
child is aged 0-1	0.15	–
child is aged 2	0.09	–
child is aged 3	0.09	–
child is aged 7-10	0.38	–
number of sisters aged 10-16	0.12	0.33
number of siblings aged 0-3	0.20	0.42
number of siblings aged 4-6	0.23	0.43
number of siblings aged 7-10	0.22	0.43
number of siblings aged 0-3 in child care	0.09	0.29
number of siblings aged 4-6 in child care	0.21	0.48
North-West[a]	0.15	–
Middle-West[b]	0.17	–
Northrhine-Westphalia	0.22	–
Baden-Wuerttemberg	0.15	–
Bavaria	0.16	–
rural area	0.12	–
local availability of child care slots	0.48	0.49
Number of observations	3103	
Mean of dependent variable	0.35	

[a] "North-West" includes Federal States of Schleswig-Holstein, Hamburg, Bremen and Lower Saxony.
[b] "Middle-West" includes Hesse, Rhineland-Palatinate and Saarland.
Source: SOEP wave 2002.

nor the frequency of her church attendance has a significant effect on the demand for childcare, at least on the 5 percent significance level.[13] The number of siblings and the presence of another adult household member apart from the parents negatively affect the demand for out of home childcare. While the size of the city does not have a significant effect on the demand for childcare, living in east Germany leads to a significantly higher demand than living west Germany.

In the supply equation, the availability of childcare slots on the county level has a positive influence on the individual probability of being offered a childcare slot.

[13] In their study on the demand for infants' and toddlers' nonrelative childcare, Joesch and Hiedemann (2002) find that religious affiliation has a significant effect.

Table 3.3: Estimation results of demand and supply of center-based childcare (partial observability model)

	Demand equation		Supply equation	
Explanatory variables	Coeff.	St. Err.	Coeff.	St. Err.
mother holds high school degree	0.2832	0.1057	–	–
mother holds university degree	0.0032	0.1871	–	–
mother holds university degree*child aged 0-3	0.8073	0.8040	–	–
mother visits church frequently	-0.1709	0.0966	–	–
other adult apart from parents living in the household	-0.3691	0.1884	–	–
mother has German nationality	0.0101	0.1557	0.0265	0.2580
father is living in the same household	-0.2206	0.1754	0.0847	0.2308
child is aged 0-1	-1.6848	0.8244	-1.6165	0.6211
child is aged 2	-1.9280	0.4611	-0.3783	0.6896
child is aged 3	-0.3869	0.1330	-0.6745	0.3640
child aged 0-3 * family living in east Germany	2.1704	0.6313	–	–
child aged 7-10 * family living in east Germany	0.5931	0.3638	–	–
child is aged 7-10	-1.5757	0.3154	-1.0631	0.8136
number of sisters aged 10-16	-0.2964	0.1316	–	–
number of siblings aged 0-3	-0.2370	0.1121	–	–
number of siblings aged 4-6	-0.7366	0.3263	–	–
number of siblings aged 7-10	-0.2092	0.0871	–	–
number of siblings aged 0-3 in child care	0.1603	0.1727	0.0170	0.1288
number of siblings aged 4-6 in child care	0.8426	0.3254	-0.0652	0.1811
North-West	-0.3668	0.1960	-0.1942	0.6054
Middle-West	-0.1217	0.1691	-0.2234	0.5194
Northrhine-Westphalia	-0.3428	0.1788	-0.0494	0.5381
Baden-Wuerttemberg	-0.0926	0.1774	-0.3920	0.4910
Bavaria	-0.2972	0.1740	0.1076	0.4799
rural area	-0.0715	0.1446	0.0726	0.1985
local availability of child care slots	–	–	1.0101	.5569
constant	1.6237	0.2446	0.1656	0.7596
rho	-0.2710	0.6946		
Number of observations	3103			
Log pseudolikelihood	-937.56108			
Wald chi2(25)	90.68			

Source: Estimations based on SOEP, wave 2002.

The age of the child also has a significant effect: For example, children aged below 2 years have a lower probability of being offered a childcare slots. This suggests that within each age group, older children are favored compared to younger children. The mother's marital status does not influence the probability of being offered a slot. This is also true for the number of siblings already in childcare.[14] Neither the

[14] Although it is known that the usual practice of childcare facilities is to favor children who have already older siblings in the same institution, I do not find a significant effect on the individual probability of a child to being offered a slot. The reason might be that I do not have information whether children are in fact attending the same institution or different ones.

regional variables nor the variable indicating rural area are statistically significant, which is not surprising since differences in the provision of childcare slots are already captured by the variable availability of childcare slots. The correlation coefficient of the error terms of the demand and supply equations (ρ) is negative yet not significant.

In order to evaluate the predictive quality of the estimation, actual and predicted values of childcare utilization can be compared. For example, the predicted value can be coded as 1 if the predicted probability is greater than 0.5. According to this rule, the model performs well, predicting the joint outcome of demand and supply correctly in 90 percent of all observations. As a comparison, a model that explains the left-hand side variable by a constant only would predict 54 percent of all cases correctly.

Estimations from the partial observability model allow to predict the marginal probabilities of demand for and supply of childcare slots (see Table 3.4). In addition to these marginal probabilities, the "rationing probability", i.e. the probability that demand equals 1 and supply equals 0 can be predicted. As shown in Table 3.4, the probability to be rationed is lowest among the group of children between three and six years (6%). For children under three years, the probability to be rationed is as high 0.34 and for children in primary school (seven to ten years) it amounts to 0.26. These probabilities, that are predicted on an individual level for every child in the sample, are used as weights $(1 - \pi)$ in equation 3.1.[15]

[15]This probability multiplied by each individual's weighting factor can be used to calculate the amount of the excess demand for subsidized childcare in Germany, see Wrohlich (2007).

Table 3.4: Predicted probabilities for demand and supply for subsidized childcare

	Children aged		
	0-2 years	3-6 years	7-10 years
Probability of parents demanding a slot	0.44	0.82	0.35
Probability of having access to a slot	0.24	0.93	0.28
Probability of being rationed with respect to center-based care	0.34	0.06	0.26
Availability rate	0.09	1.01	0.13

Source: Own calculations based on SOEP, wave 2002.

3.4.2 Estimating Parents' Fees to Subsidized Childcare

Another part of expected costs of childcare such as stated in equation 3.1 has to be estimated on the basis of individual data, namely the parents' fees to subsidized slots, c^s. As already explained above, information on individual expenditures for childcare is available in the 2002 wave of the SOEP. In order to predict these expenditures also for children who are not attending childcare facilities, I estimate the parents' fees on the basis of a Tobit model. This model is chosen since about 10 percent of parents do not have to pay for center-based childcare.[16] Explanatory variables include the age of the child, number of siblings in center-based care, regional variables and net household income.

Fees for part-time care and full-time care are estimated separately. As can be seen from Table 3.5, the age of the child significantly increases the parents' fees in the case of full-time care. Net monthly income significantly increases the parents' fees for part-time and full time care. If a child has siblings that are also attending childcare facilities, this fact significantly reduces the parents' fees. This result has also been found in previous studies for earlier years (Merkle (1994) and Kreyenfeld et al. (2001)). Furthermore, regional variables are also included, however not all of

[16]Most communities collect parents' fees to childcare centers according to their income. For low-income families, some communities provide childcare for free.

them are statistically significant.

