A Structural Model of Childcare, Welfare, and the Labor Supply of Single Mothers*

Thomas Andrén[α]

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Abstract
This paper considers the simultaneous relationship of the single mother's decision to choose paid childcare, welfare participation and labor supply, and estimates a structural model that allows for a free error covariance. We use a discrete approach to the choice of labor supply together with the discrete choices of utilized paid childcare and welfare participation, which allow formulating the model as a multiple-choice problem. The results show that there is an association between social assistance, paid childcare and labor supply, but that the relationship is non-symmetric. An increase in the social assistance norms has a relatively small effect on paid childcare utilization, but a relatively larger effect on the mean labor supply. In contrast, a corresponding reduction in the childcare cost has a relatively large effect on the social assistance utilization but a relatively small effect on the mean labor supply. Our estimates suggest that a decrease in childcare cost increases the labor supply of those working rather than encourages non-workers to start work, which implies that childcare cost is foremost a barrier to fulltime work rather then a barrier to work at all.

Keywords: labor supply, paid childcare, welfare participation, structural model, simulated maximum likelihood, Halton draws.

JEL classification: J13, J22.

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α Göteborg University, Department of Economics. E-mail: Thomas.Andren@economics.gu.se.

1 Introduction

For single mothers of young children, participation in the labor market is strongly linked with the need for childcare. Childcare is often regarded as essential for full-time work and career development of single mothers, but sometime the cost of childcare can be a barrier for entering the labor market when municipal childcare is the only option.[1] This implies that some working mothers end up below the social assistance norm after paying for the childcare fee. The childcare fee per se can therefore be seen as a factor that induces a need for income support, such as social assistance. This is especially true for single mothers located at the lower end of the wage distribution. It is therefore reasonable to expect that there is a behavioral relationship among the choices of paid childcare utilization, welfare participation and labor supply.

In Sweden, large savings have been imposed on the municipal childcare system during the last decade, resulting in changes in the childcare fees. The fee levels have increased and the construction of the fees has changed. For many single parent households, income is too low to support the family after the childcare fee has been paid. In 1996, a single mother with a gross income of 13,200 Swedish crowns (SEK) per month and with 2 children on childcare 40 hours per week, had a consumption level below the social assistance norm in over 90% of the municipalities (Socialstyrelsen, 1997).[2, 3] Recently, public attitudes towards single mothers have changed dramatically, and policy makers have been under pressure to carry out reforms that reduce single mothers' welfare dependency by means of fee ceilings (Maxtaxa). It is therefore interesting to investigate the simultaneous effect of paid childcare utilization and welfare participation on the labor supply for single mothers. Would a lower childcare fee increase labor supply and/or decrease welfare participation? Would a change in the social assistance norm affect the single mother's preferences related to the labor market activity? Would a lower social assistance norm lower the demand for paid childcare and therefore the labor supply? These are the main questions to be addressed in this paper.

[1] Childcare activities are usually operated by the municipality and therefore subject to a childcare fee.
[2] In 1996 the grant for a PhD student (utbildningsbidrag) in economics was 12,000 SEK per month in Sweden.
[3] In March 2002, 1 SEK corresponds to 0.11 Euro.

The literature is rich with studies that analyze the childcare cost or welfare effects on the labor supply for single mothers. There is also a growing econometric literature relating childcare costs to female employment, though the vast majority focus on married mothers. Heckman (1974), Blau and Robins (1988), Ribar (1992, 1995), Connelly (1989, 1992), Averet et al. (1997) and Kimmel (1998) have explored the effect of childcare costs on married women's labor force participation in the United States. Kimmel (1998) compared married and unmarried women and found single women's employment elasticity to be lower than married women's. All found significant negative effects of childcare costs on women's employment.

There are also a few studies that use Swedish data. For example, Gustafsson and Stafford (1988) estimated the effect of such costs on the market work decision of women belonging to two-parent families. Flood and Wahlberg (2000) estimate the labor supply effects from introducing fee ceilings (Maxtaxa) on households with children. They found a significant negative effect of childcare costs on women's labor force participation, although the estimated mean childcare price elasticity of employment varied extensively. Flood and Wahlberg (2000) also found that the labor supply effect very much depends on where on the income distribution the household is located.

The empirical literature on the effect of transfer programs of labor supply on women is fairly large (see Danziger et al., (1981), Moffitt (1992) and Gustafsson et al. (1993) for surveys). The literature on the incentive effects of the U.S. welfare systems has shown unequivocal evidence of effect on labor supply and participation in the welfare system. These effects arise mostly for single women, which is a major recipient group. The econometric studies show that labor supply is reduced by welfare. Flood et al. (2001) analyzed single mothers in Sweden and found rather small mean incentive effects. However, they found substantial effects for different income groups.

The literature on childcare costs and welfare participation contains only a few studies. Fore example, Connelly (1990) found small effects of childcare costs on welfare use. Kimmel (1995) using a low-income sub-sample found nearly zero elasticity. Crecelius and Lin (2000) found a one-percentage point reduction in the average probability of welfare receipt, if mothers received 20 hours of help weekly from relatives and friends. They also found that for each 10-cent reduction in childcare cost, there were 0.15 to 0.21 more hours worked per week. Connelly (2001) found significant

results indicating that subsidizing childcare reduces the welfare dependency of single mothers. To my knowledge there are no studies using Swedish data on the simultaneous effect of childcare cost, welfare participation and labor supply of single mothers.

There are at least two reasons for the lack of studies concerning the simultaneous effect. The first is the existence of self-selection into welfare programs and/or paid childcare utilization on the basis of unobserved heterogeneity. Some people are more likely to be eligible for social assistance than others, and the decision to utilize paid childcare is by no mean random. There are also individuals eligible for social assistance who choose not to participate. The latter are often referred to as welfare stigma (Moffitt 1983). This selection process, based on unobserved heterogeneity, requires that the welfare-participation equation and the paid childcare utilization equation be estimated jointly with the labor supply equation. This is a task that requires evaluation of high dimensional integrals if the choice set is large. Until recently this has not been feasible since standard quadrature methods are very burdensome when integrating over high-dimensional density functions.[4] Instead estimation methods based on simulation techniques may be used.

The second reason is the difficulty of deriving an analytical solution of the boundaries of the error space within which different choices are optimal.[5] This also makes it difficult to use high precision simulation methods such as the GHK–simulator since it requires that the residuals be expressed explicitly.[6] Instead, a frequency simulator (Lerman and Manski, 1981) may be used, but at a cost of many more random draws from the assumed distribution. The number of draws can be reduced dramatically using low discrepancy methods when evaluating the probabilities, but the method is still very computer intensive, which therefore only reduces the problem.

By assuming a discrete approximation of the hours of work distribution we may formulate the model as a multiple-choice problem. We approximate the distribution of weekly hours of work by three distinct points: 0, 20, and 40, where H = 0, if the woman does not work; H = 20, if she works part time, and H = 40, if she works full time. This

[4] The number of evaluation points grow exponentially with the dimension which means that dimensions above 5 would be too burdensome since the integral has to be evaluated for each individual, several times during just one likelihood iteration.
[5] See Keane and Moffitt (1998) for a discussion.
[6] The GHK-simulator was developed by Geweke (1991), Hajivassiliou (1990), and Keane (1994), who gave the simulator its name.

approximating assumption simplifies the estimation dramatically and circumvents the problems with kinks and piecewise linear budget sections due to transfer programs, taxes and childcare fees. This is especially convenient since we are interested in investigating the factors behind the combined decision of labor supply, welfare participation and paid childcare utilization.

Our study differs from those published earlier in several respects. First, we estimate a structural labor supply model allowing for a free error structure among the involved equations, including paid childcare utilization and welfare participation. The model is structural in that we define an explicit expression for the preferences, which is used in the estimation of the parameters in the model. Second, depending on the hours of work, we allow for several different care modes. Third, we include a wage equation that is allowed to freely correlate with the other equations.[7] This is important since a substantial percentage of single mothers have unobserved wages, which therefore have to be simulated conditional on the wage equation. Fourth, fixed cost of work is an important factor for single mothers and is incorporated in the utility structure using a linear function to control for observed heterogeneity. Fifth, we perform a policy analysis using the full structural model in a micro simulation setting that provides responses on the choice variables given various changes in the budget set. Moreover, we focus on a group of individuals sensitive to changes in childcare fees and welfare norms, namely single mothers having at least 1 child aged 1-12 years.[8] The single mother's choice problem is to choose among the discrete hours, welfare participation and paid childcare utilization, treating all choices as endogenous when the decision is taken.

The paper proceeds with Section 2, which presents the institutional background. Section 3 presents the basic theoretical set-up, and section 4 specifies and motivates the construction of the empirical model. The data is presented in Section 5 and section 6 presents and discusses the results. Section 7 summarizes the main findings of the paper.

[7] To include a wage equation in a labor supply model is by no mean a novelty, but it is an important feature of this model, since we account for unobserved wages in a theoretically proper way.

[8] It is an empirical fact that almost all single mothers stay at home with the child during the first year. Hence we exclude households with children younger then 1 year, since paid childcare won't be an option for them.

