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MODELLING LABOR SUPPLY IN A DYNAMIC ECONOMY

by

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1. Introduction

Labor supply is probably the most researched area in applied microeconomics and microeconometrics. In the last decade when taxreforms have been planned and implemented in several countries the empirical results from this kind of research have obtained considerable interest. Do decreased marginal tax rates stimulate labor supply? How much distortion does the progressive income tax system create? To what extent is a tax cut self–financing? Estimates of labor supply responses to wage rate changes (net of marginal taxes) and income changes are needed to provide answers to these questions. There is, however, a wide variety of results and politicians have been able to pick those which fit their policy. Although there are several good reviews of the labor supply literature (Killingsworth(1983), Blomquist(1985), Killingsworth & Heckman(1986), Pencavel(1986) and Blundell(1987)) recent results motivate another quick retrospective view to highlight a few major points. This paper does not discuss the whole issue of evaluating or predicting the effects of a tax reform. The topic is more narrowly defined to certain aspects of modelling and estimating labor supply functions. "Complete coverage" is not attempted and the discussion concentrates on results for Sweden.

2. A retrospective view.

Most labor supply studies are based on the assumption of myopic utility maximization, i.e. there is no forward looking or planning ahead and the budget constraint is completely determined by the incomes obtained in the current period. These assumptions *a priori* must lack in realism. Labor supply decisions belong to the most important decisions we make and usually have consequences for the future. However, the assumption of myopic utility maximization simplifies the analysis considerably and is in frequent use.

Within this group we might distinguish between three subgroups depending on how taxes have been incorporated into the budget constraint. In the first subgroup, usually consisting of very early studies, taxes have been ignored altoghether. In most countries, and in particular in Sweden, there are progressive income taxes which make the budget set nonlinear. If we also take various income dependent benefits and social security programs into account the budget set becomes highly nonlinear and also nonconvex (Andersson(1989)). For this reason these early results are less interesting.

In a second group of studies the nonlinearity of the budget set is recognized but the econometrics is simplified by a linearization of the budget set. The variables used to characterize the budget set are the marginal wage rate, i.e. the wage rate multiplied by one minus the marginal tax rate, and "virtual income" which is a theoretical construct obtained as the intersection of the earnings axis in an earnings–hours diagram, and the extended linear budget segment on which the individual finds its optimum. Estimates of the uncompensated wage elasticity are typically negative but close to zero for males. For females they vary from small negative estimates to large positive.[1] The income elasticities are generally negative and of a magnitude such that the compensated elasticities are positive, i.e. in agreement with conventional consumer choice theory. As pointed out by, for instance, Blomquist(1985) the effect of a change in the marginal tax rate is in these models not only infered from the marginal wage rate elasticity but also from the income elasticity because virtual income depends on the marginal tax rate. Thus, a small net wage elasticity does not necessarily imply a small effect on labor supply of a change in the marginal tax rate, because we might have a high income elasticity.

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[1]In the survey by Blomquist(1985) the estimates for males rage from –0.42 to –0.02 and for females from –0.31 to 2.3.

To my surprise I have not been able to find any study of this kind using Swedish data.

The approach with a linearized budget set is able to explain why an individual chooses a particular point on the observed budget segment, but it does not explain why this segment was choosen rather than another one. Although the econometrics becomes more involved a natural extention is to specify the whole budget set and allow the consumer to find a global maximum.[2] This approach also "solves" another problem of the second approach, namely that marginal taxes are endogenous. The marginal tax rate is a function of taxable income which includes earnings and thus depends on the number of hours worked. In the second approach this problem is usually dealt with by an instrumental variables approach, but the difficulties to find good instruments in micro econometric applications is well–known. A complete specification of the budget set and the application of the maximum likelihood method avoids this problem.

The third group of studies is exactly of this type. They specify a budget set which covers the whole choice range but it usually only includes nonlinearities caused by the income tax system. Nonlinearities (nonconvexities) caused by income dependent benefits etc are usually neglected. Results for males usually are small uncompensated wage elasticities around zero, negative income elasticities and positive compensated marginal wage rate elasticities. For females the uncompensated marginal wage rate elasticities range from small to large positive values and the income elasticities are clearly negative. Most of these studies thus give sizable effects on female labor supply of a decrease in the marginal tax rate.

In a series of papers Sören Blomquist has analysed the labor supply of married prime aged Swedish males.[3] In Blomquist(1983) preference parameters are estimated subject to a nonlinear budget set determined by the Swedish tax schedules. He obtains a wage rate elasticity of approximately 0.08 and an income elasticity of –0.04 for an average individual. These results are extended in Blomquist & Hansson–Brusewitz(1989) and Blomquist(1989a) where the functional form of the labor supply function is somewhat more general and the marginal effects of housing allowances (bostadsbidrag) are allowed to influence the budget set. They also model preference heterogeneity by drawings from a stochastic distribution. Depending on model variant the wage rate elasticity now varies between 0.05 and 0.13 and the income elasticity between –0.01 and 0.01.

An early unpublished study is Jakobsson(1982). Labor supply functions similar to those used by Hausman and Blomquist but with preference differences somewhat more explicit, were estimated separately for males and females. As in the case of Blomquist(1983) the 1974 LNU data were used. For males Jakobsson got a marginal wage rate elasticity of 0.06 and an income elsticity of –0.027. For females the estimates were 1.2 and –0.14 respectively. All elasticities were calculated at the sample mean point.