Table 3.5: Estimation of parents' fees for center-based childcare (Tobit)

	Part-time care		Full-time care	
Explanatory Variables	Coeff.	St. Err.	Coeff.	St. Err.
dummy variable indicating that child is aged 0-3	7.4184	10.8023	43.4753	13.0425
net monthly income	0.0076	0.0016	0.0220	0.0038
number of siblings aged 0-2 in childcare	-18.1861	6.6246	-26.4059	11.9324
number of siblings aged 3-6 in childcare	-23.7067	6.7316	-36.4697	10.5190
North-West	28.5948	8.6460	14.2949	18.0786
Middle-West	3.9476	8.5101	26.2354	13.3217
Northrhine-Westphalia	-4.5614	8.6056	26.5227	14.5548
Baden-Wuerttemberg	-2.0203	8.6098	-1.3348	16.3141
Bavaria	-7.4778	8.8023	11.7826	18.4299
constant	36.3428	8.3372	19.3916	11.9123
s.e. (ancilliary parameter)	45.9441	1.5701	63.0967	3.3076
Log-Likelihood		-2500.93		-1062.62
Number of observations		533		204
Thereof: Left-censored		72		16

Source: Estimations based on SOEP, wave 2002.

Note that selection into the sample of children who are attending center-based childcare is not controlled for in this estimation. Sample selection could be a problem if, for example, only parents who have access to centers with particularly low fees use this form of childcare (see Connelly (1992)). Wrohlich (2004) has estimated the parents' fees for subsidized childcare on the basis of SOEP data using a two-stage Heckman-type sample selection model. Identification of the selection equation is based on several exclusion restrictions such as the mother's health status, her nationality and the presence of other adult persons in the household. These variables enter the selection equation but not the estimation of the amount of the parents' fees. The selection term, however, was found to be insignificant in the second stage estimation. Thus, I decided to use the simple Tobit model such as presented above.

Since detailed information on childcare expenses are only available for the year 2002, the estimated coefficients are used in order to predict the parents' fees for 2001 and 2003. As has been noted above, the coefficient of net household income significantly affects the parents' fees. This has to be taken into account when child-

care costs shall be included in the calculation of net household incomes for all choice categories. Parents' fees are therefore predicted for each household for all working hours categories separately. The average predicted fees for part-time and full-time care for different age groups are summarized in Table 3.6 below.

3.4.3 "Expected" Costs of Childcare

Using the results of the estimation of parents' fees to subsidized childcare slots, of the partial observability model of demand and supply for childcare, and information on the average price of private childcare, expected costs of childcare such as defined in equation 3.1 can be computed. Table 3.6 summarizes parents' fees, rationing probabilities and the resulting expected costs of childcare.

Table 3.6: Average estimated parents' fees for a subsidized slot and expected costs of child care

	Children aged		
	0-2 years	3-6 years	7-10 years
Probability of being rationed with respect to center-based care	0.34	0.06	0.26
Parents' fees for center-based care:			
part-time	62	60	49
full-time	127	96	–
Total expected costs of child care:			
part-time	183	90	144
full-time	397	167	–

Note: Euro per month.
Source: Own calculations on basis of SOEP, wave 2002.

As Table 3.6 shows, childcare costs are considerably higher for children under three years than for children aged three to six years. This result is driven by the markedly higher probability to be rationed with respect to subsidized childcare for younger children. More than 30 percent of children under three years do not have access to a subsidized slot although their parents would demand one. Among children in the older age group this share only amounts to 6 percent. Thus, expected costs of childcare for children under three years are more than twice as high (183

Euro per month for part-time care and 397 Euro per month for full-time care) than for children aged three to six (90 Euro per month for part-time care and 167 Euro per month for full-time care on average).

In order to calculate total childcare costs of the family, the costs for all children aged up to ten years living in the household are summed up. Note that even though in the following empirical analysis, only mothers with at least one child under seven years are considered, all children aged up to ten years are considered for the calculation of childcare costs.

3.5 Work Incentives for Secondary Earners

The information on expected costs of part-time and full-time childcare, together with the calculation of net household income on the basis of STSM, allows to calculate disposable household incomes for different working hours categories which are shown in Table 3.8.

In general, the increase in household income resulting from employment of the secondary earner is relatively low, as will be shown below. The main reasons for these low work incentives are the joint taxation of married couples and the relatively high costs of childcare, in particular for children under three years. Moreover, for families with children under two years, the withdrawal of the parental leave benefit that is means-tested at the household level adds on to the marginal tax on secondary earnings. Single mothers are eligible to relatively high out-of-work benefits that are withdrawn at high rates. Thus, although single mothers are not affected by joint taxation, work incentives are relatively low also for this group.

The numbers in Table 3.8 provide empirical evidence of the structure of work incentives for secondary earners in Germany. For example, net household income on average increases by 116 Euro per month in the case that the mother takes up a

marginal job. However, if the mother has to purchase part-time childcare, disposable income on average increases by only 25 Euro per month. If the youngest child in the family is less than three years old, the family even faces a loss of disposable income of 16 Euro per month if the mother is taking up a marginal job.

Full-time employment on average leads to an increase in disposable income of 848 Euro per month. If full-time childcare has to be purchased, this increase shrinks to 403 Euro. For single mothers, the increase in disposable income in this case only amounts to 182 Euro per month due to the relatively high out-of-work transfers. Families with three or more children under the age of seven years on average cannot increase household income by increasing working hours of the secondary earner at all. If the mother is working full-time, they face an average income loss of about 100 Euro per month.

Note that it is assumed in these calculations that parents do not pay for childcare in the case that the mother is not working. Yet, it has been shown in Chapter 2 that it is very common in Germany that children aged three to six attend part-time care even if the mother is not working. The expenses for childcare in these cases, however, cannot be interpreted as costs associated with maternal employment but rather as consumption.

Table 3.7: Net Household Incomes by Choice Categories

Choice Categories		Net Household Income					
		Before	After	Before	After	Before	After
		Deducting child care costs		Deducting child care costs		Deducting child care costs	
working hours	child care hours	All Households		Single Parents		Families with children <3 years	
0	0	2551	2551	1015	1015	2521	2521
marginal	0	2667	2667	1085	1085	2668	2668
part-time	0	2904	2904	1211	1211	2906	2906
full-time	0	3295	3295	1518	1518	3288	3288
0	part-time	2551	2342	1015	853	2521	2273
marginal	part-time	2667	2577	1085	1010	2668	2504
part-time	part-time	2904	2806	1211	1110	2906	2738
full-time	part-time	3295	3093	1518	1366	3288	3045
0	full-time	2551	2132	1015	719	2521	2007
marginal	full-time	2667	2361	1085	864	2668	2232
part-time	full-time	2904	2586	1211	962	2906	2461
full-time	full-time	3295	2954	1518	1198	3288	2825
working hours	child care hours	Families with 1 child ≤6 years		Families with 2 children ≤6 years		Families with 3 children ≤6 years	
0	0	2463	2463	2793	2793	3099	3099
marginal	0	2617	2617	2897	2897	2797	2797
part-time	0	2857	2857	3128	3128	3050	3050
full-time	0	3257	3257	3501	3501	3433	3433
0	part-time	2463	2279	2793	2513	3099	2655
marginal	part-time	2617	2518	2897	2739	2797	2892
part-time	part-time	2857	2748	3128	2968	3050	3133
full-time	part-time	3257	3080	3501	3225	3433	3023
0	full-time	2463	2097	2793	2225	3099	2196
marginal	full-time	2617	2331	2897	2444	2797	2422
part-time	full-time	2857	2557	3128	2666	3050	2657
full-time	full-time	3257	2932	3501	3019	3433	2996

All amounts refer to Euro per month.