2 Institutional background for paid childcare

According to the Education Act of 1995, municipalities are obliged to provide childcare in the form of pre-school activity and school childcare for children aged 1-12 of the extent required for parents to be able to work or study. The act states that placement ought to be provided "without unreasonable delay", i.e., normally within three to four months after the person having custody of the child has requested placement. However, if a parent is unemployed, the child usually loses the childcare placement at once or after a period of time depending on the municipality. According to a survey done by the Swedish Board of Education (Skolverket, 1998), almost half of the municipalities allowed the child retain the placement even though a parent became unemployed, while a child lost the placement in about 40 % of the municipalities. In only 28% of the municipalities were there no requirements put on the parents to be employed or have student status.

There are two types of municipal childcare in Sweden: pre-school childcare activity and school childcare. Pre-school childcare is intended for children who do not attend school and is carried out in the forms of pre-schools, family day-care homes and open pre-schools. School childcare is intended for children who attend school and is carried out in the form of after-school centre, family day-care home and open after-school activities. In 1997 about 59 % of children aged 1-2 were enrolled in pre-school activity, while the corresponding number was 78% for children aged 3-6. The largest proportion of children (97%) participates the year before the children start school. The participation rate for children aged 7-9 was 56% and the number for children aged 10-12 was 6%.

In autumn 1999 the average hours per week at municipal pre-school for children aged 1-5 years were 31. Hours per week at private pre-school were on average an hour a week more, and at family day-care homes an hour a week less. Schoolchildren's average hours per week were just below 17 hours per week both in municipal after-school centers and family day care homes and an hour shorter in private leisure time centers. The spread is relatively great, as for example, the hours per week of a third of pre-school children were fewer than 20 or more than 40 hours per week. Hours per week are highest in big cities and suburban municipalities and lowest in industrial and rural municipalities.

The fees charged to parents finance an increased proportion of the gross expenditure on childcare. In 1999, approximately 18% of the costs for municipal childcare were met by parental payments, while in the early 1990s, this proportion was around 10%. The percentage of such financing is highest at the after-school centers, where charges to parents account for almost a quarter of the gross expenditure, compared with 16% at pre-school.

3 The Labor supply, childcare and welfare participation

In standard labor supply models, the utility of an individual is specified as a function of hours of leisure (L) and net income (Y), expressed as $U(L,Y)$. This function is equivalent to one with hours of work (H) as an argument, such as $U(H,Y)$. Expressing the utility function in terms of hours or work instead of leisure avoids the necessity of explicitly representing the total hours available to market and non-market activities. The hours of work is therefore defined as $T - L$, where T is the total time available and L the non-market hours. The non-market hours are defined to include maternal childcare, other household production activity and leisure. In these models, people are assumed to like income but to dislike working so that U increases in Y and decreases in H. In static labor supply models, people are assumed to maximize the current period utility subject to a current period budget constraint of the form $Y(H) = wH + N$, where w is the hourly wage rate and N the non-labor income. When paid childcare utilization and welfare participation is incorporated into the utility structure, the function is extended by a measure for paid childcare utilization (P_{CC}) and welfare participation (P_{SA}). The important question is how these two components work in the preferences of the individual; this is important when interpreting the parameters in the utility function. The factor that captures the utility of social assistance is assumed to be negative. [9]

We aim to analyze the structure and determinants of paid childcare utilization as oppose to non-paid childcare, and to what extent paid childcare constitutes a barrier to labor supply. We therefore follow and use Ribar (1995)'s conceptual framework regarding paid childcare, emphasizing the link between the quality of childcare and the choice of paid childcare utilization. He argues that it is the quality of childcare (Q)

[9] The reasons for this will be discussed and motivated when we discuss the empirical specification.

extended to the children that affects the preferences of the mother, and is therefore a factor in the utility function, $U(H,Y,Q(X_Q,P_{CC}),P_{SA})$. In this framework paid childcare is only one of several components inside the production function of childcare quality. Childcare quality is assumed to increase with inputs of maternal care and market goods included in X_Q, but the contribution of paid childcare to the overall quality is ambiguous and depends on the quality of paid childcare relative to maternal and unpaid non-maternal childcare. Paid childcare enters the model as an input to the production of childcare quality but also as a cost component in the budget constraint. Unpaid childcare, on the other hand enters the model only as an input to the production of quality. The decision to use paid or unpaid childcare therefore depends only on the absolute cost and relative quality of paid childcare. It is therefore assumed that non-market care is available to all families at some indirect cost, which should be incorporated into the model. The indirect cost of unpaid care is determined in terms of the care provider's time in alternative activities. This provides a measure of the availability of unpaid care. The indirect cost is incorporated directly into the utility function by reformulating the utility function as

$$U = U(H,Y,Q,P_C,P_{SA}) \tag{1}$$

where utility increases with childcare quality (Q) and paid care utilization (P_C). The utility term (P_{CC}) acts as a flexible proxy for the indirect cost of unpaid care (Ribar, 1995).

For the labor supply of single mothers with young children, the budget constraint for the simple labor supply model must be elaborated. Most importantly, since a large proportion of single mothers have a strained economic situation, the budget constraint must include the available welfare benefits. The major welfare programs for single mothers are social assistance, housing allowance, child allowance, and alimony, which are all designed to reallocate economic resources to economically weak groups such as single mothers. This reallocation process affects the single mother's labor supply behavior in different ways, and needs to be included in the model in order to capture those effects. Furthermore, single mothers that participate in the labor market also need childcare, which often is associated with substantial costs. Therefore the childcare cost

has to be included in the budget constraint in order to account for the importance of the cost of childcare on the single mother's preferences towards the endogenous variables in the model.

P_{SA} is an indicator that takes the value 1 if a single mother uses social assistance and 0 otherwise, while P_{CC} is the corresponding indicator for the decision to put her child in paid childcare. The budget constraint may then take the following form:

$$Y(H, P_{SA}, P_{CC}) = wH + N - P_{CC}B_{CC}(X_{CC}) + P_{SA}B_{SA}(X_{SA}) - T(X_T) \quad (2)$$

$B_{CC}(X_{CC})$ represents the function for potential childcare cost with a vector of conditioning factors as argument (X_{CC}), where hours of work is one such factor. As the hours of work increase, the demand for more hours of childcare increase, causing potential childcare cost to increase. Hence, the childcare cost function increases in H.[10] $B_{SA}(X_{SA})$ is the corresponding function for potential social assistance with a vector of conditioning factors as arguments (X_{SA}), which also contains hours of work. The more she works, the higher the disposable income, which reduces the potential amount of welfare she could receive. Hence, potential welfare decreases with hours of work. $T(X_T)$ represents the tax function for the individual, which increases with H.[11,12] The other welfare programs are included in N as non-labor income.

4 The empirical specification

To make the model concrete we need to specify a functional form for the utility function. A convenient way to model preferences of an individual is to use the quadratic direct utility function with household net income (Y), individual labor supply (H), paid childcare utilization (P_{CC}), and welfare participation (P_{SA}) as arguments:

$$U(H, Y, P_{CC}, P_{SA}) = \beta_H H + \beta_{HH} H^2 + \beta_Y Y + \beta_{YY} Y^2 + \beta_{HY} HY + \beta_C P_{CC} - \beta_{SA} P_{SA} \quad (3)$$

[10] B_{CC} is dependent on the age of the children, the number of children and the size of the gross household income. The system applied in this paper is described in the Appendix.
[11] B_{SA} is a function of several factors described in the Appendix, one of them being the level of housing allowance. If the housing allowance increases, the level of social assistance decreases with the same amount. Here we have a 100 % marginal effect.
[12] The income tax system used here is described in the appendix.

Y is defined by the budget constraint given by (2), and H is a discrete measure for hours of work. Specification (3) should be interpreted as a flexible approximation to (1), in which the coefficients represent combinations of utility and care quality production parameters (Ribar, 1995). The quadratic direct utility function has the disadvantage of being concave only when its arguments are below the amounts at which the utility peaks, but this is not a serious problem as long as the data falls into the concave range (Fraker and Moffitt, 1988). The quadratic utility function is simple and convenient to use, which is the main advantage for our purpose. It is also flexible enough to allow for backward bending labor supply behavior. The marginal utility of Y at $Y = H = 0$ is normalized to 1, i.e., β_Y=1, which means that the remaining parameters are expressed in terms of SEK. As mentioned above, having the utility being a function of hours of work rather then hours of leisure is arbitrary, but it affects the interpretation of the parameters, which here is a measure for hours of work rather then leisure. In the basic labor supply model it is assumed that utility decreases with H, which implies that β_H may be interpreted as a disutility factor in the preferences of the individual. No such assumption will be made here since it is more realistic to believe that utility increases in H with a decreasing pace. The sign of β_H will therefore be an empirical question. According to our earlier discussion the sign of the coefficient for the paid childcare indicator, β_C, is positive. Since quality of childcare is exogenously given, the parameter is a measure for paid childcare utilization compared to all other forms of unpaid childcare. If paid childcare in general offers higher relative quality compared to unpaid childcare, the sign of the coefficient will be positive.[13] However, the sign of the parameter is here also an empirical question. The interpretation of the parameter is in terms of utility and measures the marginal utility of paid childcare. Paid childcare also has an income effect, since childcare cost is a component in the budget constraint. The decision to use paid childcare is therefore in some sense restricted by the budget set. The coefficients β_{HH}, $\beta_{YY,}$ and β_{HY} have no clear interpretations, but play an important role in the determination of the labor supply elasticities.