Another very interesting sequence of papers have been produced by Steinar Ström and collaborators. The theoretical model structure is explained in Dagsvik(1988) and Dagsvik & Ström (1988). Their models have been applied to data from several countries. Results for Sweden can be found in Ljones & Ström(1987), Andersson et.al.(1988), Andersson(1989)

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[2]In a working paper presented at the Econometridagarna in 1988 Blomquist & Hansson–Brusewitz (1989) mention that only 61 per cent of their sample of prime aged males had their observed hours on the same budget segment as the number of hours predicted by the model. They take this result as evidence of possible bias if one would linearize the budget set. Alternatively, it indicates that their model does not do a very good job in explaining labor supply.

[3]His data set is a sample of males aged 25–55, excluding those who were retired, in military service, sick for more than 4 weeks, self–employed and unmarried.

and in Aaberge, Ström and Wennemo(1989). Their approach has a few very interesting features. The basic story which motivates the model is one of the consumer choosing a "job package" of a wage rate and a certain number of hours. These packages might not be available in any combination of wage rate and hours. They thus recognize that the distribution of hours might be concentrated to certain hours and have more than one mode.(See below!) Their model is also a household model which in principle explains both the decision to work and the number of hours worked. In Ljones & Strom(1987) the model was applied to a relatively small research data set from 1981. Data did not permit the complete household model to be estimated. They found that if all working men got a pay increase with 1 per cent the labor supply of men increased by 0.02 per cent. Changes in the wage rate of the female had no effect of the labor supply of men. Females were however, more responsive to changes in their wage rates. 1 per cent increase in pay increased the number of hours with about the same percentage. 40 per cent of this effect came from increased participation and 60 per cent from longer hours. The model has also been applied to another Swedish data set from 1981, the so called HINK data. In a model with complete cross effects between the spouses they get a Cournot elsticity of 0.08 for males and 0.13 for females. The cross wage elasticities are –0.07 and –0.11 respectively and the income elasticities are –0.39 and –0.11. If labor supply functions are estimated separately for males and females the Cournot elasticities increase to 0.23 for males and 0.33 for females and the income elasticities become close to zero.

While the estimates of the uncompensated elasticities from the second approach, i.e. with linearized budget sets, varied quit a lot for both males and females, permitting both forward and backward sloping supply curves, the results from the third approach are more homogenious. The Cournot elasticities for males are small positive numbers. For females they are also positive but usually somewhat larger. One might also note that the compensated elasticities do not violate the Slutsky conditions.

Have we now reached a consensus? The trend of research is towards a more complete and detailed specification of the budget set and more efficient maximum likelihood estimation methods. Shouldn't we thus be more confident in these more recent studies than in those of previous generations? The answere is, not necessarily! There are a few contradictory results and we have also reasons to believe that serious specification errors remain in those studies I have here called the third approach.

MaCurdy et.al.(1988) has reviewed the econometrics of the third approach. They show that if the budget set is piecewise linear, the Slutsky conditions are implicitly enforced at all interior kink points which represent a feasible option for some individual in the sample. If the budget set is continuously differentiable there is a similar but less stringent constraint on the preference parameters. The Slutsky elasticities may have the wrong sign, but they cannot deviate too much from a positive value. Their empirical analysis also shows that these implicit constraints drive the results. Using the same data source as in Hausman(1981) they find a small positive uncompensated wage elasticity and a small negative income elasticity when the Slutsky conditions are enforced, while they get a backward bending supply curve when the constraints are not enforced. Although there is no formal test, data seem to reject the Slutsky conditions. The data sets used by Blomquist and Ström have not been exposed to the same empirical analysis, but MaCurdy's results rise the suspision that the implicit assumption of a nonnegative compensated wage elasticity drives their results too.

The analysis of MaCurdy et. al. thus does not support the basic result of the well established theory of consumer choice. Although the Slutsky conditions have been rejected before, examples can be found in the litterature on consumer demand, most economists would probably not like to reject this theory altogether. One might rather suggest that serious remaining specification errors have produced the rejection of the Slutsky conditions. (This would of course not justify the estimates obtained by Hausman, Blomquist, Ström et.al.) We will now turn to a discussion of some of these problems.

3. The linearized budget set vs. the full budget set approaches reconsidered.

Let's consider a labor supply model of the Hausman–Blomquist type. If the optimal number of hours and the observed number of hours coincide a linearization of the budget set at the observed segment would give the same solution as the optimization with the complete budget set. However, if the optimum does not lie on the observed segment the linearization approach will give a solution different from the optimum point.

The basic labor supply function of Hausman's and Blomquist's models takes a rather simple form. It is linear in hours, wage rate and sometimes wage rate squared, virtual income and the age and number of children of the individual. The last two variables are the only variables which explicitly take differences in preferences into account. All other differences in preferences are stochastic. It should perhaps not come as a surprise that a model of this simple structure is not always able to predict an optimum to the correct budget segment (c.f. footnote 2). A more detailed and explicit specification of preference differences might do a better job. However, also with a very careful specification of preference differences there will always be a difference between the prediction obtained from the model and the observed number of hours. It is then of some importance to consider the causes of these deviations. Assume for a moment that there are no measurement errors. The whole discrepancy is then the result of our inability to model the choice situation correctly. If the budget set is correctly specified then the discrepancy is the result of inadequatly modeled preferences. The observed budget segment is the correct one, the segment reached by the model is not. In this situation the application of the complete budget set approach will in general lead to inconsistent and biased estimates. However, the difference between the observed and predicted hours includes information about individual preferences which one should be able to use. For the same (erroneous) specification of preferences the linearization approach is not necessarily better.

Suppose instead that the difference between observed and predicted hours is the result of measurement errors in the hours variable. Also in the case of purely random measurement errors linearization arround the observed point will lead to a negative correlation between the measurement error and the marginal wage rate and a positive correlation with virtual income. The result is that the wage rate elasticity is underestimated and the income elasticity overestimated.[4] In this situation the complete budget set approach is clearly preferable.