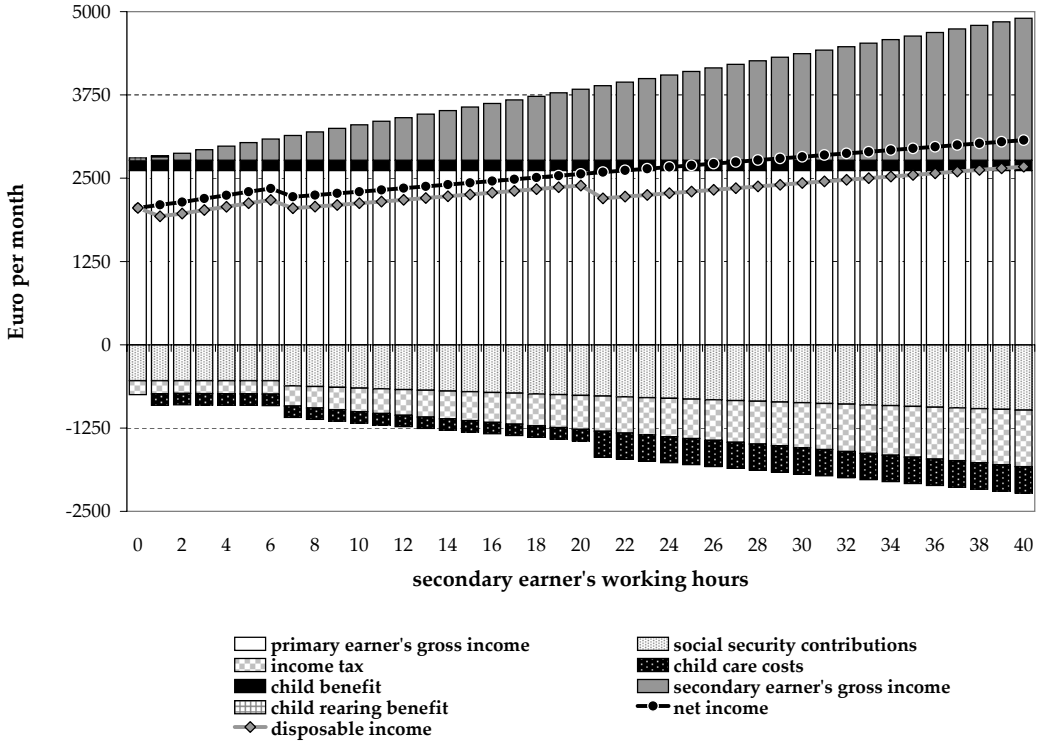
Source: Calculations based on SOEP, waves 2001 - 2003 and the micro-simulation model STSM. Note: SOEP weighting factors are used.

Another way of summarizing the structure of work incentives for secondary earners is to visualize budget lines for several example households. In Figures 3.2 to 3.6 budget lines are drawn as a function of the secondary earner's working hours. Figures 3.2 to 3.5 show couple households with one earner working full-time (38.5 hours per week). Figure 3.6 shows the example of a single mother.

In all figures, the two dotted lines refer to the family's monthly net income and disposable income. Disposable income is calculated as net household income less expected costs of childcare. These costs are assumed to be zero in the case that the secondary earner is not working. The bars show the different components of household income as a function of the mother's working hours. The bars below the zero line show the components that are subtracted from market income, namely social security contributions and income taxes of the household as well as costs of childcare. All budget lines refer to the legislation of the year 2002.

Figure 3.2 shows the case of a married couple with one child who is one year old. Gross earnings of the primary worker are assumed to be fixed at the median of the wages of full-time working men in Germany (16 Euro). For the calculation of the earnings of the secondary worker, weekly hours are multiplied by the median of the wage distribution of all working women in Germany (12.4 Euro). As the figure shows, the line depicting disposable income is not only very flat but shows several kinks. First, when the secondary earner starts working, disposable income decreases because childcare has to be paid for. According to the concept of "expected costs of childcare" as explained above, part-time costs for the care of a one-year old child amount to 172 Euro per month. These childcare costs increase slightly as household income increases. By assumption, parents have to buy full-time childcare when the secondary earner's working hours exceed 20 hours. Full-time childcare costs of this example household amount to 393 Euro per month.

Figure 3.2: Budget line of a married couple (median wages) with one child, 1 year old

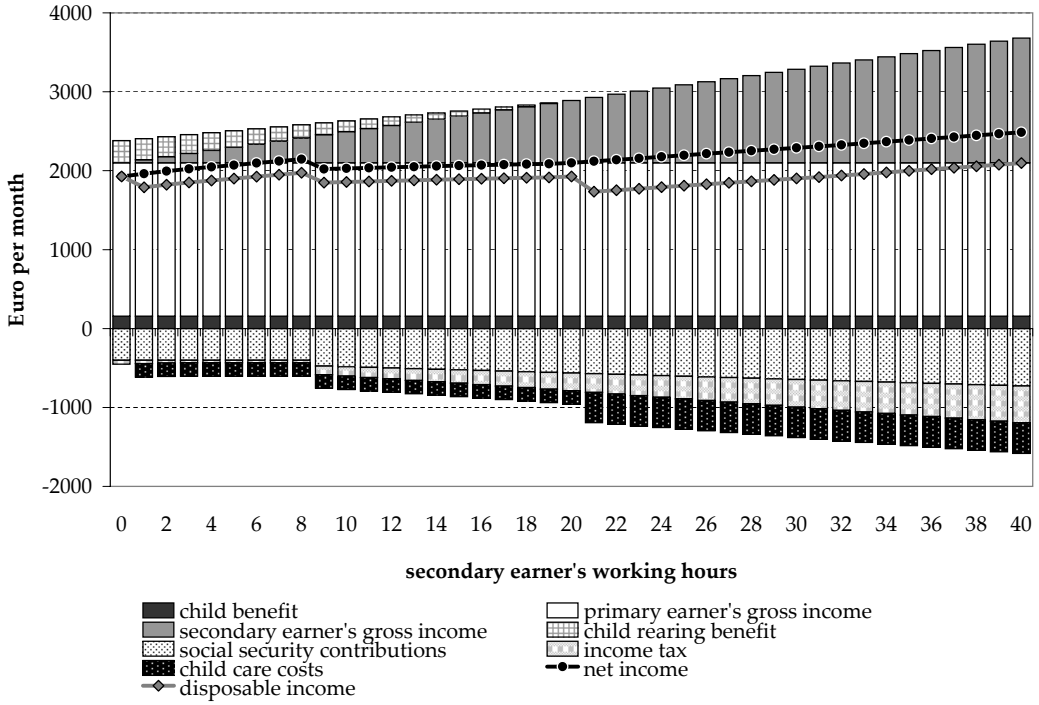


Source: Calculation based on STSM.

This example of a couple with median wages shows that it does not pay for the secondary earner to work less than 4 hours. This is due to childcare costs and the withdrawal of the parental leave benefit. At six hours of weekly work, the disposable income of the family is about 120 Euro higher than in the case that there is only one earner. At seven hours of work, there is another kink in the budget line. At this point earnings of the secondary earner exceed the threshold of "marginal employment" ("geringfügige Beschäftigung"; this threshold amounted to 325 Euro per month in 2002) and are not only due to social security contributions but also fully taxable. Due to the system of joint taxation, from that point on the secondary earner faces the same marginal tax rate as the primary earner on all her earnings. Thus, only at 12 hours of weekly work the disposable income exceeds the one achieved at 6 hours. At 20 hours the household achieves a disposable income of about 2,390 Euro per month, which implies a percentage increase in household income as compared

to the single-earner case of 16%. Due to the discontinuity in childcare costs, income resulting from part-time work can only be exceeded if the mother is working 30 hours or more. Full-time work would lead to a disposable income of 2,650 Euro per month, which implies a percentage increase of 29% as compared to non-employment of the mother.

