The systems approach to household labor supply in the Netherlands

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The Systems Approach to Household Labor Supply in The Netherlands

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Table of Contents

Abstract

Deaton and Muellbauer's Almost Ideal Demand System (AIDS) is employed to model the joint determination of family income and male and female labor supply of individual households in The Netherlands. Family composition effects are incorporated as quasi-price effects as originally proposed by Barten. The model is estimated for a cross-section of households in The Netherlands in 1982 to explain both actual hours of work and preferred hours of work. It turns out that approximately 80% of the sample households behave consistently with utility maximization. An analysis of the effects of rationing of male labor supply points at the possibility of a compensating effect on female labor supply.

1. Introduction

Econometrics received its big boost from applications to macroeconomic problems. Today, many economists have become wary of the use of advanced econometric methods in the construction of big macroeconomic models. At the same time, the increased availability of large micro data sets has opened up a vast field where econometric techniques can be applied more appropriately. Micro data have their own peculiarities which have spawned many new research directions in econometrics such as "latent variables", "limited dependent variables" and "the analysis of panel data".

A distinctive feature of empirical microeconomic models is the much closer connection between economic theory, econometric method and empirical implementation than in the big macro models. Economic theory is often formulated in terms of individual decision making units like households, and having data on the individual units makes it possible to use the theory more fruitfully and to test it more severely. This closer connection between theory and data also more narrowly defines the appropriate econometric methods to be used.

One of the areas where economic theory and econometric methodology have cooperated most closely is that of household labor supply. Where Dutch economists were in the forefront of their profession when econometrics was applied to macroeconomics, it is perhaps only natural that now they are lagging somewhat when applying econometrics to microeconomics.

In the area of household labor supply, with which this paper is concerned, there are only a few Dutch papers that use micro data to analyse household labor supply, and almost all of them are written by one person, J. Siegers of the University of Utrecht. His research concentrates on female labor force participation and its relation with fertility. For the purpose of this paper his two papers on the joint labor supply of married couples are relevant, both co-authored by P.S.A. Renaud.

In Renaud and Siegers (1983a) a rather large Dutch dataset is used to model both the participation and the number of hours worked by the male and female partner in a family.[1)] The participation equations are estimated by

1) The dataset used is known as AVO-79. The analysis covers 3114 households. The same dataset was also used by Hartog and Theeuwes (1983).

means of probit analysis. The hours equations are estimated by Tobit analysis. All equations are linear and estimated separately. Explanatory variables are male and female wage rates, age, and a number of dummies to represent family composition.

In Renaud and Siegers (1983b) the same dataset is used to estimate a variant of a model proposed by Leuthold (1978). Now only hours equations are estimated by Tobit analysis for female hours and by regression for male hours. The specifications are again linear and the explanatory variables are almost the same as in the previous article with one exception. The partner's wage rate has been replaced by the partner's labor income.

However valuable these studies may be, they are subject to a number of limitations. First of all, the linear specifications used are quite restrictive, implying for instance that labor supply functions are either everywhere forward bending or everywhere backward bending. Secondly, the model used in Renaud and Siegers (1983a) is not derived from a well-developed theory of household behavior. Neoclassical theory would imply restrictions on the parameters in the participation and hours equations, for example, but such restrictions are neither imposed nor tested. The Leuthold model underlying the analysis is Renaud and Siegers (1983b) implies a simultaneity between the labor incomes of husband and wife, but in the estimation this simultaneity is not taken into account so that the parameter estimates are probably inconsistent.

In this paper we start from the neoclassical theory of labor supply, which takes the household as a homogeneous decision making unit. Although this may seem a strong assumption to some, our empirical analysis shows that the restrictions implied by the neoclassical theory hold up rather well. As an empirical specification we adopt the Almost Ideal Demand System (AIDS) proposed by Deaton and Muellbauer (1980a, 1980b). This system is derived from neoclassical theory and it is quite flexible. Labor supply functions can be forward bending in a certain range of wages and backward bending in a different range. We estimate female and male labor supply as one system, thereby attaining maximal efficiency of the estimates.

One important assumption in the neoclassical model is that the household decision is subject to no other restriction than a budget constraint and a time constraint. So institutional restrictions are ignored. In our data we have not only information on how many hours each partner works per week, but also how many hours they would like to work. It is the extra availability of this latter variable which allows us to investigate the biasing effects of institutional constraint.

Once we have estimated the model and have found that the neoclassical framework fits the data rather well we go on to illustrate the value of a model rooted firmly in theory for the analysis of policy issues. We briefly investigate the measurement of the cost of children and the effects of a rationing of male labor supply, proposed by many people in The Netherlands as a means of reducing unemployment, on female labor supply.