In evaluating the results obtained with the complete budget set approach one thus has to consider the relative importance of measurement errors and specification errors. If specification errors dominate, then the estimates are likely to be biased and inconsistent. How would we in practice know anything about specification errors? If observations on taxes actually payed are available, which is usually the case in Sweden, we would know *without error* the marginal income tax and thus the true budget segment. This information could be used in a diagnostic test. If the model frequently predicts the wrong segment there are serious specification errors. But one should be able to do even better. With a sufficiently flexible specification of preferences one could use the linearized budget set approach and make sure that the predicted number of hours always falls within the correct segment. If there are measurement errors, assumptions about their properties will be needed.

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[4]This result has also been confirmed in sampling experiments. There is an unpublished paper by Roger Jakobsson(1982) and an interesting working paper presented at Ekonometridagarna 1989 by Sören Blomquist(1989b).

4. Measuring hours of work

Data used for labor supply studies are usually based on surveys in which the respondents have been asked about their normal or stipulated working hours per week and about the number of weeks worked in a year. These data tend to give distributions of working hours which for males are highly concentrated around 40 hours per week (1800 hours per year) and lepto curtic, while the distribution for females may have more than one mode. People do not report temporary sickness, child care or "nonwork at work". These distributions are thus far from normal, which suggests that conventional assumptions about normal errors in labor supply models are not realistic. Steinar Strõm and his colaborators have recognized this problem and they assume nonnormal distributions which allow for the possibility of more than one mode. They also attach a particular interpretation to these distributions as they suggest that the concentration to certain hours is the result of institutional restrictions and inertia in the labor market. Job openings tend to come in the form of fulltime or halvtime jobs, while it is difficult to find 30 per cent or 80 per cent jobs. Although this interpretation is plausible it is not the only one possible. The models of Ström et.al. do not use any data or external information about the labor market restrictions they have in mind, and it is thus not possible to distinguish the effects of restrictions from those of, for instance, people's way of answering particular survey questions.[5] From an econometric point of view, however, the particular explanation to curtosis and several modes of the distribution of hours might be of secondary interest. It is more important that the model is able to predict well the observed distribution of hours, which implies that at least from this point of view it gives a satisfactory basis for tests of economic behavior.

Although it is important to develop a good statistical model (in the terminology of David Hendry, see Spanos(1986)) for the variables one have (chosen) to work with, an even more basic issue is what measure of labor supply we ideally would like to have. For most purposes we would like to measure the number of hours people actually work, not their stipulated hours or the number of hours they believe they normally work. Data which come close to this ideal are time–use data. As these data measure the details of peoples adjustment to economic and noneconomic incentives and the resulting distribution of hours is much less concentrated to fulltime and halftime hours, one might expect that estimates based on time–use data should show higher responses to changes in incentives than "ordinary" survey data do. Lennart Flood(1988) has compared estimates of a labor supply function for males obtained from time–use data with those from ordinary survey data on "normal hours including overtime". His results have also been reviewed and somewhat extended in Flood & Klevmarken (1989) from which Table 1 is taken.

The model used is a self–selection type of model with two equations. The first equation is a probit equation which explains the probability of observing nonzero working hours and the second equation is a linear labor supply equation which explains the number of hours per week given that the respondent worked. It was estimated separately for males and females using the maximum likelihood method. Labor supply is explained in a life–cycle framework. The budget constraint is modeled by the variables schooling and experience, the households present net wealth and the wage rate net of marginal income tax. The schooling and experience variables are assumed to catch expected future wages. The progressive income tax system is only accounted for by the marginal income tax rate.[6] The

[5]This raises a much broader issue, namely if it is at all realistic to anlyse changes in labor supply and take the demand side as given.

[6]In an attempt to capture the nonlinearity of the budget set a model with both the marginal wage rate and the wage rate net of average tax was estimated in Flood & Klevmarken (1989). Both variables were significant for females, but they did not change the result of a backward bending supply curve.

problem with an endogenous marginal tax rate is avoided by the assumption that people base their decisions on last years marginal tax rate. This is a quit realistic assumption as people can in general not know their marginal taxrate until they have completed their self assessment form in February the year after the incomes accrued. This assumption also has empirical support in the study by Wahlund(1987). Differences in preferences are modeled by marrital status, age, number of children, household size, if the the household owns the house/appartment in which they live, and region.

Table 1 shows the combined marginal effects of the decision to work and the number of hours worked, or more precisely, the marginal effect is defind as the derivative of the expected number of hours. All results indicate a backward bending supply curve for males as well as for females. Contrary to what one might have expected, for males there is no significant difference between the two types of data in the marginal effect of the wage rate variable, and for females the estimate from time–use data is smaller in absolute value than the estimate from ordinary survey data. Thus, time–use data do not show a greater sensitivity to changes in the wage rate than survey data do.

A backward bending supply curve for females is a rather unusual result, although examples can be found in the literature. One is the study by Nakamura & Nakamura(1981). Is it possible that this result is an artefact produced by the model specification or the estimation method? In both Flood & Klevmarken(1989) and Nakamura & Nakamura(1981) the problem with unobserved wages for nonworking males and females was solved by imputing wages from wage rate equations of the human capital type. These equations were estimated from the selected sample of individuals who had a job and had reported a wage rate. The implicit assumption is that those who do not work have the same expected market wage rate given their schooling, experience etc as those who work. This might not be true. It is even plausible that they are a selected group with relatively low market wages. To investigate if the backward bending supply curve was caused by relatively high imputed wages to individuals with no or few working hours Lennart Flood and I have also estimated the model using only observations with truly observed wage rates. This was possible because there is a fair share of individuals who have a wage rate but did not work on the particular days the time–use survey was carried out. For males we got virtually the same marginal effect. For females the marginal effect increased from –0.35 to –0.22, but also in this case we thus got backward bending supply curves.