So far we have not discussed the role of social assistance in the preferences. A problem that appears when estimating labor supply models that account for welfare

[13] Many arguments about the importance of having the child on public childcare stress that this is not just a labor supply issue for the single parent but also an educational issue for the intellectual development of the child.

participation is the well-known selection problem that appears when individuals who are eligible to participate choose not to. This welfare stigma must be accounted for if we are to receive consistent estimates. It is irrelevant whether the choice not to participate is truly stigmatic, or whether there are other reasons for it. The fact still exists that some people do not end up on the budget line, which means that those people prefer or choose a utility level lower than the maximum attainable. This must be taken into account if we assume that individuals are utility maximizers. This also makes it difficult to interpret parameter as a stigma effect, since it does not reflect truly stigmatic behavior, but rather a combination of non-stigmatic factors such as lack of information or too little gain from participation. It is therefore more reasonable to think of the parameter as representing a threshold cost of taking social assistance.

There are two different ways in which this disutility can manifest itself. First, there may be a flat component that arises from the mere fact of participation itself, but which does not vary with the size of the benefit received. Second, there may be a variable component that varies with the size of the benefit. In this paper we choose to model it as a flat component for social assistance. In order to adjust for the non-presence of eligible single mothers the flat component is incorporated additively as a negative component ($-\beta_{SA}P_{SA}$) in the utility function (3). Hence, if β_{SA} is sufficiently large, the program may not be chosen even thought participants increase the utility. β_{SA} is therefore a "cost" parameter or simply the marginal disutility of welfare, and P_{SA} the discrete indicator for whether or not a person participates in the welfare program. Maximizing the utility function (3) with respect to the endogenous variables in the model subject to the budget constraint gives us the functions that represent the single mother's equilibrium combination of hours of work, welfare participation and paid childcare utilization.

4.1 Preference Heterogeneity

Observed heterogeneity is introduced linearly through parameters $\alpha=\{\alpha_1,\alpha_2,\alpha_3,\alpha_4\}$, that are allowed to vary in the population conditional on a set of observable socio-economic characteristics. In order to econometrically estimate the model, we must also specify a stochastic structure. That is, since single mothers with identical observed characteristics make different decisions about labor supply, welfare and paid childcare,

we must allow for random influences on these decisions. We therefore define the following equations:

$\beta_H = X_1\alpha_1 + \varepsilon_H$	Marginal utility of work	(4)
$\beta_{SA} = X_2\alpha_2 + \varepsilon_{SA}$	Marginal disutility of welfare	(5)
$\beta_C = X_3\alpha_3 + \varepsilon_C$	Marginal utility of paid childcare	(6)
$\text{Log}(w) = X_4\alpha_4 + \varepsilon_w$	The wage equation	(7)

where $\varepsilon = (\varepsilon_H, \varepsilon_{SA}, \varepsilon_C, \varepsilon_w)$ captures unobserved heterogeneity, and is assumed to be distributed jointly normal with mean zero and covariance Σ_ε.

4.2 Fixed entry cost of work

In general it is reasonable to believe that there is an entry cost associated with work for any individual moving from the non-working state to the working state (Cogan, 1981). This is especially true for single mothers who need childcare in order to participate in the labor market. Entry cost of work is usually decomposed into two parts, namely: money cost, and the time cost of work. Both are of special importance when modelling single parent households with young children. Money cost is usually related to childcare costs, commuting costs or any other costs associated with work, which are paid for by the individual. For single mothers, the ages of her children and the number of children are important factors that determine the major part of the money cost of work. Time cost of work is typically the time it takes to transport the child/children to a day-care centre or the time it takes to commute to the working place, and therefore is directly related to the distance to the day-care centre and work. A longer distance is associated with a higher cost since leisure time will be reduced by the same amount.

How does the fixed cost of work affect the single mother's labor supply? If money cost of work increases, the likelihood of an unemployed single mother waiting to supply labor decreases, but if she is employed, such an increase will increase labor supply and reduce leisure time. On the other hand, a rise in time cost to work has two consequences. First, it reduces "full income", that is, the maximum earning power of the single mother. Second, the increase in time cost of work also reduces total time available for either leisure or work, as long as the single mother continues to work. If

consumption and leisure are normal goods, and "full income" decreases, the single mother will reduce both consumption and leisure.

In this paper we express fixed cost of work by a linear function, allowing for observed heterogeneity: $Fc = X_5\alpha_5$, where X_5 is a matrix of explanatory variables and α_5 a corresponding vector of parameters. Fc will be used to reduce the net income for those who are working, by replacing Y by $(Y - Fc)$ in the utility function. The variables in such a function would be presence of children in different age categories, and the use of paid childcare, as well as the residence location. If a single mother lives in a city region, her transportation cost might be different from those who live in the country.

4.3 Estimation

In order to estimate the structural labor supply model we formulate a multiple-choice problem with 3 choices of hours of work, 2 welfare choices, and 2 childcare choices, which add up to a total choice set of 12 different alternatives. Letting j = 1, …, 12 indices the alternatives in the choice set, the problem is to choose the alternative generating the highest utility level. That is: an individual chooses alternative j if and only if $U_j > U_k \;\; for\; all\; k = 1, ...,12, k \neq j$, where U_j denotes the evaluation of the stigma adjusted utility function for combination j obtained by inserting the budget constraint evaluated by setting H, P_{SA} and P_{CC} at their appropriate values for combination j.

To formulate the likelihood function, we need to determine the contributing probabilities that correspond to each alternative (utility level). Given the nature of the problem, we can only express differences between utility functions rather then being able to extract the residuals explicitly. This requires the use of a method that does not require such error bounds. The standard frequency simulator (Lerman and Manski, 1981) does not have such requirements and therefore makes the problem solvable. The standard frequency simulator has certain problems, which make it intractable. It is a step function, which therefore excludes the possibility of using gradient-based optimization methods. It may also happen that the estimated probabilities sum to a number different from one. McFadden (1989) proposed a remedy for these two problems, suggesting a

Kernel-Smoothed frequency simulator to handle them.[14] The basic idea behind this simulator is to add "noise" in a systematic way to the simulated choice probabilities, thereby making the probability space continuous. The method is based on the extreme value distribution function that is used as a kernel for the frequency simulator, which also by necessity imposes the sum-up criterion.

Let $P(j|\theta,X,w)$ be the likelihood contributing probability of the event that the individual chooses alternative j conditional on a parameter vector (θ), observed characteristics (X) and the wage rate (w), and ϕ being the normal p.d.f. If δ_{ij} is an indicator that is 1 if person i chooses alternative j and 0 otherwise, we have the following log likelihood function:

$$L(\theta,\Sigma_{\varepsilon} \mid X,w) = \sum_{i=1}^{n}\sum_{j=1}^{12}\delta_{ij}\ln\left[P(j \mid \theta,X_i,w_i)\phi(w_i \mid \theta,X_i)\right] \tag{8}$$

A critical assumption here concerns the observability of gross wages for all single mothers.[15] Since wage rate is unobserved for non-workers, it is important to specify an equation for the wage offer determination process so that the unobserved wages of non-workers can be inferred. According to economic theory, a person works as long as the wage offer exceeds the reservation wages of the individual. Hence, in all cases of non-workers, we know that the individual has been offered a wage rate that is below her reservation wage. By introducing a distribution for the wage offer we are able to average over the section of the distribution that is relevant for the unemployed single mother, and thereby use the resulting probability as the contribution to the likelihood in the estimation. We can do this by simulating wages for each individual over the truncated region of the wage offer distribution and then average out.

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[14] The kernel smoothed frequency simulator defines the choice probability as $P(choose\ k \mid \theta) = \exp(U_k(\theta)/\sigma)/\sum_{j=1}^{J}\exp(U_j(\theta)/\sigma)$, and the choice probability is received by averaging over repeated draws from the assumed distribution for the unobserved components of the utility function (McFadden, 1989). This simulator converges to the standard frequency simulator when σ goes to zero. Choosing a suitable σ is time-consuming. It should be as small as possible, but when choosing it too small the convergence property of the simulator gets worse, which makes it harder for the model to converge. We use $\sigma = 0.5$ in the estimation.

[15] See Van Soest (1995) for a discussion.

$$P(j \mid \theta, X) = \int P(j \mid \theta, X, w)\phi(w \mid \theta, X)dw \tag{9}$$

$P(j|\theta,X)$ is the probability of participation–hour combination j conditional on a vector of observed characteristics for the individual (X), and a vector of parameters of the model (θ), for those with unobserved wages. The likelihood function is adjusted and modified by replacing the likelihood contributing components in (8) by the logarithmic version of (9) for those with unobserved wages.

A way to reduce the computational burden is to use low discrepancy methods when simulating the probabilities. One such method is the so-called Halton sequence (Halton, 1960), which is a commonly used low discrepancy sequence that is much more efficient then standard random draws.[16]

4.4 Identification

When estimating the model we apply some normalizations. For example, the variances of the two choice parameters (β_{SA},β_C) are normalized to one. These normalizations are not used as identifying normalizations. We impose them to make the model more stable. The parameter for net income (β_Y) in the utility function is normalized to one. This normalization also makes the parameters more interpretable. The variance of β_H is identified since we have three H categories rather then two. We use exclusion constraints between the labor supply equation and the wage equation; these include variables in the labor supply equation that are not in the wage equation, and variables in the wage equation that are not in the labor supply equation. We use different sets of variable specifications for the welfare participation equation and the paid childcare equation to make the estimation more stable, but also since we believe that these two choices to some extent are explained by different factors. No other restrictions or normalizations have been applied.

[16] Train (2001) indicates that 100 Halton draws can outperform 1000 standard random draws. This implies that the computational burden can be reduced by a factor of 10 using low discrepancy methods.