Figure 3.3: Budget line of a married couple (wages at the 25th percentile) with one child, 1 year old

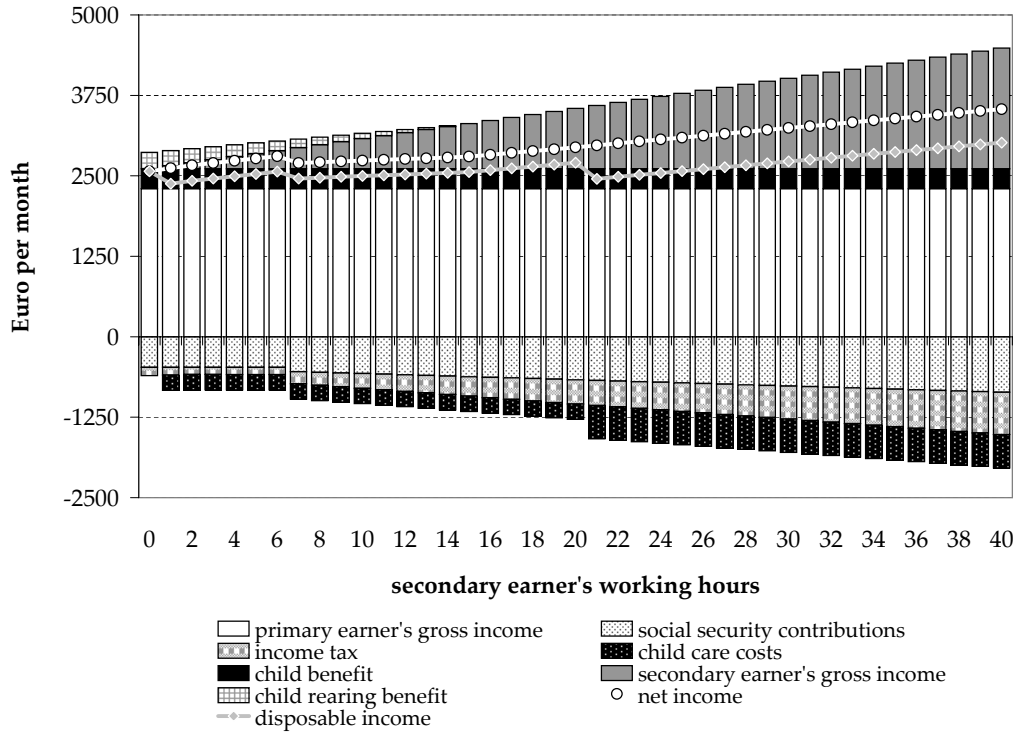


Source: Calculation based on STSM.

Another interesting example is the case of a couple with a one-year old child where both parents earn hourly wages equal to the 25th percentile of the male and female wage distribution (12.2 and 9.4 Euro, respectively). In this case, the family is eligible to the child-rearing benefit over a larger range of working hours of the secondary earner (see section 2.3). As can be seen from Figure 3.3, this benefit increases the households' disposable income by about 300 Euro per month. However, it makes the budget line even flatter due to the benefit's withdrawal rate of 62.4

percent. As the figure shows, the household can increase its disposable income by a small amount of 30 to 50 Euro only when the secondary earner is working 7 or 8 hours. Above that threshold, employment of the secondary worker does not pay off. Only from 32 hours on, household income exceeds the income if the mother is not participating, however only by a small amount. For example, full-time work leads to a monthly household income of 2,060 Euro, exceeding income in the single-earner case only by 133 Euro (7%).

Figure 3.4: Budget line of a married couple (median wages) with two children, 1 and 4 years old



Source: Calculation based on STSM.

In the case that a couple earning median wages has two children aged one and four years, the budget line becomes almost as flat as in the case of the lower-income couple, as can be see in Figure 3.4. This is because the income threshold up to which the child-rearing benefit is granted is increased by more than 2,500 Euro per year for every additional child in the household. Moreover, childcare costs are higher in

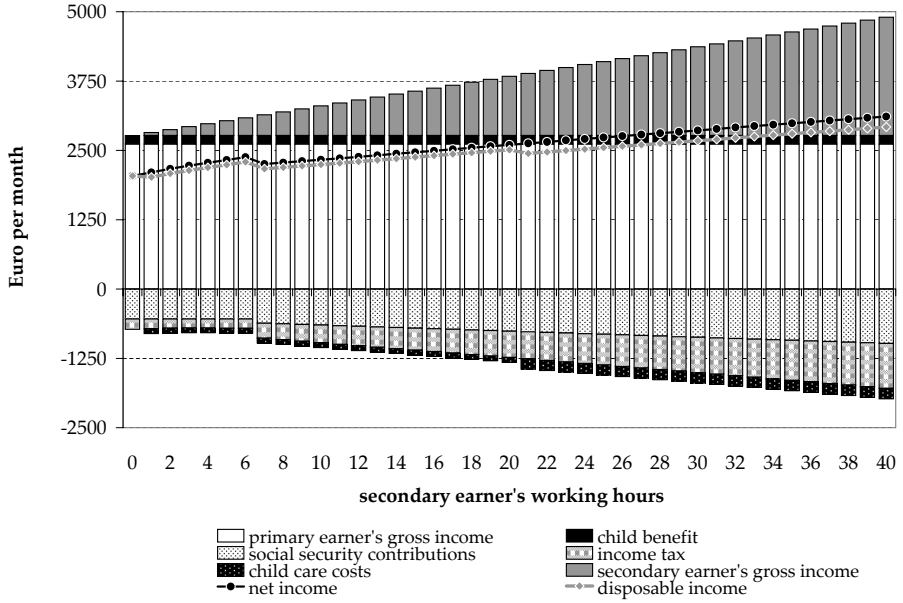
this case than for the one-child family. Thus, marginal employment of the mother does not pay off for this example family. Only between 16 and 20 and above 30 hours of work, disposable income is higher than in the single-earner case. Part-time work (20 hours) and full-time work (38.5 hours) increase household income by 5% and 15% percent as compared to non-participation, respectively.

For couples with one child aged four years (Figure 3.5), the budget lines become steeper since the child rearing benefit is not granted any more and childcare costs are markedly lower for children in this age group. In this example, marginal employment increases household income by 12% compared to the case that the mother is not working. Part-time work increases disposable income by 23% and full-time work by 41%. Comparing these numbers to the ones for the family with two children that has been described above, shows how dramatically childcare costs and the parental leave benefit reduce work incentives for mothers with young children.

Figure 3.6, finally, shows the budget line of a single mother with a four-year old child. For this example household the budget line is completely flat up to 16 hours. This is due to the social assistance that this group is eligible to that amounts to 570 Euro per month, plus expenses for housing.[17] Social assistance is withdrawn at a rate of almost 100 percent. Part-time work of 20 hours increases the income of this family by only 10%. Due to the relatively high costs for full-time care, working 21-30 hours is relatively unattractive compared to working 20 hours. Full-time work, however, leads to an absolute increase of family income by 334 Euro per month compared to non-participation, which implies a percentage increase of 32%.

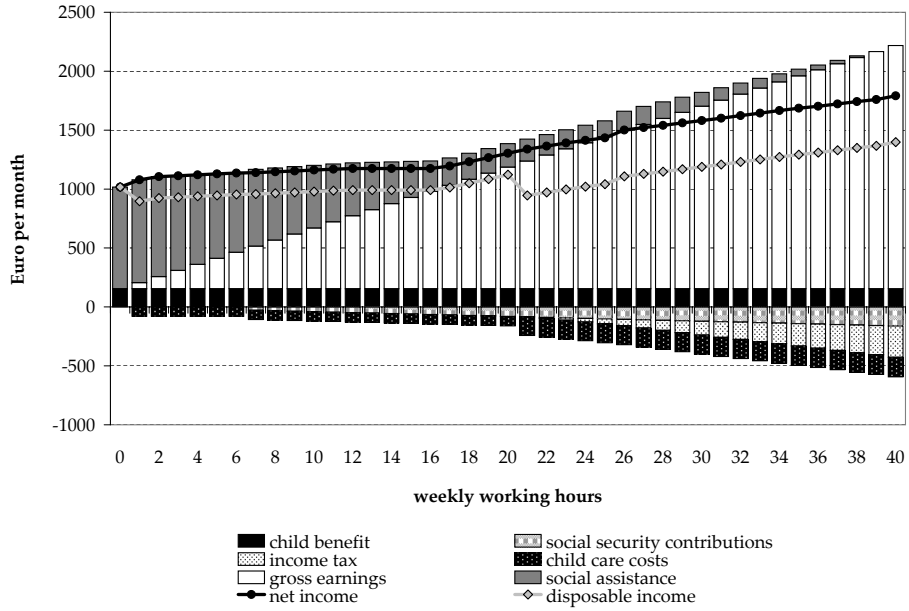
[17] Expenses for housing that are covered by social assistance depend on a variety of characteristics, among them the number of persons in the household, average rents in the community, heating costs etc.