Another explanation to the backward bending supply curves for women is that we have underestimated the reservation wage of nonworking females. The decision to work is assumed to be a function of the difference between the marginal market wage rate and the reservation wage rate. The marginal market wage rate is the product of an imputed market wage as described above and one minus the marginal tax rate. As the marginal tax rate usually is relatively low for nonworking females, sometimes even zero, they on average get relatively high imputed marginal market wage rates. The burden to explain why these females do not work then falls on the reservation wage which is an unobservable and assumed to be a function of a set of explanatory variables. If we have not been successful in explaining the reservation wage the result might become a spurious negative correlation between the marginal market wage and the probability to work. However, the support for this interpretation would have been stronger if the marginal effect of the wage rate variable in the conditional labor supply function had been positive. As this estimate is significantly negative the backward bending supply curve interpretation gains in support.

The wealth variable becomes insignificant for females. For males and with time–use data it is significantly positive. A positive estimate is perhaps not what we had expected. A likely explanation is that this is the result of the possibility to deduct interest payments from incomes when they are declared for taxation. Owner occupied houses make up a large share of household wealth and those who owns a house pay interest on their mortgages. Interest deductions are most effective if the household member with the highest marginal tax rate (usually the male) makes the deduction. The more interest payments (larger house and larger wealth) the more it pays to work long hours and deduct the interest payments against earnings. If this is a correct explanation the budget set is incorrectly specified. The work incentives of deductions should be brought out explicitly.

There is also another problem related to the specification of the budget set when time–use data or data on hours per week are used. In a model which attempts to explain weekly hours of market work the dependent variable does not enter the budget set expression in the usual way. This is so for two reasons. First, a budget constraint is usually not enforced for such a short period as a week. Second, disregarding overtime and long leaves of absence an employee is usually payed for his stipulated hours not for the hours he actually works. Also, many white collar workers do not get payed for overtime. Leaves of absence caused by sickness or child care duties are usually payed for by the social security system.
A complete specification of the budget set would thus include the relation between hours actually worked and hours payed and the rules for sickness and parental benefits.

5. Life cycle models.

With the exception of the model just reviewed above, the results discussed so far were explicitly or implicitly based on myopic utility maximization. It is natural to relax this assumption and allow for the possibility that people are forward looking and taking the likely future consequences of their decisions into account.

In life cycle models one usually assumes that an intertemporal utility function is maximized subject to a life cycle budget constraint. Given initial wealth, wage rates and interest rates the consumer chooses a consumption and work path such that utitily is maximized without violating the requirement that end of life wealth is nonnegative. In this model labor supply becomes a function of current assets, the current wage rate and expected future wages and nonlabor incomes.[7] In practice variables like schooling, experience and age have been used to model the accumulation of human capital and thus also to control for future evolutionary wage changes, while nonearned income have been used to capture the effects of current assets.

Most life cycle models of labor supply have assumed intertemporal separability of utility. The resulting labor supply functions come in two alternative formulations, one which conditions on marginal utility of wealth and one which conditions on "full income". In these models the marginal utility of wealth and full income respectively summarizes all intra–period allocations. Although unobserved, with panel data these summary statistics can be differenced out and a relatively simple life cycle consistent structures estimated. (For an extensive discussion see Blundell(1987)).

The assumption of intertemporal separability of utility is thus very convenient but there is no strong theoretical reason to justify it. Equally or more plausible are assumptions of learning behavior, habit persistence, and inertia because of transaction costs and institutional restrictions. One approach to model these alternative assumptions is to include past behavior as a determinant of current utility. This will in general lead to models with current labor supply explained by lagged labor supply. Blundell(1987) suggested that choices about family composition, labor supply and purchases of major consumer durables are jointly determined and that past behavior should be reflected by current family composition, current stocks of consumer durables and other household characteristics. In cross–sectional studies and in short panels these variables could

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[7]As pointed out in Heckman & MaCurdy(1980) the participation decision depends on future as well as *past* wage rates. If preferences are assumed to shift as the demographics of the household changes labor supply at time t is also in general a function of all those past and expected future changes.

therefore be used to control for past behavior or to supplement data on past behavior if the observed lag is short.

The simple life cycle model only allows for the effects of investments in human capital in a rather primitive way. Expected future earnings are a function of present schooling and experience. However, decisions about work today influences the accumulation of human capital and thus also future wages. A taxreform which is expected to decrease future marginal taxes should thus stimulate investment activities already today, i.e. people, and in particular young people, should tend to shift from consumption activities or noninvestment activities to market work which involves investments for the future. A budget constraint which includes these incentives would thus not only be a function of the present income tax scales operating on current incomes but also of future scales operating on expected future incomes. It would also be a function of the taxation of nonearned income and wealth, not only of income taxes. An analysis of this scope has not yet been made. In many studies of life–cycle labor supply taxes have been ignored altogether. An exception is, for instance, Blundell & Walker(1986) which use marginal wage rates in their empirical work. The tax structure is, however, not part of their model framework.

In his survey Blundell(1987) concludes that the intertemporal labor supply elasticities reported in studies of life–cycle behavior are small and unreliable for prime age men. For women they are larger but more various. There are no results for Sweden.

6. Labor supply is a joint family decision.

Most labor supply studies have treated singles and married/cohabiting couples alike and ignored that labor supply is a joint family decision. Separate labor supply functions were fitted for males and females. For males this might historically not have been a very unrealistic assumption, but for Sweden today it most certainly is. In an attempt to stay in the utitlity framework of one individual, people have sometimes conditioned on the spouse's earnings by adding it to nonearned income. Again, this might have been a reasonable thing to do when analysing female labor supply, but it does not appear to correspond to the behavior of Swedish families today.