Although we admit to be rather pleased by the empirical results obtained, we should stress that this paper is primarily an investigation into the potential of the AIDS as a model for household labor supply. Before the results can really be used in policy with a fair degree of confidence, quite a few extra steps have to be taken. In the concluding section we outline a number of these steps.

In order not to burden the presentation with a number of technicalities from neoclassical demand theory or from econometrics, most mathematical details have been relegated to three appendices.

2. The Model

We only consider households[1] with both a male and a female partner present. Each household is supposed to behave as if it maximizes a well-behaved utility function $U(\ell_m, \ell_f, y)$, where ℓ_m is male leisure, ℓ_f is female leisure and y is total household consumption. Maximization of the household utility function takes place subject to a full income constraint:

$$w_m \ell_m + w_f \ell_f + y = Y \equiv \mu + w_f T + w_m T, \tag{2.1}$$

where w_m and w_f are the male and female wage rate respectively, T is the total number of hours available per time period and μ is unearned family income[2] (e.g. property income or welfare benefits); Y is full income.

Maximization of the utility function subject to (2.1) yields demand for leisure functions and a demand for consumption function. The mathematical form of these functions depends on the specification of the utility function. Since economic theory is unspecific about the funtional form of demand functions (or utility functions, for that matter), it is advisable to choose a flexible specification, so that the data help to specify the functional form of the demand equations. One particularly convenient specification of the flexible functional form variety is the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980a, 1980b). In Appendix A we give a brief exposition of AIDS. There it is also shown that in the present context, AIDS looks as follows:

$$s_m = \alpha_m + \gamma_{mm} \log w_m^* + \gamma_{mf} \log w_f^* + \gamma_{my} \log p^* + \beta_m \log Y - \beta_m . a \tag{2.2}$$

$$s_f = \alpha_f + \gamma_{mf} \log w_m^* + \gamma_{ff} \log w_f^* + \gamma_{fy} \log p^* + \beta_f \log Y - \beta_f . a \tag{2.3}$$

where $s_m = w_m \ell_m / Y$, $s_f = w_f \ell_f / Y$ and

$$p^* = N^{\theta_y} \tag{2.4}$$

1) "Household" and "family" are used as synonyms.

2) The wage rates and unearned income are all measured after taxes.

$$w_m^* = N^{\theta_m} . w_m \tag{2.5}$$

$$w_f^* = N^{\theta_f} . w_f \, , \tag{2.6}$$

with N the number of persons in a family.

$$\begin{aligned} a = a_0 &+ \alpha_m \log w_m^* + \alpha_f \log w_f^* + \alpha_y \log p^* + \frac{1}{2} \gamma_{mm} \log^2 w_m^* \\ &+ \gamma_{mf} \log w_m^* \log w_f^* + \gamma_{my} \log w_m^* \log p^* + \frac{1}{2} \gamma_{ff} \log^2 w_f^* \\ &+ \gamma_{fy} \log w_f^* \log p^* + \frac{1}{2} \gamma_{yy} \log^2 p^* \end{aligned} \tag{2.7}$$

and

$$\alpha_y = 1 - \alpha_m - \alpha_f \tag{2.8}$$

$$\gamma_{my} = -\gamma_{mm} - \gamma_{mf} \tag{2.9}$$

$$\gamma_{fy} = -\gamma_{ff} - \gamma_{mf} \tag{2.10}$$

$$\gamma_{yy} = -\gamma_{my} - \gamma_{fy} \tag{2.11}$$

The parameters a_0, α_m, α_f, β_m, β_f, γ_{mm}, γ_{mf}, γ_{ff}, θ_y, θ_m, θ_f have to be estimated.

The demand equations are written in share form; s_m is the share of male leisure in the household's full income and s_f is the share of female leisure. Of course, one can also derive a corresponding demand equation for s_y the share of total consumption in full income.
Since, according to (2.1), $s_f + s_m + s_y = 1$, this equation will not provide any new information. Hence it is omitted.

The effect of family size on labor supply has been modelled here as a quasi-price effect along the lines set out in Barten (1964). Of course, the number of persons in a family is a rather crude indicator of family composition and one could think of including more indicators like the number of children younger than six. To keep the number of parameters to manageable proportions we will stick to this rather simple specification. In any case, we allow the effect of family size to be different for different expenditure categories. As such it is more general than the specification used by Ray (1982).

The full income shares s_m and s_f are non-negative and are bounded from above. If both partners decide not to work, s_m and s_f attain their maximum, respectively $w_m T/Y$ and $w_f T/Y$. Of course, a demand for leisure equation is equivalent with a labor supply equation and we shall also refer to (2.2) and (2.3) as labor supply equations.