5 Data

The data used in the empirical analysis belong to the Swedish Household Income Survey (HINK) provided by Statistics Sweden. HINK provides information on labor market activities and incomes for a random sample of about 20,000 Swedish households per year, with information about each member of the household. It is comprised of two sections; a survey and a register. This construction provides us with relatively high quality income data, as well as with useful variables describing the household. However, the single mothers form a rather small group of the total Swedish population, and therefore the sample size of a cross-section is not big enough. To remedy this we decided to pool the 1997 and 1998 cross-sections of HINK. From each cross-section we selected single women aged between 18 and 64 that have at least one child in the ages 1-12. We excluded women who were self-employed, early retired, and students. Having done this we ended up with a sample of 533 single mothers.

Hours of work and wage rate are important variables in any labor supply study. In the estimation we use a discrete approximation for the continuous measure of hours of work. We use 3 discrete hour points $H = \{0, 20, 40\}$. In HINK the continuous variable for hours of work is derived with information from the survey section, which asked for the number of weeks of gainful employment (K_1) and for the number of worked hours per week with gainful employment (K_2). These two variables were used to construct the degree of employment as a percentage of normal working time. Normal full-time work is defined to be 1880 hours per year, assuming 5 weeks of vacation, and 40 hours of work per week (40*47=1880). This leads to the following formula $S = (K_1 * K_2) * 100 / 1880$, where S is used to construct the discrete time points used in the analysis.

$$H = \begin{cases} 0 & if \quad S = 0 \\ 20 & if \quad 0 < S \leq 88 \\ 40 & if \quad S > 88 \end{cases}$$

The wage rate is computed as the ratio of annual income from work, and annual hours of work.[17] This construction could lead to division bias in the case of measurement errors in annual hours of work. This is something that we do not consider and therefore implicitly assume that hours of work is measured with no errors.

The variable for paid childcare utilization is based on observed data. For each child in the household there is information about attendance of paid childcare during a year. If at least one child has been in paid childcare for at least one month, the household is registered as a paid childcare user. In general a single parent is not entitled to municipal childcare when unemployed, though, there are exceptions. If someone uses municipal childcare and becomes unemployed, it is sometimes possible to keep the child in the childcare centre. But since childcare cost is a function of hours of work the cost for such children is 0. In the analyzed sample, there are a few cases were the wage rate is unobserved while the single mother uses paid childcare. For these households the childcare is free of charge.

Since the childcare fee varies by hours of work it is necessary to specify a time use schedule for the households. This is important since we need to determine the potential childcare cost for different hours of work combinations during the estimation. Table 1 reports the assumed time use for the households in the model. It is assumed that a pre-school child stays at a childcare centre as long as the mother is working. It is assumed that a school-aged child spends half the time at school, and the rest of the working day at the care centre. This schedule is applied for those with observed childcare, and is considered a good approximation of the actual cases since we have information whether a particular child is within a childcare program.

[17] Each individual is asked how many hours she has been working each and every month a specific year. By summing the number of hours we receive a measure for total numbers of hours worked during the year. A variable from the tax register gives us the annual income from work. The ratio of these two gives us the wage rate.

Table 1 Time use of paid childcare in hours per week for the household [18]

Hours of work	Age of child		
	1 – 5	6 – 8	9 – 12
H = 0	0	0	0
H = 20	20	10	10
H = 40	40	20	20

The variable for social assistance utilization is a discrete indicator for those who received *any* social assistance during the year. Table 2 presents the distribution of the number of months with social assistance the single mothers received over the year, stratified over the discrete points of hours of work. We observe that the behavior differs, depending on whether the single mother is employed or not. If unemployed, the number of months of welfare participation is uniformly distributed, while if employed, just one or two months are used. In general, single mothers seem to take social assistance just a few months per year. This behavior is nothing that we control for since we define a welfare participant as someone who has received social assistance for at least one month during the year.

Table 2 Distribution of welfare dependency

Number of months	Hours of work					
	0		20		40	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	7	10.14	13	18.31	10	45.45
2	5	7.25	11	15.49	6	27.27
3	2	2.90	3	4.23	1	4.55
4	8	11.59	3	4.23	1	4.55
5	5	7.25	9	12.68	0	0
6	8	11.59	1	1.41	1	4.55
7	1	1.45	4	5.63	0	0
8	8	11.59	4	5.63	0	0
9	7	10.14	7	9.86	1	4.55
10	5	7.25	9	12.68	1	4.55
11	6	8.70	3	4.23	0	0
12	7	10.14	4	5.63	1	4.55
	69	100.00	71	100.00	22	100.00

[18] Lately, it has been common practice to link the childcare fee to the number of hours the child stays at the childcare centre. In 1999 almost all municipalities (90%) used a construction with a time-varying fee. In 1993 the corresponding number was 40% (Skolverket, 2000).

When choosing variables for the equations, the aim has been to have a specification as parsimonious as possible, yet still including what is relevant. The labor supply equation contains standard variables such as age, region and education. Since we model paid childcare utilization, we also included dummies controlling for presence of children in different age intervals, which can affect the labor supply. The wage equation also contains standard choices namely region, education and years of work experience.

The social assistance equation should contain variables that are associated with social assistance utilization, such as age, region, education and types of childcare. Younger people are more often exposed to social assistance then others. Educational level is typically related to how successful an individual is in the labor market, which in tern is associated with the need for social assistance. The link between paid childcare utilization and social assistance is explored in this paper and we therefore include a dummy for this. We also include a corresponding dummy indicating if the child was at home with a parent as oppose to being in paid childcare.

The childcare equation measures the marginal utility of using paid childcare. It should therefore contain variables that capture such effects. Since the attendance duration differs across regions, regional dummies were included. The educational level of the parent is associated with the need for childcare. People with higher educations tend to work more than those with lower education. One could therefore argue that people with higher education potentially demand more childcare. The need for childcare also varies dependent on the age of the child. When children are younger the need is greater, compared to the case when children are older and therefore more able to take care of themselves.

Table 3 presents sample means of variables used in the estimation, stratified into various groups dependent on hours of work, the choice of utilized paid childcare and welfare. The overall average age for a single mother is 35. Single mothers working part-time, using paid childcare and receiving social assistance are the youngest (about 30 years old), while single mothers working full-time using neither paid childcare nor social assistance have an average age of 39. This implies that social assistance is something that younger single mothers receive before they have established themselves on the labor market. On the other hand, we observe that older single mothers also have higher educations and live in big city regions. The number of children per household is

quite stable, ranging from 1.73 to 1.93. Younger mothers receiving social assistance and childcare more often have young children, while older mothers not using childcare or welfare more often have children aged 9-12.

Table 3 Variable means of household characteristics (standard deviations within parentheses for continuous variables)

Variable	All	H=0 SA=1	H = 0 SA=0	H = 20 CC = 1 SA = 1	H = 40 CC = 1 SA = 1	H = 20 CC = 1 SA = 0	H = 40 CC = 1 SA = 0	H = 20 CC = 0 SA = 0	H = 40 CC=0 SA=0
Age	35			30	33	35	37	36	39
	(7.4)	32	35	(6.3)	(7.2)	(6.6)	(6.8)	(6.5)	(6.1)
Age groups									
18-34 years	0.47	0.61	0,56	0.76	0.60	0.50	0.38	0.39	0.22
35-44 years	0.41	0.37	0,27	0.21	0.33	0.44	0.46	0.49	0.57
45-64 years	0.12	0.02	0,18	0.03	0.07	0.06	0.16	0.12	0.21
Experience	8.9	3.7	5,9	7.4	11.8	12.6	16.2	6.3	10.1
	(9.3)	(6.6)	(7,1)	(6.1)	(8.0)	(6.6)	(6.8)	(9.3)	(11.7)
Education									
Primary school	0.34	0.59	0,31	0.52	0.27	0.24	0.27	0.29	0.20
Secondary school	0.57	0.37	0,67	0.48	0.66	0.61	0.59	0.63	0.67
Post secondary	0.09	0.04	0,02	0.00	0.07	0.15	0.14	0.08	0.13
Number of children	1.78	1.90	1,56	1.88	1.93	1.88	1.80	1.73	1.79
	(0.84)	(1.07)	(0,78)	(0.94)	(0.96)	(0.85)	(0.79)	(0.81)	(0.71)
If children aged									
1- 5 years	0.43	0.54	0,42	0.76	0.67	0.52	0.49	0.24	0.14
6- 8 years	0.38	0.42	0,33	0.41	0.47	0.47	0.47	0.31	0.26
9-12 years	0.49	0.42	0,56	0.29	0.27	0.44	0.38	0.64	0.74
13-17 years	0.24	0.24	0,16	0.12	0.33	0.13	0.24	0.25	0.47
If paid childcare for children aged									
1- 5 years	0.28	0.31	0,24	0.74	0.67	0.52	0.49	-	-
6- 8 years	0.22	0.18	0,16	0.41	0.47	0.47	0.46	-	-
9-12 years	0.11	0.03	0,09	0.15	0.00	0.32	0.29	-	-
If home with the parent for children aged									
1- 5 years	0.05	0.07	0,02	0.09	0.13	0.02	0.05	0.05	0.03
6- 8 years	0.03	0.03	0,04	0.03	0.00	0.05	0.01	0.02	0.01
9-12 years	0.25	0.18	0,31	0.18	0.27	0.18	0.15	0.35	0.43
Region groups									
Big city	0.43	0.31	0,36	0.30	0.40	0.32	0.47	0.53	0.54
Small city	0.30	0.32	0,27	0.41	0.20	0.37	0.30	0.20	0.30
Rural	0.27	0.37	0,38	0.29	0.40	0.31	0.23	0.27	0.16
N	533	71	45	34	15	62	100	83	76

Note: CC=paid childcare. SA=social assistance.