Relatively few studies have attempted to model the joint decisions of two spouses. Examples are Hausman & Ruud(1984) and the work by Ström et.al. refered to above. These studies assume a "family utility function". The problem with this approach is that the axioms which lie behind a utility function only applies to a single individual. We thus do not know what properties a "family utility function" should have and in particular there is no reason to assume that the Slutsky conditions hold. To find a solution to this problem people have assumed individual utility functions, but embeded in an objective function for the family. Again, we know very little about the properties of this objective function. We have to impose some structure in order to get any predictions from our theory. A frequent assumption is that of weak separability of the individual utilities. This is a convenient assumption, but *a priori* unrealistic. The truth is that we have no satisfactory framwork for modelling the joint family decisions about work and consumtion. Only by collecting information, data about family decision making we are likely to get such a framwork.

The presence of small children and their effect on decisions about market work is another aspect on joint family decisions. In Flood(1988) and Flood & Klevmarken(1989) it is shown that in families with small children *both* the male and the female shift their time from the market to child care and household work. Their estimates suggest that males with a child three years or younger work on average about 6 hours less per week in the market and females about 13 hours less. Although not explicit in their model these relatively large effects are probably a result of the generous benefits parents of small children get from the Swedish social security system. In other studies the wage rate effect has been differentiated due to the presence of children. For instance, Wales & Woodland(1977) find Cornout elasticities for females in families without children in the range 0.13 – 0.39 and i families with children in the range –0.01 – 0.13. Blundell & Walker(1982) find a relatively high positive elasticity for females with no children and a negative elasticity for those who have 2 children.

The decisions to work depend on the supply of child care services. The interaction between labor supply and demand and supply of child care services has not been much researched. One exception is the study by Gustafsson & Stafford(1989). They find that the degree of rationing is very important for the females decision to work.[8] For those communes where there is no rationing they find that families are sensitive to the price of child care services. The decision to work and the demand for child care services are joint decisions. A proper specification of the "budget set" should thus include both the presence of rationing and the price schedule for the commune to which the family belongs.[9]

In a life cycle perspective decisions about work and children are joint decisions and they should be modeled and analysed jointly. This is a relatively new area for economic research, see for instance Heckman & Walker(1987, 1988)

7. A dynamic labor supply model; an application to panel data.

Due to the very limited supply of panel data, cross–sectional data have commonly been used in labor supply studies.[10] With cross–sectional data we have the wellknown problem of infering changes from individual differences. Cross–sectional differences do not in general translate in any obvious way to intertemporal changes. A Cournot elasticity estimated from a cross section does not say anything about the dynamics of, for instance a tax change, nor does it necessarily say anything about "the long term" effects. In a dynamic economy a single cross–section can not be exptected to represent a steady state. A reliable analysis of the likely changes in labor supply as a result of certain policy changes can only be made with repeated measurements, preferably panel data.

In the following estimates are presented of a dynamic labor supply model for married or cohabiting couples. It is an attempt to model the joint decision of two spouses using features of a life cycle model. This model is applied to a short panel of only two waves spanning the period 1983–1985. Data were obtained from the Swedish HUS–panel (Klevmarken & Olovsson(1986), Klevmarken(1984)). Because the panel is so short changes in labor supply do not only reflect changes along a lon–run life cycle path but also to a large extent deviations from this path and adjustments towards it.

Our first basic assumption is that in general the labor supply behavior of singles differ from that och couples and that males behave differently from females. This justifies that we analyse couples separately from singles. There are four types of couples: Both spouses work, only the male or the female works and non of the spouses work. Our second assumption is that these four groups in general also differ in behavior, for instance, the husband in a household where both spouses work does not necessarily behave as the husband in a household where only he works. A third assumption is that households with at least one

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[8]In Sweden the local communes are the dominant providers of child care services, at subsidiced price. The result is that families in many communes have to que to get their children into a day care center.

[9]In many communes the price of child care services depends both on family income and on the number of children the family have been able to get into the system. Each commune decides about its own price list. Some communes have a flat rate price.

[10]The Michigan Panel Study of Income Dynamics have been used in a number of papers, for instance in Heckman & MaCurdy(1980) and MaCurdy(1981). Browning, Deaton & Irish (1985) used British pooled cross–sectional data to get artificial cohort data.

spouse 65 years of age or older behaves differently from younger household. In Sweden almost everyone retire at the age of 65. For this reason we have excluded those who were older than 64 years in 1985. This gave us a working sample of 563 couples and 1126 individuals. In this sample of married/cohabiting couples almost 90 per cent of the men and 75 per cent of the women were working in 1985. 70 per cent were couples with both spouses working, 21 per cent couples with only the husband working, 6 per cent with only the wife working and the remaining 3 percent were couples with non of the spouses working. In the following results will only be presented for the largest group, i.e. with both spouses working.

The econometric specification of the model is the following,

$$h^* = \alpha' z + \epsilon;$$

$$h_m = \beta_m' z_m + u_m; \quad \text{if } h^* > 0.$$

$$h_f = \beta_f' z_f + u_f; \quad \text{if } h^* > 0.$$

h^* is a latent variable such that $P(h^* > 0)$ is the probability that both spouses work more than 100 hours a year. h_m and h_f are the hours worked by males and females respectively and z, z_m and z_f are vectors of explanatory variables. They will be discussed in some detail below. ϵ, u_m and u_f are multivariate normal errors with zero mean and covariance matrix Σ. No constraints are put on the parameters (except for the necessary normalization in the probit equation). This model was estimated by a quasi maximum likelihood method of the HotzTran program by Avery & Hotz(1985). The estimates are consistent but not maximum likelihood.