One of the assumptions underlying the neo-classical model sketched here is that people are free to choose the number of hours they work. Obviously, in practice there may be various institutional constraints on the number of hours one is able to work. A particular feature of the data we use is that it not only contains information on the number of hours household members work, but it also tells us how many hours each household member would like to work at the going wage rate. We refer to the former concept as actual hours and to the latter as preferred hours. We will estimate the model twice, once to explain actual working hours and once to explain preferred working hours.

3. The Data

The labor supply model (2.2)-(2.11) has been estimated for data from a labor mobility survey in The Netherlands, conducted in the Fall of 1982 by the Netherlands Central Bureau of Statistics and the Institute for Social Research of Tilburg University. The sample has been drawn randomly from the population of all households in The Netherlands whose head is between 18 and 65 years of age. The sample contains 1315 households. Within each household each member of 18 years or over has been interviewed. As a result the sample contains 2677 respondents.

For our empirical analysis we only consider households where both the male and the female partner work in a paid job for at least 15 hours per week. The 15 hours cut-off point is dictated by the survey design by which certain items of information are not collected for people who work less than 15 hours per week. As a result, we analyse a sample of 139 households for whom a sufficient amount of information has been collected to be able to estimate model (2.2)-(2.11).

Although from a theoretical point of view the preferred hours version of the model would seem to be superior to the actual hours version, there are some data problems that may adversely affect the quality of the parameter estimates in the preferred hours version. First of all, there are some context effects: Question 198 of the questionnaire asks whether the respondent would prefer to work more hours than he or she does at the moment, or fewer hours, or just the present number of hours. In this question, no mention is made of the financial consequences of changing the number of hours worked. It is not surprising, therefore, that in our 139 households there are only 3 males and only 5 females who would like to work more hours, whereas 39 males and 50 females would like to work less.

The next question, 199, then asks whether the respondent is willing to work less and have a proportionately lower income. The respondents who dare to say no to this question are then asked (question 200), "Why not?". Question 201 finally asks the respondents how many hours they would prefer to work if their present <u>income per hour</u> would remain constant. The phrase "income per hour" may have been understood by some as saying that their total labor income would remain constant. Thus it appears that both the sequence of questions preceding the preferred number of hours question and the phrasing of the question itself tend to bias the respondent's answer in a downward direction.

There is an additional econometric problem caused by the survey design. The preferred number of hours question is only asked to respondents who work at least 15 hours a week in a paid job. So those respondents who work less than 15 hours, but would like to work more than 15 hours, are left out of our sample of 139 households. This causes an extra selection bias for the preferred hours version which does not arise with the actual hours version. See Appendix B for technical details.

4. Estimation Results

The estimation method is outlined in Appendix B. Here we first present the parameter estimates in Table 1. Next we discuss their economic significance. The α's and γ's are significant at the 5%-level for both specifications, except for γ_{ff} in the preferred hours version. The β's are generally insignificant and so are the θ's. One should be careful, however, to base any far-reaching conclusion on the significance or non-significance of parameters. The model is highly non-linear, so that one cannot generally associate a parameter with a particular variable, as in a linear model. A non-significant coefficient, therefore, does not necessarily point at the possibility that a particular explanatory variable could be discarded without loosing much predictive power. In a non-linear context parameters also determine the curvature of the function and often it is not possible to look at parameters in isolation. For that reason we do not try, generally, to interpret parameters separately but concentrate on the performance of the model as a whole.

Table 1. Parameter Estimates[a)] (asymptotic t-values is parentheses).

Dependent Variable :	Preferred Hours	Actual Hours
Parameters		
α_m	0.31	0.29
	(6.5)	(6.2)
α_f	0.23	0.38
	(4.9)	(6.1)
γ_{mm}	0.23	0.18
	(14.3)	(8.0)
γ_{mf}	-0.16	-0.16
	(-6.6)	(-12.5)
γ_{ff}	0.08	0.20
	(1.2)	(19.7)
β_m	-0.07	0.11
	(-1.1)	(1.2)
β_f	0.18	-0.15
	(2.4)	(-1.6)
θ_y	0.03	0.14
	(0.1)	(0.5)
θ_m	0.05	0.36
	(0.17)	(0.6)
θ_f	0.22	0.22
	(0.3)	(0.8)
log-likelihood (up to an additive constant)	641.8	658.7
log-likelihood when $\theta_m = \theta_f = \theta_y = 0$	637.5	653.8
Likelihood ratio test[b)] statistic for $\theta_m = \theta_f = \theta_y = 0$	8.6	9.8

a) a_0 was fixed a priori for computational reasons (see Deaton and Muellbauer (1980) and Ray (1982)).

b) This statistic follows asymptotically a χ^2-distribution with three degrees of freedom. The critical levels for 5% and 2,5% are 7.81 and 9.35.