Table 4 reports mean statistics of variables that appear in the budget restriction of the household. Hours of work are expressed in annual numbers, and averages 1151 hours by individuals in the sample. The overall hourly wage rate was 73 SEK per hour. The wage rate for women who work part time, use paid childcare and no social assistance, was 102, and for women who work full time, use social assistance and have children at paid

childcare was 72. This latter group is very special, but also very small in our sample; only 15 individuals. Therefore these numbers should be interpreted with certain reservations. This group also works most on average; 2153 working hours per year.

Table 4 Variable means of household budget components (standard deviation within parentheses)

Variable	All	H=0 SA=1	H = 0 SA=0	H = 20 CC = 1 SA = 1	H = 40 CC = 1 SA = 1	H = 20 CC = 1 SA = 0	H = 40 CC = 1 SA = 0	H = 20 CC = 0 SA = 0	H = 40 CC=0 SA=0
Hours of work, year	1151			600	2153	1051	2024	1068	2145
	(893)	-	-	(517)	(796)	(476)	(270)	(474)	(428)
Hourly wage rate (SEK)	73			82	72	102	97	92	96
	(47)	-	-	(51)	(29)	(44)	(26)	(22)	(15)
Monthly (potential) care	577			1243	1753	1196	1651		
expenditure (SEK)	(796)	-	-	(384)	(601)	(432)	(587)	-	-
Weekly potential social	318	1170		1054	663				
assistance (SEK)	(593)	(626)	-	(783)	(464)	-	-	-	-
Parental Allowance	5.61	0,63	0,55	6.29	12.49	7.98	6.68	6.39	5.45
(KSEK)	(13.26)	(1,60)	(1,42)	(7.33)	(21.05)	(17.32)	(9.58)	(17.41)	(14.99)
Child Allowance	14.87	16,55	12,79	16.10	15.68	16.21	14.75	14.81	14.19
(KSEK)	(8.62)	(11,12)	(7,45)	(12.23)	(8.34)	(8.70)	(8.32)	(7.80)	(6.97)
Housing allowance	16.76	21,85	19,61	20.40	15.79	18.85	11.13	17.82	11.36
(KSEK)	(11.59)	(11,29)	(12,38)	(10.83)	(9.88)	(11.28)	(10.11)	(10.90)	(11.09)
Alimony (KSEK)	16.51	20,11	16,86	16.85	18.71	18.23	14.94	16.59	14.08
	(14.75)	(17,95)	(14,14)	(14.79)	(16.14)	(13.88)	(13.54)	(15.53)	(13.99)
Sickness benefit (KSEK)	4.68	0,41	0,09	3.66	3.45	8.45	3.99	7.97	3.52
	(15.89)	(1,43)	(0,39)	(9.94)	(9.92)	(21.58)	(12.65)	(20.02)	(15.22)
Unemployment comp.	12.11	12,64	36,21	18.34	3.13	13.02	2.79	20.44	0.24
(KSEK)	(25.98)	(24,93)	(47,12)	(28.45)	(10.19)	(20.26)	(10.64)	(31.51)	(1.82)
Income from capital	0.53	0,02	0,63	0.01	0.02	0.45	1.74	0.21	0.42
(KSEK)	(3.90)	(0,07)	(1,88)	(0.02)	(0.07)	(1.53)	(8.63)	(0.88)	(1.42)
Housing rent per month	2.72	2,75	2,68	4.49	4.68	3.59	3.94	1.28	1.94
(KSEK)	(2.44)	(2,35)	(2,57)	(1.02)	(1.21)	(1.94)	(2.07)	(2.09)	(2.64)
N	533	71	45	34	15	62	100	83	76

Note: KSEK means thousands of SEK.

Table 5 reports how the endogenous variables in the model are distributed over the sample. Most single mothers (41%) work part-time, and 22% of them are unemployed. Across the choices the smallest group of single mothers (1.5%) are full-time workers with no childcare but with social assistance, and the largest group (19%) are also full-time workers with childcare but with no social assistance.

Table 5 Distribution of women across welfare, childcare and hours of work (in %)

Welfare and childcare utilization		Hours of work			Row total
		0	20	40	
P_{CC}=1	P_{SA}=1	5.6	6.4	2.8	14.8
P_{CC}=0	P_{SA}=1	7.7	7.3	1.5	16.5
P_{CC}=1	P_{SA}=0	3.2	11.6	18.8	33.6
P_{CC}=0	P_{SA}=0	5.2	15.6	14.3	35.1
Column total		21.7	40.9	37.4	100.0

Table 6 reports the distribution of the choice combinations by education. Most single mothers have high school degrees and do not receive social assistance, while the less represented have post secondary education and receive social assistance. The distribution across the choice combinations is uniformly distributed among those with a primary educations, and no clear pattern can be distinguished.

Table 6 Distribution of labor supply and welfare and social assistance utilization by education

Welfare and childcare utilization		Education			Row total
		Primary	Secondary	Post Secondary	
P_{CC}=1	P_{SA}=1	7.3	6.9	0,5	14.8
P_{CC}=0	P_{SA}=1	9.0	7.1	0,4	16.5
P_{CC}=1	P_{SA}=0	8.4	20.8	4,3	33.6
P_{CC}=0	P_{SA}=0	9.4	22.3	3,4	35.1
Column total		34.1	57.2	8.6	100.0
H = 0		10.5	10.5	0.8	21.8
H = 20		14.6	23.1	3.1	40.9
H = 40		9.0	23.6	4.7	37.3
Column total		34.1	57.2	8.6	100.0

When it comes to the labor supply we see that single mothers with primary educations concentrate on no work or part-time work, while those with post secondary educations concentrate on full-time work. There is a clear pattern of labor supply increasing with level of education.

Table 7 presents the distribution of the choice variables by age groups. The largest group (17%) is that of single mothers aged 35-44, without paid childcare and with no social assistance. The next largest group is that of single mothers aged 18-34, with paid childcare and no social assistance. The smallest group (0.4%) is that of single mothers aged 45-64 with both paid childcare and social assistance. The probability of having social assistance is much lower for older mothers compared with younger mothers. Using paid childcare is also less frequent for older mothers than with younger mothers.

One reason is that older mothers have somewhat older children and therefore do not require childcare to the same extent.

The distribution of the labor supply by age groups shows that most single mothers are aged 18-34 and work part-time (21.4%), while the group less-represented is that of single mothers aged 45-64 who do not work at all.

Table 7 Distribution of labor supply, welfare and social assistance utilization by age

Welfare and childcare utilization		Age 18-34	Age 35 - 44	Age 45 - 64	Row total
P_{CC}=1	P_{SA}=1	10.9	3.6	0.4	14.8
P_{CC}=0	P_{SA}=1	8.8	6.6	1.1	16.5
P_{CC}=1	P_{SA}=0	15.2	14.4	3.9	33.6
P_{CC}=0	P_{SA}=0	11.6	17.3	6.2	35.1
Column total		46.5	41.8	11.6	100.0
H = 0		12.8	7.1	1,9	21.8
H = 20		21.4	16.1	3,4	40.9
H = 40		12.4	18.6	6,4	37.3
Column total		46.5	41.8	11.6	100.0

6 Results

Tables 9 and 10 report the parameter estimates for the model containing 4 equations, i.e., the labor supply, the welfare participation, the paid childcare utilization and the wage equation. Fixed cost of work is not included as a separate effect, and therefore this model will be used as a reference when we later analyze the model that includes fixed cost of work. Our estimates are based on a simulated log-likelihood function using 100 Halton draws per individual.[19] According to Train (2001), 100 Halton draws are a suitable number for our purpose. However, later we will investigate the sensitivity of the parameter estimates to the number of draws by comparing estimates from a model using twice as many draws.

The variable specification used in this paper is a result of extensive testing in the spirit of making a parsimonious variable specification. In general, structural models are sensitive to the choice of variable specification and starting values. However, after testing a range of specifications we found that the significant parameters were quite

[19] This is a sufficient number based on studies in the literature where similar numbers are used. One should keep in mind that the simulated maximum likelihood is a biased estimator for the log likelihood for a finite number of Monte Carlo draws. The simulated log likelihood is only asymptotically unbiased as the number of draws used to simulate the choice probabilities grows large, and obtain consistency only as simulation size goes to infinity.

stable, and the choice of different but reasonable starting values mainly affected the convergence time. The labor supply equation in the model is a measure for the marginal utility of work. The marginal utility of work increases with age at a decreasing pace, which is no surprise since the supply of labor is lower for younger mothers as well as for older mothers compared to the middle-aged group. Single mothers living in big city regions or having higher educations have higher marginal utility for work then others. The age of the children in the household is important for the single mother's labor supply: the older the children, the more likely the mother is working.[20]

The equation for social assistance should be thought of as a marginal disutility (cost) measure in the sense that a parameter with a positive sign indicates a reduced utility. Almost all parameters of the social assistance equation are significant. The parameter for younger mothers is negative which implies that the younger they are the more likely that they use social assistance, which might be related to difficulties of working or in finding a job. Those living in a big city region or having higher educations are less likely to participate, as these factors are associated with having higher earnings therefore being less likely to require additional income support. Having children aged 9-12 at a paid after-school centre is also associated with a lower probability of receiving welfare, compared to having younger children at paid childcare. Having children in the same age group at home without using paid day-care is not associated with welfare participation. The need of paid childcare for children aged 9-12 is most likely less urgent, which implies that low-income groups choose not to utilize municipal childcare for these children. From official statistics we also know that a rather small group have their children at after-school centre when the children are of this age.