The basic idea is to take advantage of the panel character of the data and explain changes in labor supply and not allow cross–sectional differences to determine the estimates. The measures we have on labor supply are estimates of annual hours in 1983 and 1985 based on a sequence of questions about hours per week and weeks worked including overtime and secondary jobs. In principle one could decomposed an observed change into one component which is the change along a long–run life cycle path and one which is a movement from or towards this path. As we prefer to put the model in levels form rather than in change form, labor supply in 1985 is thus explained by lagged supply, changes in those variables which captures long–run changes and variables indicating deviations from a long–run path.

Past work behavior is modeled by the number of workhours in 1983 (TIM83), a dummy variable which which takes the value one if the respondent did not work at all in 1983 (NOWRK83) and the ratio of the number of hours in 1984 over 2000 truncated at one (DEXP84).[11]

The probit equation is based on a conventional comparison of a reservation wage and a market wage. As these two wage rates are not observed for everybody, the model is specified in reduced form. In addition to the variables for past behaviour, the z vector will include variables which capture changes in the two wage rates. **Changes in the market wage** is determined by schooling (SCH83), the change in schooling (DSCH84), years of experience (EXP83) and the change in this variable (DEXP84). Because of the definition of

[11]This variable was designed to capture the change in experience in 1984. The number of work hours in 1984 was also obtained by a slightly different sequence of questions as compared to 1983 and 1985.

experience it has not been possible to obtain an experience measure independent of the number of hours worked in 1984. It is assumed that **changes in the reservation wage** can be indexed by the financial, real estate and consumer durable wealth of the household in 1983/84 (WEALTH84) and the change in the same variable between 1983/84 and 1985/86 (DWEALTH) and a dummy variable which takes the value 1 if the respondent moved from a rented flat to an owner occupied house or appartment, –1 if for the reverse move and else 0 (DBOSTAD). We also experimented with age variables and the change in the number of children but they did not contribute.

The variables suggested to explain the changes in market and reservation wages are likely to catch only long–run changes in this difference. Temporary deviations from a long–run life cycle path may be the result of market imperfections or constraints put on the household which makes it difficult to adjust to a long–run path. For instance, there might be a queue to the public daycare and nursing homes which makes one of the parents stay at home until their child is allowed to start in one of these centers. The local labor market conditions may be such that it is almost impossible to get a job locally or with the desired number of hours for one of the spouses, usually the wife. Spells of unemployment and sickness are also examples of more or less temporary deviations from a "normal" supply of hours. Our data set includes a few indicators of temporary **deviations from normal or desired work behavior**. If the household is queuing for a place at a public daycare center the dummy variable CHIQUE86 takes the value one. Most households responded to this question in the first half of 1986. NONWRK is the number of vacation weeks and weeks of illness in 1983. We also unsuccessfully tried indicators of people looking for a job in 1984. The probit function in principle include the variables mentioned above both for the male and for the female. Male variables have the prefix M and female variables W.

The supply of hours given a decision to work is also conditioned on past behavior and changes and lagged values of variables which hopefully capture long–run labor supply. In addition to variables already explained the change in nonlabor income 1983–1985 was included. Taxable incomes were reduced by one minus the marginal tax rate and added to nontaxable incomes. The marginal tax rate was intrumented, see below. The labor supply functions also included measures of the marginal wage rate in 1984 and the change in this variable 1984/86. There are several ways of handling the endogeneity of the marginal tax rate. The approach used here is an instrumental variables method. An estimate of the marginal tax rate in 1985 τ^* was obtained by applying the tax schedules of 1985 to the sum of earnings in 1983 and nonearned income in 1985. τ^* was used to calculate a marginal wage rate for 1985 from which the observed marginal wage rate in 1983 was substracted. This difference jointly with the variables NOWRK83 and NONWRK were used to instrument the observed change in the marginal wage rate. The instrumented variable is called DNWHAT. The observed netwage in 1983 (NETW84) is also among the explanatory variables.[12]

The parameter estimates and their estimated t–ratios in Table 2 show that past behavior is the best predictor of current behavior. The estimates of the probit equation exhibit a type of counter balancing lagstructure. In a comprision between couples who worked the same number of hours in 1984, the probability that both spouses work in 1985 is higher if they increased their supply of hours from 1983 to 1984. However, if one of the spouses did not work at all in 1983 the probability that they will both work in 1985 is reduced.

The lag structure in the censored regression equations is not the same. The more hours worked *both* in 1983 and 1984 the more did both spouses work in 1985. Those who did not

[12]Wage rates were obtained in the beginning of 1984 and 1986 respectively. As revisions of pay scales usually takes place later in the year the lack of coordination between the hours measures and the wage rate measures is not seen as a great problem.

work at all in 1983 did not behave differently from anyone else who worked in 1985 (NOWRK83 is insignificant).

The effects of future expected wage rates as captured by the schooling and expericence variables are mixed. The effects of the schooling variables were estimated with low precision. In the probit equation the point estimates indicate that more schooling for males increases the probability at a decreasing rate that both spouses will work (the coefficient of SCH84S is negative), while the opposite is true for females. The probability that both spouses work thus increases more if the female has an academic education than if the male has one. In the censored regression equations the schooling variables did not have any explanatory power.

The interpretation of the DEXP84 variable is difficult as it captures both the effects of changes in experience and those of lagged bahavior. For females in the probit equation the estimate of the effect of the level of experience has the expected negative sign, corresponding to a reversed U–shaped earnings profile. The corresponding estimate for males is insignificant.