Figure 3.5: Budget line of a married couple (median wages) with one child, 4 years old



Source: Calculation based on STSM.

Figure 3.6: Budget line of a single mother (median wage) with one child, 4 years old



Source: Calculation based on STSM.

3.6 The Behavioral Model

3.6.1 Previous Research

In the following, I will describe the behavioral model of the joint decision on labor supply and the demand for childcare of mothers with children up to 6 years in Germany. To the best of my knowledge, such a model has not been estimated yet for the German case.[18] An early study by Merkle (1994) estimates a bivariate probit model of mothers' labor force participation and childcare utilization. The intensive margin of the employment and childcare decision is not considered. Moreover, neither is the rationing of childcare slots taken into account, nor does the model tackle the non-linearities of the German tax-transfer system as only the gross hourly wage rate is included as an explanatory variable. Other studies have estimated the labor supply of women in Germany separately from the demand for childcare. Althammer (2000) provides a detailed overview of these studies. Most of them however, do not focus on the effect of childcare costs on mothers' labor supply decisions.

In the international literature, the relationship between childcare costs and mothers' labor supply has been studied extensively, in particular for the case of the US (see Blau (2001) for an overview of the US literature). Most of the more recent studies estimate mothers labor supply decisions and the demand for childcare jointly on the basis of a structural utility model (see, among others, Michalopoulos et al. (1992), Ribar (1995) or Blau and Hagy (1998)). In the past few years, similar studies have been undertaken for Canada (Powell (2002)), UK (Parera-Nicolau and Mumford (2005)), Russia (Lokshin (2004)), Sweden (Gustafsson and Stafford (1992)), Norway (Kornstad and Thoresen (2007)), Italy (Del Boca and Vuri (2007)) and France (Chone et al. (2003)), just to mention a few. Most of these studies, however, do not take rationing of center-based childcare into account. For many countries such as the US, UK or Canada this is due to the fact that accessability of childcare is

[18] Beblo et al. (2005) estimate a simpler version of the model presented here for mothers with children between 6 and 12 years.

not considered as an important issue compared to its high costs. In their studies on Russia and Norway, respectively, Lokshin (2004) and Kornstad and Thoresen (2007), model rationing of childcare by restricting the choice set for those families who report to be restricted. For the German case, however, information whether a family is restricted to center-based childcare is not available. As has been described above, I therefore follow a different approach and consider rationing of subsidized childcare explicitly within the families' budget constraints.

3.6.2 The Mother's Choice Set

Mothers' labor supply and the demand for childcare are estimated using a discrete choice approach. It is assumed that mothers choose out of several possible combinations of working hours and hours of paid childcare. The main advantage of using a discrete choice approach for the estimation of labor supply is that taking non-linearities in the budget set into account - that have shown to be important in the previous sections - remains computationally feasible.[19]

The choice set of a mother in my model consists of combinations of 4 working hours categories and 3 hours of paid childcare categories. The working hours categories include non-participation, full-time work, part-time work, and marginal employment. For mothers who have access to unpaid childcare arrangements, there are three possible childcare choices for each working hours category: no paid childcare, full-time or part-time paid childcare. Implicitly, it is assumed that in the case that mother's working hours are greater than zero but no paid childcare is observed, the family makes use of informal care. In the data set I will use for the estimation, it is not possible to distinguish between maternal and other informal unpaid childcare. Therefore, I assume that in the categories where the mother is not working, maternal care is the primary childcare choice. If the mother's working hours are greater than zero and paid care is not observed, informal care is assumed to be used

[19] See, for example, van Soest (1995).

for the number of the mother's working hours. Further, I assume that a mother cannot work and care for the child herself at the same time.

Mothers who do not have access to unpaid care opportunities have a restricted choice set: These mothers have to purchase childcare for the hours of their market work. Thus, the choice set following from this time constraint thus consists of 8 categories, including no market work/no childcare, no market work/part-time or full-time childcare, part-time work/part-time or full-time childcare and full-time work/full-time childcare.

It should be noted that the assumption concerning the availability of unpaid care by someone else than the parents is a controversial one. Previous studies have dealt with this problem in different ways. While some authors (such as Blau and Robins (1988), Michalopoulos et al. (1992), Ribar (1995), Blau and Hagy (1998) and Lokshin (2004)) explicitly assume that free care is available for all mothers, others (such as Gustafsson and Stafford (1992) and Kornstad and Thoresen (2007)) stress that this assumption is unrealistic. In the latter studies, employment of mothers always implies that childcare has to be purchased. As the descriptive data for Germany show, more than 10 percent of mothers are observed to be working but not using paid center-based or private childcare for their children. However, assuming that this possibility exists for all households, is unlikely to be a realistic representation of their choice set.

Thus, I decided to restrict the choice set for households who do not have access to these unpaid arrangements in the way explained above. The SOEP data does not contain explicit information on availability of informal care arrangements. As a proxy indicator I use information from the question *"Are there additionally (to the utilization of childcare facilities and paid nannies) other persons outside the household who regularly watch or take care of your children?"* Mothers who answer that relatives or friends regularly care for their children, are assumed to have access to unpaid care arrangements, while the others have not.

3.6.3 Theoretical Background

The utility function specified in this paper is similar to the one used by Blau and Hagy (1998) in a study for the US, although in contrast to them, I do not explicitly model quality characteristics of paid childcare.[20] The mother's utility U is assumed to depend on disposable household income y, her leisure time l, "child quality" Q, and a vector of demographic characteristics such as age and number of children D, formally

$$U = u(y, l, Q; D) \tag{3.12}$$

Utility is assumed to be increasing in leisure,[21] income and child quality.[22] The "quality" of a child Q depends on the hours of maternal care m, hours of paid (formal) childcare p and hours of unpaid (informal) childcare[23] up,

$$Q = q(m, p, up) \tag{3.13}$$

"Child quality" Q is only defined for the youngest child. For simplicity, it is assumed that in the case that more than one child is living in the household, all children have the same values of maternal, formal and informal care, which are those of the youngest child.

[20] Unlike in the US, childcare centers are strictly regulated in Germany as far as measurable quality characteristics such as staff/child ratio, other equipment and education of staff are concerned.

[21] Only leisure of the mother is included in the utility function, since only families with full-time working fathers or single mothers are considered. Thus, there would be no variation in the leisure of fathers.

[22] Note that preferences are intertemporally separable by assumption. State dependence is ignored. As Haan (2005) shows on the basis of an intertemporal model of female labor supply on a sample of married women in Germany, state dependence does play a role in female labor supply. Short-run elasticities have shown to be significantly lower than long-term elasticities, however the latter elasticities have been found to be equal to elasticities obtained in a static framework similar to the one suggested here.

[23] In the following, I will use the terms formal, paid and center-based childcare as synonyms. The same applies to the terms informal and unpaid childcare. Strictly speaking, this is not correct, since informal childcare can also be paid for, e.g. in the case of babysitters, whereas formal child care can be for free, as it is the case for many low income families in Germany who live in communities who have an income-dependent fee scheme for childcare centers. For simplicity, in my model, the term "paid" includes all sorts of paid childcare, either in facilities (subsidized or private) or home-based, as well as care in facilities that is for free, whereas "unpaid" only includes non-institutional, informal care arrangements.