All estimated parameters of the equation associated with marginal utility for paid childcare utilization have the expected signs. Single mothers living in a big city region have lower utility from paid childcare and therefore use it to a lesser extent. From the labor supply equation we know that the marginal utility to work is higher for single mothers living in big-city regions as oppose to those living in other regions, and from official statistics we know that mothers in city regions use more hours of paid childcare

[20] Since the utility function is normalized (β_Y=1) by weakly income, Y, all parameters in the model are expressed in income units. As an example, at H=40 moving from a rural region to a big city region is roughly equivalent to an increase in weakly income of 27.8 SEK in utility terms, ignoring the quadratic income term (0.696*40=27.8).

compared to other single mothers. With that in mind one would expect a greater need for paid childcare. But it seems as though these mothers use means other than municipal childcare. This might be an indication of a supply problem in that it is easier to find a childcare placement in regions where the concentration of people is lower. Education has also a significant effect on the childcare utilization, and the utility of paid childcare increases with the educational level of the single mother. This is associated with younger mothers being unemployed to a higher extent and therefore not being entitled to municipal childcare. To have younger children is obviously a reason for demanding childcare and the estimates suggest that the demand decreases with the age of the children.

Finally, the estimates for the wage equation are also in line with what we would expect. Single mothers living in big-city regions have higher wages compared to those living in other regions. Single mothers with higher educations have higher wages compared to other single mothers. However, the return to years of experience is basically zero. We included a squared experience term initially and found the sign of the parameter to be negative but with no significance. We therefore decided to exclude the squared term but to keep years of experience as an indication of its lack of significance. This lack of effect is due to the system of equations since estimating the wage equation separately gives significant effects of years of experience on wages.

Table 10 shows the utility parameters and the error covariance estimates for the model. The utility parameters have no clear interpretation but they are important components in the expression for the labor supply elasticities. Except for the component related to social assistance all other covariances among the unobserved components are significant. The unobserved factor for the decision to receive social assistance seems to be unrelated with the other choices. We observe that the unobserved component for the social assistance equation is negatively correlated with hours of work yet with large standard errors. On the other hand, the corresponding component for childcare utilization is positively correlated with hours of work. That is intuitively appealing since more hours of work implies that someone else has to take care of the child to a greater extent, which therefore implies an increased demand of paid childcare. The unobserved components of social assistance and paid childcare utilization are negatively correlated, which could be interpreted as though the utility for paid childcare increases the utility of

social assistance. One would expect the opposite sign since paid childcare increases with hours of work and therefore the earning level increases as well, which would reduce the potential amount of social assistance. Here the standard errors are also large and the parameter should therefore be interpreted as being zero.

Table 9 Parameter estimates for single women with young children, 100 Halton draws, no fixed costs of work[21, 22]

	Behavioral equations			
Observed Characteristics	Marginal utility of work	Marginal disutility of SA	Marginal utility of paid childcare	Wage equation
Constant	2.369*	0.457	0.191	2.635*
	(0.844)	(0.059)	(0.183)	(0.199)
Age	0.057*	-	-	-
	(0.017)			
Age squared/100	-0.061*	-	-	-
	(0.021)			
Age (18-34)	-	-0.494	-	-
		(0.143)		
Big city region	0.696*	0.182	-0.408*	0.618*
	(0.051)	(0.087)	(0.087)	(0.091)
Small city region	0.399*	-	-	0.342*
	(0.074)			(0.096)
Primary school	-1.129*	-	-0.653*	-
	(0.265)		(0.124)	
Secondary school	-0.473*	0.651	-0.541*	0.708*
	(0.163)	(0.056)	(0.089)	(0.099)
P. Secondary school	-	1.115	-	1.205*
		(0.295)		(0.118)
If children aged 1 - 5	-	-	0.726*	-
			(0.119)	
If children aged 6 - 8	-	-	0.559*	-
			(0.087)	
If children aged 9 - 12	-0.058	-	-0.392*	-
	(0.044)		(0.088)	
If children aged 13 - 17	0.263*	-	-	-
	(0.038)			
If children aged 9-12 on paid childcare	-	0.821*	-	-
		(0.245)		
If children aged 9-12 with parent	-	0.072	-	-
		(0.137)		
Work experience	-	-	-	-0.003
				(0.009)
Mean Log-likelihood	-3.738			
N	533			

Note: * significant at the 10% level. Standard errors are in the parentheses.

[21] The eigenvalues of the Hessian are all negative, ensuring the Hessian to be negative definite.
[22] The GFBS approximated Hessian is used in the optimization of the simulated log likelihood function and therefore used to determine the standard errors of the parameters.

Table 10 Utility and covariance parameters

a) Utility parameters

Parameter	β_{HH}	β_{YY}	β_{HY}
Estimate	-0.489*	-0.665*	-4.185*
Standard error	(0.136)	(0.081)	(0.307)

Note: β_{HH} is multiplied by 100, β_{YY} is multiplied by 1000000, and β_{HY} is multiplied by 10000.

b) Covariance matrix

	ε_H	ε_{SA}	ε_C	ε_w
ε_H	2.164*	-0.088	0.278*	2.712*
	(0.282)	(0.158)	(0.036)	(0.191)
ε_{SA}		1.000	-0.063	-0.238
			(0.095)	(0.215)
ε_C			1.000	0.263*
				(0.082)
ε_w				3.437*
				(0.098)

Table 11 reports the estimates of the model when including fixed cost of work. In general, fixed cost of work is important in any labor supply study, and is especially the case when dealing with single mothers. The parameter estimates are basically unchanged for those parameters, which previously were significant. However, after including fixed cost of work, the efficiency of the model decreased, even though the point estimates were basically unchanged compared to the reference model that excluded fixed cost of work. A city region dummy, and three dummies indicating the ages of the children in the household are assumed to capture observed heterogeneity in fixed cost of work, but only the child-age dummies capture this effect, having significant parameters. Unfortunately, including fixed cost of work made the childcare utilization equation lose all significant effects. The basic problem behind this is most likely the small sample size that simply cannot offer enough variation to separate the effect for fixed cost of work and marginal utility of paid childcare utilization in the same model, even though the functions have different variable specifications. Our conclusion is therefore to include only one of the equations, and the choice of equation must be based on what kind of model one would like to estimate. In our case we have a multiple-choice model and the choice of paid childcare utilization is essential for the purpose of this study. It is therefore natural for us to exclude the fixed cost of work equation. After all, fixed cost is captured indirectly in the equation for paid childcare utilization. The rest of the analysis will therefore be based on the model excluding fixed cost of work.

Table 11 Parameter estimates for single women with young children, 100 Halton draws, with fixed cost of work

	Behavioral equations				
Observed characteristics	Marginal utility of work	Marginal disutility of SA	Marginal utility of paid childcare	Wage equation	Fixed Cost of work
Constant	3.397*	0.142	0.478	2.632*	2.470
	(1.387)	(0.194)	(0.477)	(0.145)	(1.940)
Age	0.058				
	(0.038)	-	-	-	-
Age squared/100	-0.055				
	(0.051)	-	-	-	-
Age (18 – 34)		-0.359*			
	-	(0.198)	-	-	-
Big city region	1.043	0.205	-0.517	0.619*	-0.281
	(0.674)	(0.155)	(0.347)	(0.124)	(0.383)
Small city region	0.468			0.347*	
	(0.248)	-	-	(0.154)	-
Primary School	-1.326*		-0.101		
	(0.514)	-	(0.192)	-	-
Secondary School	-0.558*	0.702*	-0.366	0.711*	
	(0.302)	(0.161)	(0.293)	(0.160)	-
P. Secondary School		1.104*		1.199*	
	-	(0.315)	-	(0.274)	-
If children aged 1 – 5			0.654		
	-	-	(0.693)	-	-
If children aged 6 – 8			0.481		0.227*
	-	-	(0.464)	-	(0.086)
If children aged 9 – 12	-0.508*		-0.491		0.781*
	(0.258)	-	(0.367)	-	(0.338)
If children aged 13-17	-0.402				1.048*
	(0.425)	-	-	-	(0.468)
If children aged 9 – 12 on		1.463*			
paid childcare	-	(0.529)	-	-	-
If children aged 9 – 12		0.172			
With parent	-	(0.189)	-	-	-
Work experience				-0.005	
	-	-		(0.006)	-
Mean Log-likelihood	-3.717				
N	533				

Note: * significant at the 10% level. Standard errors are in the parentheses.

Table 12 reports the corresponding utility and covariance parameters and less than half of them are significant at a conventional level. The utility parameters are all significant but larger in magnitude compared to the reference model. How this affects the labor supply elasticities is difficult to say and needs to be examined, which will be done later on.