The change in wealth and the level of wealth are both significant in the probit equation, but with a positive sign. The explanation is probably the same as offered above, namely that the possibilities to decuct interest payments against earnings when incomes are declared for taxation might induce both spouses to work in order to finance a house. Our wealth variables catch this effect because owner occupied houses make up a major share of people's wealth. In the censored regression equations the wealth variables are insignificant except for the level of wealth in the equation for females. Thus, wealthy females tend to decrease their hours. The number of hours supplied by women also depends on their housing. Those who moved into a house from a rented flat tended to increase their hours. There is no effect of the same kind for men, presumably because most of them already worked full–time.

If any one of the spouses had several weeks of absence from work in 1983, for instance, because of unemployment or illness, the probability that they both would work in 1985 was reduced. For males who actually worked in 1985 the variable NONWRK83 captures deviations from a normal situation. Those who were temporarily absent in 1983 increased their hours in 1985 in an effort to return to normal. This variable did not contribute to the explanation of female behavior. Females are not commited to work to the same degree as men are.

If the family is queuing to get their child into the public child care system this reduces the probability that both spouses work. It has no effect on the number of hours supplied given that both spouses work, which is logical. If they both work their child care problem has already been solved.

It remains to analyse the estimates for the wage rate variables. For males they are all small and insignificant. For females we find that an increase in the marginal wage rate *decreases* the number of hours supplied. The precision of this estimate is low though. A counter intuitive result is the positive cross effect of the males wage rate on female hours.

Finally, it is interesting to note that there is a significant negative residual correlation between male and female hours which indicates an unexplained trade off in hours between the two spouses.

This model is just a first attempt to capture some of the dynamics of labor supply. The results demonstrate the high variability (noise level?) there is in observed changes and the resulting difficulty in obtaining reliable estimates. Economic signals have a tendency to become dominated by socio–demographic changes and by noise.

8. Concluding remarks

What do we know about labor supply responses in Sweden to changes in wage rates, marginal tax rates and incomes? A truthful answer based on evidence from micro data is unfortunately, not very much! As pointed out there are good reasons to disbelieve the estimates of a forward bending supply curve obtained in the static approach with a "completely" specified budget set. We have also presented cross–sectional results obtained by different methods which indicate backward bending supply curves both for men and women.

Looking back at the major trend in labor supply of this century we find that a large share of the increase in well–being has taken the form of increased leisure. In this perspective a backward bending supply curve is not that implausible. The trends of household time–use after the second world war in Sweden, as well as in other countries, are that women increase their market work and decrease their household work, while the reverse is true for men. Although there are evidence that young cohorts of well educated women have such high productivity both in market work and in household work that they can cope with both and still get some leisure time, the time constraint is probably perceived "more and more" binding as less productive women are drawn into the hustling life of combined market and household work. It is not at all implausible that preferences for children and leisure are such that additional increases in real income will not increase the market work of women (or men). However, if this would not be true, and women actually continue to increase their market work, we have to note the trade off between women's hours and men's hours. If the woman increases her market work her spouse has to decrease his if the quality of child care and other labor intensive household duties will not detoriate. It is sometimes said that part time working women compose the largest potential source of labor in Sweden. It might thus be much smaller than a simple count of hours would suggest.

Cross–sectional labor supply and time–use results are difficult to translate into dynamic changes. We need estimates from panel data. The estimated model in section 6 above is only a "first instalment in future research" and it cannot be used to evaluate the total effects of changes in the marginal wage rate, because the probit equation was estimated in reduced form, but it is interesting to note that there is no evidence of a forward bending supply curve for women who already work at least part time.

Much of the discussion above has concentrated around the slope of the labor supply curve, and one might object that interest should be more focused on the substitution effects, which tell us something about the distortions of a progressive tax system, and less on the income effect. One might argue that the sign of the income effect is of secondary interest because people know best if they increase their well–being by increasing their leisure or their consumption of goods and services. But this is a very onesided view, everyone knows that politicians are interested in the distribution of leisure and incomes and thus in the size and magnitude of the income effects for various household groups. Another problem is that estimates of the substitution effects depend very much on the assumptions made about preferences and the specification of the budget set. We know even less about compensated elasticities than about uncompensated.

Realistic labor supply models would seem to become very complex, in particular if we take a life–cycle perspective. How could we find a balance between realism in details and useful applicability? How much *a priori* structure should we impose on data? Assumptions about more or less sophisticated utility functions has the advantage of suggesting functional forms which involve economic parameters of interest. They have the disadvantage of imposing constraints on data which are not always that obvious and might have been rejected by data if properly tested. One lesson we have learned is that a model must be exposed to very careful misspecification testing. A model which does not explain data well in a statistical sense is not a good basis for economic analysis.

Among the items on the agenda for future research on labor supply I would like to suggest the following:

Realistic modelling of people's true budget set should involve major features of income related and means tested transfer programs, in particular those of the social security system. It would also involve modellling of multiperiod budgets to accommodate a dynamic analysis. It is obvious that a model which tracks all details would be very data demanding and cumbersome to handle. The degree of detail needed is an open question. The discussion in section 3 shows that a detailed specification of the budget set might not be all that useful unless we are able to do a good job in modelling preference differences.

The dynamics of labor supply and joint family decisions must also become central themes in future research. It is not obvious that the full apparatus of the life–cycle model is needed, but the idea of an average life–cycle path from which there are individual and temporary deviations I find useful. Given that our theoretical position with respect to joint family decisions and the dynamics of labor supply is relatively weak, an approach which puts less *a priori* structure on the problem than that currently esteemed might be preferable.