Note that there is no distinction between different forms of paid childcare. Thus, childcare in centers, family day care or a private nanny are assumed to be of equal quality and thereby yielding the same utility for the mother. Although this assumption might seem restrictive, it is necessary since there is not enough variation across different types of paid care in order to differentiate various types of paid childcare.

The household's budget constraint, i.e. its disposable income y, can be formally written as

$$y = t(h \cdot w, Z) - ec \cdot p \tag{3.14}$$

where $t(\cdot)$ denotes the tax-transfer function, h hours of market work, w the mother's wage rate and Z income from other sources than the mother's earnings. ec denotes expected costs of childcare, and p refers to hours of paid childcare.

For families with access to unpaid childcare arrangements, the time constraint of the mother can be written as

$$h + m + l = m + p + up = T \tag{3.15}$$

Equation 3.15 states that a mother can allocate her time to three activities, which are market work h, maternal childcare m, and pure leisure l. Since a child has to be cared for over the whole day, hours of maternal care m, paid care p, and unpaid care up must add up to T which refers to the total time per week available. As explained in the previous section, I assume that unpaid care does not exceed working hours of the mother. In other words, unpaid care is the residual in the case that working hours of the mother exceed hours of paid care, i.e.

$$up = \max(h - p, 0) \tag{3.16}$$

From equations 3.15 and 3.16, it follows that the mother's pure leisure only takes on positive values in the case that paid childcare hours exceed the mother's market work hours, i.e. if $p > h$.

Household activities other than childcare are not explicitly modeled. Thus, "pure leisure" might include household work that a mother undertakes while the child(ren) is(are) cared for by another person. To be more precise, the term "pure leisure" in the context of this model includes all activities except market work and childcare.

Substituting equations 3.13, 3.14 and 3.15 into the utility function as stated in equation 3.12 yields the mother's maximization problem

$$\max_{h,p} u = u\{[t(h \cdot w, Z) - ec \cdot p], (T - h - m), q(m, p, up); D\} \tag{3.17}$$

subject to the additional constraint stated in 3.16 and non-negativity of the choice variables. The utility index should be concave in household income and in the mother's leisure time, i.e.

$$\frac{\partial U(.)}{\partial y} > 0 \quad ; \quad \frac{\partial^2 U(.)}{\partial y^2} < 0 \tag{3.18}$$

$$\frac{\partial U(.)}{\partial l} > 0 \quad ; \quad \frac{\partial^2 U(.)}{\partial l^2} < 0 \tag{3.19}$$

As far as the expected sign of these derivatives with respect to paid and unpaid childcare are concerned, the theoretical predictions are not clear. It cannot be derived from economic theory whether mothers consider non-parental childcare as a normal good or whether it constitutes a "bad" that is necessary in order to generate income through employment. Thus,

$$\frac{\partial U(.)}{\partial p} = ? \tag{3.20}$$

$$\frac{\partial U(.)}{\partial up} = ? \tag{3.21}$$

Table 3.8 shows the values of the choice variables (market work and paid childcare) and the values of the variables that are given by the constraints (unpaid care, maternal care and pure leisure), when the total time available T is normalized to 80.[24] For mothers without access to unpaid childcare opportunities, the time constraint from equation 3.15 changes to

$$h + m + l = m + p = T \tag{3.22}$$

The time constraint of the mother is the same as in the unrestricted case, however, the time of the child can only be spend with the mother (m) or in paid childcare (p). Thus, the mother's market work and leisure together cannot exceed the hours that the youngest child spends in paid childcare. The choice categories following this model include those from the unrestricted model (see Table 3.8) except categories 2,3,4 and 8.

Table 3.8: Values of market work, pure leisure and hours of childcare by choice category

Choice Category	Working hours (h)	Paid childcare (p)	Unpaid childcare (up)	Maternal care (m)	Pure leisure (l)
1	0	0	0	80	0
2	8	0	8	72	0
3	20	0	20	60	0
4	37	0	37	43	0
5	0	20	0	60	20
6	8	20	0	60	12
7	20	20	0	60	0
8	37	20	17	43	0
9	0	37	0	43	37
10	8	37	0	43	29
11	20	37	0	43	17
12	37	37	0	43	0

Source: Own calculation.

[24]The choice of 80 hours per week is motivated by the consideration of 5 working days at maximum 16 hours. Weekends are excluded from the analysis. This is due to the fact that market work by mothers is far less prevalent on weekends, and center-based childcare cannot be purchased on weekends. Moreover, it is more difficult to distinguish leisure from childcare duties on weekends.

3.7 Econometric Specification

The discrete choice model used for the estimation is based on the mothers' utility comparisons of the different choice categories in every period. Regarding the specification of the utility function, I will assume that the terms of the "child quality" function linearly enter the utility function as stated in equation 3.17. The utility function itself is assumed to have a quadratic form.[25] Thus, the utility index U of mother i for a particular working/childcare hours category k at time period t can be stated as follows:

$$U_{ikt} = V_{ikt} + \epsilon_{ikt} = X'_{ikt}\beta + X'_{ikt}AX_{ikt} + \epsilon_{ikt} \tag{3.23}$$

with

$$X_{ikt} = (p_{ikt}, up_{ikt}, l_{ikt}, y_{ikt})' \tag{3.24}$$

The components of X_{ikt} are disposable household income y, the mother's pure leisure time l, hours of paid care p and hours of unpaid care up, which all vary by household (i), choice category (k) and time period (t). ϵ_{ikt} is an unobserved error term that is assumed to follow an extreme value distribution and to be independently distributed over time, households and choice categories. Matrix A contains the coefficients of the quadratic terms and the cross terms. Vector β contains the coefficients of the linear terms. Preferences are allowed to vary across mothers through taste shifters of the linear terms of income, leisure and paid childcare. In addition to the variation of choices across households that can be explained by differences in the levels of income and its interactions with demographic variables, there are many other sources of heterogeneity, in particular differences in the access to paid and unpaid childcare and differences in attitudes towards these forms of childcare, which are unobserved. I will account for this unobserved heterogeneity by letting

[25] Stern (1986) provides an overview of estimating labor supply using different functional forms. The quadratic specification was found to be relatively flexible and suitable to a context where labor force participation is low, which is the case for the sample of mothers with young children.

the preference parameter on the linear term of hours of paid childcare, β_p vary across households:

$$\begin{aligned} \beta_y &= \alpha_y^0 + D_1'\alpha_y^1 \\ \beta_l &= \alpha_l^0 + D_2'\alpha_l^1 \\ \beta_{p_i} &= \alpha_p^0 + D_3'\alpha_p^1 + \nu_i \end{aligned} \tag{3.25}$$

where D_1, D_2 and D_3 are column vectors including age of the mother, number of children less than three years, number of children between three and six years, region of residence, a dummy variable indicating whether the mother holds a university degree and a dummy variable indicating whether the mother is single. Following Heckman and Singer (1984), it is assumed that ν can be described by an arbitrary discrete probability distribution G with a small number of mass points $M^r, \forall r(r = 1, 2, ..., R)$ and corresponding probabilities τ^r, where

$$E(\nu) = \sum_{r=1}^{R} \tau^r M^r = 0 \tag{3.26}$$

and

$$\sum_{r=1}^{R} \tau^r = 1 \tag{3.27}$$

Mass points and their probabilities are jointly estimated with the parameters of the model using maximum likelihood. The estimation is based on the assumption that unobserved heterogeneity is uncorrelated with the explanatory variables. Since β_{p_i} is not known to the researcher, the unconditional probability P_{ikt} has to be estimated using

$$P_{ikt} = \sum_{r=1}^{R} \tau^r(M^r) \frac{\exp(V_{ikt})}{\sum_{j=1}^{J} \exp(V_{ijt})}; \quad k \in J \tag{3.28}$$

where V_{ikt} contains the random component ν_i.