Table 12 Utility and covariance parameters

a) Utility parameters

Parameter	β_{HH}	β_{YY}	β_{HY}
Estimate	-0.862*	-1.017*	-6.405*
Standard error	(0.435)	(0.159)	(2.749)

Note: β_{HH} is multiplied by 100, β_{YY} is multiplied by 1000000, and β_{HY} is multiplied by 10000.

b) Covariance matrix

	ε_H	ε_{SA}	ε_C	ε_w
ε_H	2.995*	0.045	-0.201	3.174*
	(1.279)	(0.136)	(0.144)	(1.208)
ε_{SA}		1.000	-0.951	-0.028
			(1.265)	(0.194)
ε_C			1.000	-0.161
				(0.215)
ε_w				3.431*
				(0.194)

Table 13 reports the actual and fitted probability values of the choices in the model with no fixed cost of work. The fit is quite good, but it is evident that the model has a tendency to over-predict those cells with small representations and under-predict others. The fitted probability values were computed using the parameter estimates in Tables 9 and 10 and using 100 Halton draws for each individual. The mean values were then calculated and reported as the choice probabilities in the table.

Table 13 Actual and fitted distributions of labor supply and program participation (in percent)

Welfare and childcare utilization		Hours of work			Row total
		0	20	40	
			Actual		
P_{CC}=1	P_{SA}=1	5.6	6.4	2.8	14.8
P_{CC}=0	P_{SA}=1	7.7	7.3	1.5	16.5
P_{CC}=1	P_{SA}=0	3.2	11.6	18.8	33.6
P_{CC}=0	P_{SA}=0	5.2	15.6	14.3	35.1
Column total		21.7	40.9	37.4	100.0
			Fitted		
P_{CC}=1	P_{SA}=1	5.97	5.53	3.94	15.44
P_{CC}=0	P_{SA}=1	8.28	5.83	3.39	17.50
P_{CC}=1	P_{SA}=0	3.03	14.22	15.61	32.89
P_{CC}=0	P_{SA}=0	4.03	16.33	13.77	34.17
Column total		21.4	41.9	36.7	100.0

Table 14 reports predicted probabilities conditional on the endogenous variables in the model. The relationship between social assistance and paid childcare utilization presents the most interest. Paid childcare utilization and welfare participation work in different directions in their effects on changes in employment. Welfare participation

reduces the probability of working, while paid childcare utilization is associated with an increased probability to work. The probability of having social assistance is reduced when conditioning on childcare and the probability of using paid childcare is also reduced when conditioning on social assistance, which indicates that the two variables are stochastically related to each other.

Table 14 Conditional choice probabilities (in %)[23]

Labor force participation		Welfare participation		Paid Childcare	
P(H>0)	78.66	P(SA=1)	32.98	P(CC=1)	48.32
P(H>0|SA=1)	56.74	P(SA=1| H>0)	23.79	P(CC=1|H>0)	49.97
P(H>0|CC=1)	81.35	P(SA=1|CC=1)	31.97	P(CC=1|SA=1)	46.84
P(H>0|SA=1,CC=1)	61.34	P(SA=1| H>0,CC=1)	24.11	P(CC=1|SA=1,H>0)	50.64

6.1 Policy simulation

Table 15 presents the elasticities for single women with children. These numbers are based on comparative static analysis. The estimated choice probabilities have been evaluated before and after a specific change in the budget set. Based on these changes the corresponding change in labor supply has been calculated. The sign of the wage elasticity is ambiguous according to economic theory, but in the empirical literature the sign is typically positive. One should hold in mind that the elasticities are just a measure of the mean effect, and different individuals may well have different wage elasticities. Even the same individual may have different wage elasticities both in sign and magnitude at different hour levels. Any inference drawn from single wage elasticities could therefore be dangerous. The sign of the income elasticity is unambiguously negative if leisure is a normal good. The signs of the elasticities in Table 15 are therefore all expected. Single mothers have a strong inclination for both net income and leisure (i.e., a sensitive trade-off), which might imply that they should have elasticities that differ greatly for different wages and hours of work combinations. The childcare cost elasticity on labor supply suggests that if childcare cost increases by 1%, the labor supply would be reduced by 0.16%. The welfare elasticity on labor supply measures the response on labor supply with respect to a change in the social assistance norm. If the

[23] The conditional probabilities are computed using the mean choice probabilities in the model. The conditional probability of having social assistance given labor force participation was calculated in the following way: P(SA=1|H>0) = P(SA=1,H>0)/P(H>0). The other values were computed analogously.

social assistance norm increases by 1%, the elasticity suggests that the labor supply would decrease by 0.06%, which is a much lower figure compared to childcare cost elasticity.

The right side of Table 15 contains two measures for the elasticities between social assistance norm and childcare cost. The first one shows that if the social assistance norm increases by 10%, the probability of using paid childcare would decrease with 0.19%. Hence, the responsiveness in paid childcare utilization is very small from changes in the social assistance norm. The second elasticity, which measures the relationship in the opposite direction, shows that if the municipal childcare cost was reduced with 10% the probability of receiving social assistance would decrease by 1.6%. This shows the importance of the childcare cost for single mothers in relation to social assistance. The reason for this is the fact that a reduction in childcare cost directly affects the level of disposable income, which directly affects the level of social assistance a single mother could receive. A change in the social assistance norm does not provide a direct link to the preferences to use paid childcare.

Table 15 Mean elasticities for single women with children

Labor supply elasticities	Mean	**Other elasticities**	Mean
Uncompensated wage elasticity	0.771	Social assistance norm effect (+10%)	-0.186
Income elasticity	-0.098	on paid childcare utilization	
Childcare cost elasticity on labor supply	-0.163	Childcare cost effect (-10%) on social	-1.607
Welfare elasticity on labor supply	-0.061	assistance participation	

Table 16 reports the simulated mean responses to changes in the budget set. The simulated responses are obtained by computing mean probabilities for each of the alternatives in the choice set across the individuals and for different alterations in the budget constraint using the SML estimates of Tables 9 and 10. The simulations are performed separately for each individual in the sample and then averaged across the individuals. The baseline represents the predicted probabilities of paid childcare utilization, welfare participation and hours of work as they are at the optimal point before any change in the budget set. These numbers are compared with the new numbers received after the change in the budget constraint. The simulation results show that a 1% increase in wages corresponds to a 0.77% increase in labor supply. This

corresponds to the uncompensated wage elasticity given in Table 15. The mean labor supply is derived from the corresponding probabilities in Table 16 as the expected values of hours of work.[24] The values suggest that the wage effect on labor supply is non-linear and increases with a decreasing pace. There appear to be only a small impact on the part-time workers, the major change being on full-time work. The exact picture of the transitions would require a transition matrix. It is more reasonable to believe that non-workers move to part-time work and part-time workers to full-time work. What we see in the table is therefore only the net effect after the changes.

Table 16 Simulated responses to changes in the budget set. SML 100 Halton draws

	Participation (%)		Work hours distribution (%)			Mean hours worked	Hours change (%)
	P(SA=1)	P(CC=1)	P(H=0)	P(H=20)	P(H=40)		
Baseline	32.98	48.32	21.33	41.93	36.74	23.08	-
Wage change							
+ 1 %	32.63	48.50	20.93	41.85	37.22	23.26	0.771
+ 10 %	30.32	49.91	17.97	41.97	40.06	24.42	5.797
Change in the tax structure							
Municipality tax: - 1 % point	32.74	48.45	21.14	41.80	37.06	23.18	0.431
Basic deduction: 18kkr flat	32.54	48.74	21.22	41.30	37.48	23.25	0.745
Social assistance norm: +10 %	34.50	48.23	21.95	42.03	36.02	22.81	-1.151
Childcare cost: - 10 %	32.45	48.56	21.29	41.52	37.19	23.18	0.433

Note: SA=social assistance, CC=paid childcare utilization

A reduction in the tax level for low-income persons would most likely reduce welfare participation, and it would therefore be interesting to simulate how large such a response would be. Reducing the municipality tax by a 1-percentage point was found to have a positive effect on labor supply by a 0.43% increase and a reducing effect on welfare participation by 0.73%. The last effect is most likely the result of the increase in net income that has an immediate effect on the welfare amount received. The probability of using paid childcare also increases slightly. This effect comes from the increased labor supply inducing a need for childcare.

A change in the structure of the tax system is believed to have an effect on the labor supply and welfare behavior. When we simulate a system with a flat basic deduction of 18,000 SEK (modeled to be the same for all individuals independent of the income level) the labor supply increases by 0.75%, while the probability of using social

[24] The expected value is given by E[H] = 0*P(H=0) + 20*P(H=20) + 40*P(H=40).

assistance decreased and the probability of using paid childcare increased. This is a change that affects the low-income groups most and the results show that it promotes full time work.

Changes in the social assistance norm have important incentive effects on the labor supply. If the norm is increased by 10 %, a transfer from full-time work to part-time work takes place, which implies that the part-time work increases from the increased norm. There is also an increase in the probability of not working at all, which implies a decrease in the need for paid childcare.

Finally we simulated the effect of changing the overall childcare fee for those with paid childcare. A 10% decrease in the total cost has several implications. It increases the income opportunities, which lead to a welfare reduction, which induces the single mother to increase her labor supply. However, the transfer from non-work to work is very small; the major transfer instead being from part-time to full-time work.

6.2 Sensitivity analysis

Table 17 presents key components from different estimations of the model using different specifications. The figures to the left are considered to be the base model using 100 Halton draws, imposing no restrictions on the covariances, but excluding fixed cost of work as a separate effect. When using SML it is important to know how sensitive the estimates are to the number of draws used in the estimation. This is easily evaluated by comparing the results with estimates determined with twice as many draws. If the parameter estimates differ extensively it is a sign of using too few draws since the estimated probabilities are far from convergence. In Table 17 we see that the parameter estimates hardly changed at all when using twice as many draws. This indicates that more draws add little to the precision of the point estimates. We therefore conclude that 100 Halton draws are a sufficient number when estimating the choice probabilities. This confirms the results from Train (2001), which claim that 100 draws are a sufficient number for stable and reliable estimates.