We must also become more critical and demanding as to the data we use. We too often use much effort in accomodating theory and models to the data we happen to get access to in the faint hope of being able to say at least something. The labor supply literature gives many examples. I find a lack of experimental planning in our science. Why not spend more resources on carefully planned data collection operations rather than on complex econometric modelling to compensate for deficiencies in data collected for other purposes. Isn't the whole idea rather peculiar, that we should be able to say something about the numerical magnitude of labor supply responses to a tax reform without access to experimental data, i.e. without observed responses to similar changes?[13]

[13] A taxreform usually involves more than changes in the income tax scale, for instance changes in the taxation of capital and changes in indirect taxes, and as pointed out in Lindbeck(1982) a tax reform is usually accompanied by changes in public spending which also affect the behavior of people. A proper econometric analysis should in general include all these joint changes in order to give consistent estimates of labor supply responses to various partial changes.

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Table 1. Marginal effects from a labor supply model estimated from time–use data and conventional survey data. (Standard errors in parenthesis)

Variables	Men Time–use	Men Survey	Women Time–use	Women Survey
Marginal wage	–0.326	–0.437	–0.344	–0.634
	(–0.088)	(–0.048)	(–0.071)	(–0.045)
Net wealth	0.635	0.277	–0.127	0.064
	(0.2618)	(0.178)	(–0.215)	(0.142)
Compulsory schooling	–0.276	–4.032	–3.853	–9.092
	(2.430)	(1.724)	(–1.952)	(–1.381)
High school	2.138	–1.622	1.651	–5.921
	(2.381)	(1.721)	(2.021)	(–1.446)
Experience	0.229	0.692	1.885	1.490
	(0.386)	(0.269)	(0.259)	(0.160)
Experience squared	–0.009	–0.015	–0.038	–0.024
	(0.006)	(0.004)	(–0.006)	(0.003)
If single	5.158	–1.165	6.873	2.250
	(2.918)	(1.781)	(2.366)	(1.634)
Age 18–30	1.839	3.612	15.805	17.067
	(4.791)	(3.313)	(2.660)	(1.703)
Age 31–45	4.471	4.142	5.092	7.785
	(2.857)	(1.895)	(1.926)	(1.280)
# children age 0–3	–6.186	1.645	–11.480	–8.710
	(2.435)	(1.775)	(–2.152)	(1.440)
# children age 4–7	–3.699	–1.360	–3.783	–5.106
	(2.181)	(1.441)	(–1.783)	(1.238)
# children age 8–12	–4.202	–0.141	–3.242	–3.874
	(2.055)	(1.331)	(–1.673)	(1.204)
# children age 12–18	–1.155	–0.414	–3.895	–1.779
	(2.100)	(1.313)	(–1.725)	(1.295)
Houseowner	4.928	4.300	2.696	0.492
	(1.938)	(1.215)	(1.697)	(1.101)
Household size	3.408	0.202	4.041	3.009
	(1.469)	(0.878)	(1.234)	(0.926)
Big city	4.418	2.485	2.551	0.489
	(2.165)	(1.408)	(1.853)	(1.228)
"Other" areas	8.024	2.207	2.775	0.0145
	(1.891)	(1.219)	(1.638)	(1.079)

Dependent variable in censored regression is hours worked per week. This table shows marginal effects taking both the probability to work and the number of hours working into account.

Source: Flood & Klevmarken(1989) tables 9 and 10.

Table 2 **Estimates of a dynamic labor supply model for married/cohabiting couples from panel data.** (t–statistics in parenthesis)

Variable	Probit equation			Censored regression	
	Male	Household	Female	Male eq.	Female eq.
TIM83S	–0.6809		–0.6274	0.2707	0.1722
	(–2.7688)		(–3.2283)	(3.4051)	(3.4763)
NOWRK83	–2.7047		–1.9042	+0.2523	0.1876
	(–4.3268)		(–5.7814)	(–0.5149)	(1.3622)
DEXPP84	3.1825		3.5771	1.7625	1.4647
	(6.7461)		(8.7054)	(6.1341)	(10.3381)
EXP83S	0.1655		–0.2234		
	(1.2149)		(–1.9377)		
DSCH84	1.5549		–0.1739	0.6814	
	(1.7958)		(–0.3857)	(1.6326)	
SCH84S	–0.1781		0.2510		
	(–1.6664)		(1.9628)		
DWEALTHS		0.3246		0.0073	–0.0088
		(2.7374)		(0.3567)	(0.4652)
WEALTH84S		0.3797		0.0095	–0.0296
		(2.3581)		(0.3858)	(–2.1566)
DNETIBS				–0.3720	–0.0179
				(–2.8388)	(–1.0903)
DBOSTAD		0.6164			0.2541
		(1.2524)			(2.2809)
NONWRKS	–0.2759		–0.2842	0.2071	
	(–1.9068)		(–2.5889)	(3.3139)	
CHIQUE86		–0.9439			
		(–2.1421)			
MDNWHATS				0.0020	0.0022
				(0.1274)	(0.1424)
MNETW84S				0.0248	0.0422
				(1.0533)	(2.0891)
WDNWHATS				0.0094	–0.0347
				(0.4021)	(–1.6373)
WNETW84S				–0.0015	0.0082
				(–0.0691)	(0.3298)
CONSTANT		–4.5024		–1.9452	–0.8274
		(–7.4410)		(–5.7370)	(–7.4861)
Sigma		1.0000		0.2840	0.3406
				(12.2174)	(11.7838)
Rho 21				0.09955	
				(0.6722)	
Rho 31				0.2015	
				(1.5666)	
Rho 32				–0.0568	
				(–2.2912)	
R^2				0.7057	0.7505
Mean probability when both spouses are working		0.905			

Note 1: There is only one probit equation including male, female and household variables, while there are separate regression equations fore males and females.

2: In a few cases the two spouses did not belong to the same households in 1983. In these cases the wealth variables in the probit equation apply to the male's household in 1983/84 and DBOSTAD to housing changes of the female.