Since I observe many households in more than one period, the individual likelihood contribution is

$$L_i = \sum_{r=1}^{R} \tau^r(M^r) \prod_{t=1}^{T_i} \prod_{j=1}^{J} \left(\frac{\exp(V_{ikt})}{\sum_{j=1}^{J} \exp(V_{ijt})} \right)^{d_{ikt}} ; \quad k \in J \tag{3.29}$$

where d_{ikt} is a dummy variable that takes on the value 1 if the household i chooses category k in time period t and 0 otherwise.

This model is estimated using an unbalanced panel. Households are observed 1, 2 or 3 periods. In addition to cross-section variation, variation over time in disposable income comes from various sources. First, since childcare costs are a decreasing function of a child's age, disposable household income changes due to the fact that children grow older every year. Second, in the observed period from 2000 - 2002, several reforms have been implemented that imply variation in disposable household income, such as the German tax reform (see Haan and Steiner (2005)), and a reform of the child benefit, which has been increased in 2001.

3.8 Estimation Results

Estimated coefficients of the model described above are shown in Table 3.9. The interpretation of these coefficients is not straight-forward due to the large number of interaction terms. Thus, I have calculated partial derivatives of the utility function with respect to income, leisure, paid and unpaid childcare. This allows to check whether the estimates are in line with predictions based on theory. It turns out that the model yields plausible results: The first derivatives of the utility function with respect to income and leisure are positive for all households. The second derivative of the utility function with respect to income is negative, while the second derivative with respect to leisure is zero for all households. The first derivative of the utility function with respect to formal childcare is positive for about 25 percent of all

households, for the other 75 percent it is negative. A more disaggregate analysis shows that for the majority of households in east Germany, the first derivative is positive. For mothers whose youngest child is older than three years, this derivative is positive for almost 50 percent of all households. The first derivative of informal childcare is negative for all households.

These results suggest that some households consider formal childcare to be a good, whereas other households consider it as a "bad", i.e. having a negative influence on the mothers' utility. This is not surprising given the general attitudes towards mothers' employment and non-parental childcare of children under three years in Germany. As descriptive results from a representative survey on attitudes conducted in 2002 show, 66 percent of all women in west Germany fully agreed to the statement "A child under three years would suffer from the employment of its mother", while the share of women in east Germany giving the same answer only amounts to 39 percent (see BMFSFJ (2006)).

A comparison with estimation results of a specification without unobserved heterogeneity shows that unobserved heterogeneity is present in this model. The Akaike Information Criterion is lower for the model with unobserved heterogeneity than for the one without unobserved heterogeneity.[26] For the distribution of β_p, two mass points could be identified.[27] The corresponding probabilities can be interpreted as respective shares of groups of households in the population. There is one large group for whom the coefficient of formal childcare hardly changes, however for the smaller group, the positive effect of formal childcare on utility is much larger than for the other group.

[26] I also estimated several models with different specifications of unobserved heterogeneity, such as a parametric specification of the random term of formal childcare and both a parametric and a semi-parametric specification of a random term on net income. All these specifications lead to very similar results as the ones reported here.

[27] In model specifications with a larger number of mass points convergence could not be achieved.

Table 3.9: Estimation results

	Model with unobserved heterogeneity		Model without unobserved heterogeneity	
Explanatory Variables	Coeff.	St. Err.	Coeff.	St. Err.
net income	0.2250	0.0262	0.2156	0.0286
net income squared	0.0001	0.0004	0.0002	0.0004
leisure	-0.0010	0.0110	-0.0022	0.0112
leisure squared	-0.0004	0.0002	-0.0003	0.0002
paid childcare	0.0061	0.0092	0.0430	0.0115
paid childcare squared	-0.0014	0.0001	-0.0025	0.0002
unpaid childcare	-0.1235	0.0131	-0.1226	0.0136
unpaid childcare squared	0.0015	0.0002	0.0016	0.0002
unpaid childcare * youngest child < 3 years	-0.0878	0.0038	-0.1151	0.0056
paid childcare * east Germany	0.0619	0.0046	0.0657	0.0006
paid childcare * German nationality	0.0088	0.0005	0.0139	0.0007
paid childcare * single mother	0.0092	0.0060	0.0071	0.0080
paid care * mother holds university degree	0.0309	0.0055	0.0359	0.0076
net income * leisure	0.0008	0.0002	0.0008	0.0003
net income * paid childcare	-0.0005	0.0002	-0.0003	0.0002
net income * unpaid childcare	-0.0012	0.0003	-0.0012	0.0003
Probabilities and locations of random effects				
location of mass point 1 (M^1)[a]	0.1220	0.0132		
log-odd of probability 1[b]	-1.7613	0.2158		
log likelihood	-4990.9261		-4728.8779	
Akaike Information Criterion (AIC)[c]	9386.3156		9489.7558	
number of observations	28512			
number of households	1495			

[a] The location of the second mass point can be calculated using the formula $M^2 = -\frac{M^1 \cdot \tau_1}{\tau_2}$ and amounts to -0.0209.

[b] The two corresponding probabilities, τ_1 and τ_2 are 0.1466 and 0.8534.

[c] AIC is calculated as $-2 * (log - likelihood) + 2 * p$ where p is the number of parameters of the model.

Source: Estimations based on SOEP, wave 2001-2003.

In order to compare the estimation results with the previous literature, I calculate wage elasticities and childcare costs elasticities of labor supply by simulating a one percent increase in gross hourly wages and expected childcare costs, respectively. These elasticities are presented in Table 3.10. According to these estimates, a 1-percent increase of the gross hourly wage leads to an increase in the participation rate of mothers with at least one child under six years by 0.14 percentage points and an increase in average working hours by 0.53 precent. These are very similar to elasticities that previous studies found for German mothers (see Beblo et al. (2005) or Steiner and Wrohlich (2004)).

Labor supply elasticities with respect to childcare costs are found to be relatively low, compared to previous estimates in Germany and also compared to estimates for other countries: A 1-percent increase in expected costs of childcare would lead to a decrease of the labor force participation rate of mothers with at least one child under six years by 0.03 percentage points and a decrease of average working hours by 0.15 percent. For Germany, Beblo et al. (2005) estimate a decrease in average working hours by 0.11 percent in east and 0.25 percent in west Germany in the case that childcare costs increase by 1 percent. These results however, have been estimated on a sample of mothers with children aged seven to ten years. Second, the authors use a model that does not allow the option of unpaid non-parental childcare, which also leads to higher elasticities than the more flexible model used here. An earlier study by Merkle (1994) on German mothers with children under seven years does not find a significant influence of childcare costs on mothers' labor supply. This might be due to the reason that this study does not control for the shortage of childcare centers but assumes that all families can purchase childcare at the "price" of average parents' fees.

Compared to the international literature, the estimated elasticities of labor supply with respect to childcare costs lie at the lower end of what different authors found for various countries. For example, Kornstad and Thoresen (2007) find for Norway that the mothers' participation rate would fall by 0.12 percentage points in the case of a one percent increase in childcare costs. Similar results are reported for Russia by Lokshin (2004). For the French case, however, Chone et al. (2003) find values more similar to those for Germany, amounting to -0.04 percentage points. For the US, different authors report a wide range of values lying between -0.03 and -0.09 Ribar (1995) up to -0.20 found by Blau and Hagy (1998). The reason for the relatively low childcare costs elasticities of maternal labor supply in Germany might be the relatively weak link between employment and childcare for children aged less than six years, as has been described in Chapter 2.