Table 17 Sensitivity analysis

	Cov free 100 Halton No fixed cost	Cov free 200 Halton No fixed cost	Cov free 100 Halton With fixed cost	Cov zero 100 Halton No fixed cost
β_{HH}	-0.492	-0.494	-0.862	-0.414
β_{YY}	-0.765	-0.768	-1.017	-0.664
β_{HY}	-4.235	-4.768	-6.405	-1.686
Simulated mean Log-Likelihood	-3.738	-3.739	-3.717	-3.942
Wage elasticity	0.771	0.773	0.878	0.548
Income elasticity	-0.098	-0.091	-0.141	-0.052

The next specification adds fixed cost to the model. As discussed above including fixed cost makes all parameters in the equation for paid childcare utilization lose their significance. We consider this to be a negative sign even though a likelihood ratio test would say that the model improved. The elasticities did not change greatly, even though the wage elasticity increased slightly and the income elasticity increased in magnitude.

Finally, we have the estimates from a model restricting all the covariances to zero, which show that the utility parameters differ slightly from the other models. A likelihood ratio test is easily rejected when testing if the reference model differs from one with covariances being zero.

7 Summary

In this paper we have applied a simulation method to estimate a structural labor supply model incorporating welfare participation and paid childcare utilization for single mothers in Sweden. By approximating the hours of work for three discrete points (unemployed, part-time work, full-time work) and defining the choices of welfare and paid childcare as discrete alternatives, we were able to formulate the model as a multiple-choice problem, giving the single mothers a choice set of 12 alternatives. We estimated the full structural model with and without a separate effect of fixed cost of work, and found a conflict in having both fixed cost of work and paid childcare utilization incorporated in the model at the same time. When estimating the model including fixed cost of work, the parameters in the paid childcare equation all lost their significance while some of the parameters in the fixed cost equation were significant. The transport of significance into the fixed cost might be an indication that it is the

fixed cost component that should stay in the model. However, if the model is design to analyze the relationship between the endogenous choices, the equation for paid childcare utilization has to stay.

The model excluding fixed cost of work was used in the remaining part of the study, and was used to perform simulations of the responses to changes in the budget constraints. Simulations of the labor supply elasticities showed inelastic values, with an uncompensated wage elasticity of 0.77 and an income elasticity of -0.1. The elasticity between childcare cost and welfare participation on labor supply is of special interest, and the results show a childcare cost elasticity of -0.16 and a welfare norm elasticity of -0.06. The relation between social assistance and childcare cost is non-symmetric, as a 10% increase in the social assistance norm reduces the probability of using paid childcare by 0.19% while a 10% reduction in childcare cost reduces the probability of having social assistance by 1.6%.

The performed micro simulations suggested that an increase in the social assistance norm has a relatively large mean labor supply effect where the major change is from full-time work to part-time and non-work. In comparison, a reduction in the childcare cost has a relatively small effect on the mean labor supply; the major change was within the group of those who already were working, by reducing part-time work with full-time work. The effect on overall employment was therefore very small. Childcare cost can therefore be seen as a barrier to full-time work rather than as an obstacle to employment.

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Appendix

A1 The Swedish tax system in 1997

The tax system applied in this study is based on several components, namely the municipality tax rate, the public tax rate, the basic deduction (grundavdrag), and the tax rate on capital. Municipality tax varies among the municipalities and has an average rate of 31.76% in 1997. We have access to each rate, and apply them here. The public tax rate has a basic flat rate of 200 SEK, and 25% of the taxable income exceeding 209,100 SEK. The tax rate on capital is 30%. Table A1 presents how the basic deduction works, while Figure A1 presents how the marginal and average taxes work.

Table A1 Basic deduction 1997

Income intervals	Basic deduction
8,700 – 67,800	8,700
67,900 – 104,600	8,712 + 25% of income > 67,518
104,700 – 110,900	18,000
111,000 – 202,900	18,059 – 10% of income > 110,352
203,000 –	8,700

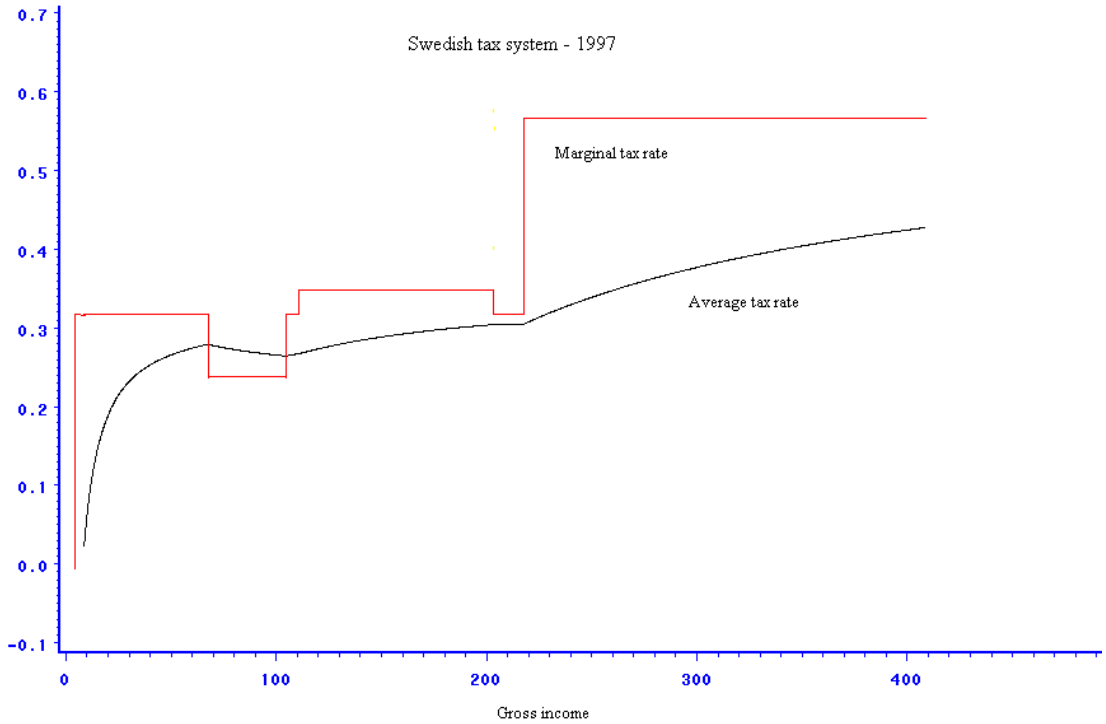

Figure A1 Marginal and average tax rate

A2 The social assistance norm

The level of social assistance an individual may receive is decided by each municipality, which has the right to pinpoint the exact amount. The National Board of Health and Welfare (Socialstyrelsen) gives guidelines to the municipalities so that the program will be equally defined throughout the country. Nevertheless, differences exist. This study uses the general guidelines proposed by the National Board of Health and Welfare and thereby assumes a unified system throughout the country. The assumed system consists of 4 parts. Individual parts for adults and children, a common part and the housing rent cost.

Table A2 The social assistance norm (SEK)

Single person component	2,320						
Child component	**Age of the child**						
	0	1-2	3	4-6	7-10	11-14	15-18
	1,230	1,440	1,120	1,410	1,530	1,830	2,070
Common component	**Individuals in the household**						
	1	2	3	4	5	6	7
	580	670	760	820	910	960	1020

For example: a single mother with two children aged 4-7 would receive:

MAX[0, 2320 + 1410 + 1530 + 760 + rent – disposable income] = *SA amount per month* .

A3 The potential cost of childcare

The cost of childcare differs extensively among the municipalities in Sweden. A single parent with an average income, and 1 child at a day care centre 26 hours a week, pays 200 SEK per month in the cheapest municipality and 1,600 SEK per month in the most expensive municipality. That is a difference of about 17,000 SEK per year. It is not feasible to try to model each and every system into the model. We therefore have to assume a united system, one that is the same for all individuals and represents an average situation. Most of the childcare cost systems in Sweden have several common components that are important to incorporate, such as the cost reduction for extra children on childcare, differentiated cost dependent on the age of the children, and a

fixed and variable cost component. Table A3 presents the unified cost of childcare system used in this study.

Table A3 The unified cost of childcare system (SEK)

	Children			
Base fee	1	2	3	4
Children aged 1 – 5	500	300	100	0.0
Children aged 6 – 8	450	270	90	0.0
Children aged 9 – 12	400	240	80	0.0
Variable fee per hour	1	2	3	4
Children aged 1 – 5	8.50	5.10	1.70	0.0
Children aged 6 – 8	7.65	4.59	1.53	0.0
Children aged 9 – 12	6.80	4.08	1.36	0.0

The cost of childcare is also a function of the household yearly income and is related to the base amount (basbelopp). If a household has an income lower than 20 % of the base amount, there is no charge for childcare. If the income is between 20-70 % of the base amount, the childcare cost is reduced linearly. When the household has an income higher then 70% of the base amount, the household pays the full childcare cost. The base amount was 36,300 SEK in 1997 and 36,400 SEK in 1998. We used the value for 1997 in this paper.