Table 3.10: Elasticities of labor supply and demand for childcare

	Elasticities of labor supply	
	1% increase in gross hourly wage	1% increase in expected childcare costs
	Change in participation rates (in percentage points)	
All mothers	0.14	-0.04
	(0.12 - 0.15)	(-0.04 - -0.03)
Mothers whose youngest child is <3	0.13	-0.03
	(0.12 - 0.15)	(-0.04 - -0.03)
Mothers whose youngest child is ≥ 3	0.14	-0.04
	(0.13 - 0.16)	(-0.05 - -0.04)
	Change in working hours (in percent)	
All mothers	0.53	-0.13
	(0.47 - 0.58)	(-0.14 - -0.11)
Mothers whose youngest child is <3	0.57	-0.16
	(0.51 - 0.63)	(-0.18 - -0.13)
Mothers whose youngest child is ≥ 3	0.47	-0.09
	(0.42 - 0.51)	(-0.10 - -0.08)
	Change in childcare "participation" (in percentage points)	
All mothers	0.05	-0.06
	(0.04 - 0.06)	(-0.07 - -0.05)
Mothers whose youngest child is <3	0.04	-0.05
	(0.03 - 0.05)	(-0.06 - -0.04)
Mothers whose youngest child is ≥ 3	0.06	-0.07
	(0.05 - 0.07)	(-0.08 - -0.06)

Note: Numbers in parentheses show 95%-confidence intervals obtained by the boostrap method (100 repetitions).
Source: Estimations based on SOEP, wave 2001-2003.

The model also allows to calculate elasticities of the demand for childcare. The demand for childcare is positively influenced by wage increases. A 1-percent increase of the gross hourly wage leads to an increase in the "childcare participation" rate by 0.03 to 0.05 percentage points. The own-price elasticities of the demand for childcare are relatively large. A 1-percent increase in expected childcare costs decreases "childcare participation" between 0.05 and 0.07 percentage points, which implies an elasticity of 0.2.

3.9 Conclusion

In this chapter, I have developed a behavioral model of mothers' labor supply and the demand for childcare. The families' budget constraints include childcare costs, such that the model can be used to evaluate not only reforms of the tax-transfer system but also childcare policy reforms. The measure of childcare costs explicitly takes into account the fact that center-based childcare slots are not available for all children. Estimation results of a partial observability model of the demand and supply of childcare show that there is considerable excess demand for subsidized childcare, in particular for children under three years. By taking into account the shortage of subsidized childcare, two dimensions of childcare policy reforms can be analyzed, namely a change in the parents' fees to formal childcare and a change in the number of available slot.

The estimation results of the behavioral model show that the parameters of the utility function lead to plausible results as far as the theoretical predictions of its derivatives with respect to income and leisure are concerned. Whether formal childcare has a positive or negative influence on the mother's utility can not be predicted on the basis of theoretical considerations. As the empirical analysis shows, for the majority of mothers, in particular mothers with children under three years living in west Germany, formal childcare has a negative influence on utility. However, for 50 percent of mothers whose youngest child is between three and six years old, formal childcare has a positive influence on utility, reflecting differences in attitudes towards non-parental childcare by age group of the youngest child and region.

An important finding of this study is that the labor supply elasticities do not differ significantly from those obtained in previous studies that neglect childcare costs as part of the budget restriction and estimate labor supply separately from the demand for child care, such as Steiner and Wrohlich (2004). This is reassuring evidence for estimations of female labor supply that neglect costs of childcare. Yet, if a labor supply model shall be used for the evaluation of childcare policy reforms,

the consideration of childcare costs in the way as suggested here is an important prerequisite.

It should be noted at this point, however, that the assumptions concerning the choice set of the mothers, in particular the question whether mothers who are working have to purchase childcare or are assumed to have the opportunity to make use of some sort of unpaid, non-parental childcare significantly affect the labor supply elasticities. In the Appendix, I show estimation results and corresponding labor supply elasticities derived from models with different specifications of the choice set. In Model A, all mothers have the opportunity of unpaid childcare, whereas in Model B, all mothers have to purchase childcare in the case that they are working. For the estimation of the second model, all mothers who report to are working and not using paid childcare are dropped. The results show that labor supply elasticities are considerably higher in the model that allows all mothers to be engaged in market work without using paid childcare. On the other hand, Model B, in which market work always implies the use of paid childcare, leads to lower elasticities of labor supply with respect to an increase in the hourly wage. Elasticities with respect to an increase in childcare costs, however, are larger in absolute terms than in Model A. The estimations based on the choice set I have chosen for my model lead to elasticities that are in between the estimations of the two models shown in the Appendix.

Before I turn to an application of the model and present how it can be used to evaluate childcare and family tax policy reforms in the next chapter, let me reflect on some potential shortcomings of the approach presented here.

The first restriction of the model is that it assumes the labor supply of other members of the household, in particular the male partner's labor supply, to be exogenous. In the context of the model developed here, the reason for "ignoring" the male partners is to restrict the choice set to a maximum of 12 categories. Thereby, the model relies on the assumptions of the so-called "male chauvinist" model (see Killingsworth (1983)) which basically states that the male partner is the "first mover" and the fe-

male partner adjusts her behavior to her partner's labor supply decisions. Previous studies (for example Steiner and Wrohlich (2004)) have estimated female labor supply in a household utility context, which assumes that both spouses jointly decide on their labor supply. A comparison of the estimates of the female labor supply elasticities with those obtained by Steiner and Wrohlich shows that there is no significant difference to the elasticities estimated in the present model. I therefore conclude that the fact that husband's labor supply is assumed to be exogenous does not bias the results, if the household utility model is taken as the point of reference.

There is, however, an increasing strand of the literature that challenges the household utility model in stating that the bargaining process within the couple over time and resources is not taken into account. The so-called "collective" or "bargaining" models take this process explicitly into account. As Beninger et al. (2007) point out, the pre-requisite to estimate such a model is a data set that contains information on family members' labor supply, wage incomes and individual consumption levels. Since such a data set is not available for Germany, preferences for individuals in couples are estimated on the basis of information from single households.[28] Drawing on this model, Beninger et al. (2007) conclude that the household utility model underestimates wage elasticities of females in couples. However, since it is unclear what sort of distortion is introduced by assuming that singles and individuals in couples have the same preferences, it is difficult to assess on this basis what sort of bias is produced when the male partner's labor supply is ignored in the case of women with young children.

Finally, another potential shortcoming results from the definition of the sample that only includes mothers with young children. Unbiased estimates can only be obtained in this case if there are no unobserved characteristics that influence the selection into the sample and the labor supply decision at the same time. In other

[28] In a collective model on labor supply and retirement behavior of elderly couples Michaud and Vermeulen (2004) estimate preference parameters of recently widowed persons and transfer them to couples.

words, fertility is treated as an exogenous variable. In a static labor supply model this assumption can be justified by arguing that age and number of children in the current year are predetermined. If, however, the individuals in the sample have unobservable characteristics that are systematically different from those of women who are not part of the sample (one could think of unobservable attributes such as "family commitment"), and if these unobservables are correlated with one of the explanatory variables (for example wages that are part of net household income), then the estimation results will be biased (see Browning (1992)). As a comparison with estimations for the full sample of women in Germany by Steiner and Wrohlich (2004) shows, the elasticities obtained from the model presented here are not significantly different from those obtained for the full sample. However, this comparison does not reveal the presence or the magnitude of the bias that could result from treating fertility as an exogenous variable, since this is also assumed in the previous studies.

In order to find out whether this bias significantly influences labor supply elasticities, the model would have to be compared with one that treats labor supply and fertility as a joint decision. To the best of my knowledge, such a model has not yet been estimated for Germany. Some studies exist for other countries, for example Hotz and Miller (1988), Keane and Wolpin (2002a and 2002b) and Francesconi (2002) for the US as well as Del Boca and Sauer (2006) for France, Italy and Spain. These studies, however, do not quantify the bias that is introduced by assuming that fertility decisions are exogenous in an estimation of mothers' labor supply (see also section 5.3).