In the first place, we notice that the log-likelihoods for the two versions do not differ very much, although it appears that actual hours are explained somewhat better by the model than preferred hours. Since the two versions of the model are non-nested one cannot draw any firm inference from this difference in log-likelihood.

Secondly, although the t-values for the θ-estimates might suggest that family size can be neglected as a determinant of labor supply, a likelihood ratio test of the hypothesis $\theta_f = \theta_m = \theta_y = 0$ rejects this hypothesis at the 5% significance level (cf. the bottom of Tabel 1).

In the third place, the neoclassical model of household utility maximization requires the own welfare compensated (Hicksian) price elasticities to be negative and, more generally, the cost function (see Appendix A) should be concave. One can check per observation point whether these conditions are satisfied. (See Appendix A for details). It turns out that for preferred hours the own compensated price elasticity is negative for 89% of the observations. For actual hours the own compensated price effect is negative in 80% of all cases.

The negativity of the own compensated price effect is only a necessary condition for consistency of the observations with utility maximization. When we check the necessary and sufficient concavity conditions, we find that for the preferred hours specification 79% of all households behave consistent with utility maximization, whereas 60% do so for the actual hours specification.

Since any empirical model is bound to suffer from some degree of misspecification, and because there are random factors not captured by the model, these numbers are quite encouraging. Also in comparison with other studies these numbers compare favorably. Wales and Woodland (1976), for example, find rejection of utility maximization for approximately 50% of their data points.

It is also worth noticing that the preferred hours specification is doing better in this respect than the actual hours specification. Apparently, institutional and other constraints on numbers of hours worked forces some households away from a utility maximum. For these households the preferred hours are consistent with utility maximization, but the actual hours are not.

Encouraged by these results, we will take utility maximization as our maintained hypothesis and explore some further implication of the empirical results. In Tabel 2 we present for both versions the welfare compensated elasticities of working hours and total consumption with respect to the wage rate and price of consumption.[1)] All quantities are evaluated at the sample mean.

Table 2. Compensated wage and price elasticities at the sample mean.

Elasticity of:	male leisure		female leisure		total consumption	
with respect to	preferred	actual	preferred	actual	preferred	actual
w_m	-0.03	-0.13	-0.03	-0.04	0.11	0.33
p	-0.02	-0.04	-0.28	-0.05	0.60	0.15
p	0.05	0.17	0.31	0.09	-0.71	-0.48

In both specification male and female leisure are complements and both are substitutes for consumption. So, if either the male or the female wage rate goes up, both partners will work less, keeping welfare constant. If the price of total consumption goes up, both partners will respond by working more, once again keeping welfare constant. The results do not seem to differ greatly between both versions of the model.

For comparison, Table 3 presents the uncompensated elasticities evaluated at the sample mean and these tell a slightly different story.

Table 3. Uncompensated wage and price elasticities at the sample mean.

Elasticity of:	male leisure		female leisure		total consumption	
with respect to	preferred	actual	preferred	actual	preferred	actual
w_m	0.07	0.01	0.16	0.05	0.15	0.47
w_f	0.02	0.08	-0.14	0.00	0.58	0.24
p	0.00	0.00	0.00	0.00	-0.98	-0.96

1) We denote the price of consumption by p. In model (2.2)-(2.11) p did not appear because we set p = 1, without loss of generality.

The own price effect of male leisure is now positive, indicating that the income effect of a change in the male wage rate dominates the substitution effect. For the rest, the differences between compensated and uncompensated elasticities are small, with the exception of the numbers in the buttom row. According to Table 3 the income and substitution effects for male and female leisure cancel almost exactly. Consequently, an uncompensated change in the price of consumption would not affect labor supply, but merely reduce consumption proportionately.

It should be borne in mind, however, that these conclusions pertain to the sample mean only. In Figure 1 we present the complete uncompensated labor supply functions for both versions of the model. The flexibility of AIDS is borne out by the various shapes taken by the labor supply functions. In particular, for the actual hours version female labor supply is partly forward bending and partly backward bending. In general, a linear specification would be unduly restrictive. One sees, once again, that the preferred hours version suggests more elastic labor supply functions than the actual hours version, especially for female labor supply.

Finally let us compare the own wage elasticities found here with those by Renaud and Siegers (1983a, 1983b). Since these authors present labor supply elasticities rather than demand for leisure elasticities, we transform our elasticities accordingly and obtain the results of Table 4. The differences are remarkable.

Table 4. Estimated elasticities of labor supply with respect to own wage.

	Preferred hours	Actual hours	Renaud and Siegers (1983a)	Renaud and Siegers (1983b)
Male hours	−0.25	−0.03	0.24	0.05
Female hours	0.79	0.00	1.55	1.44

Preferred hours

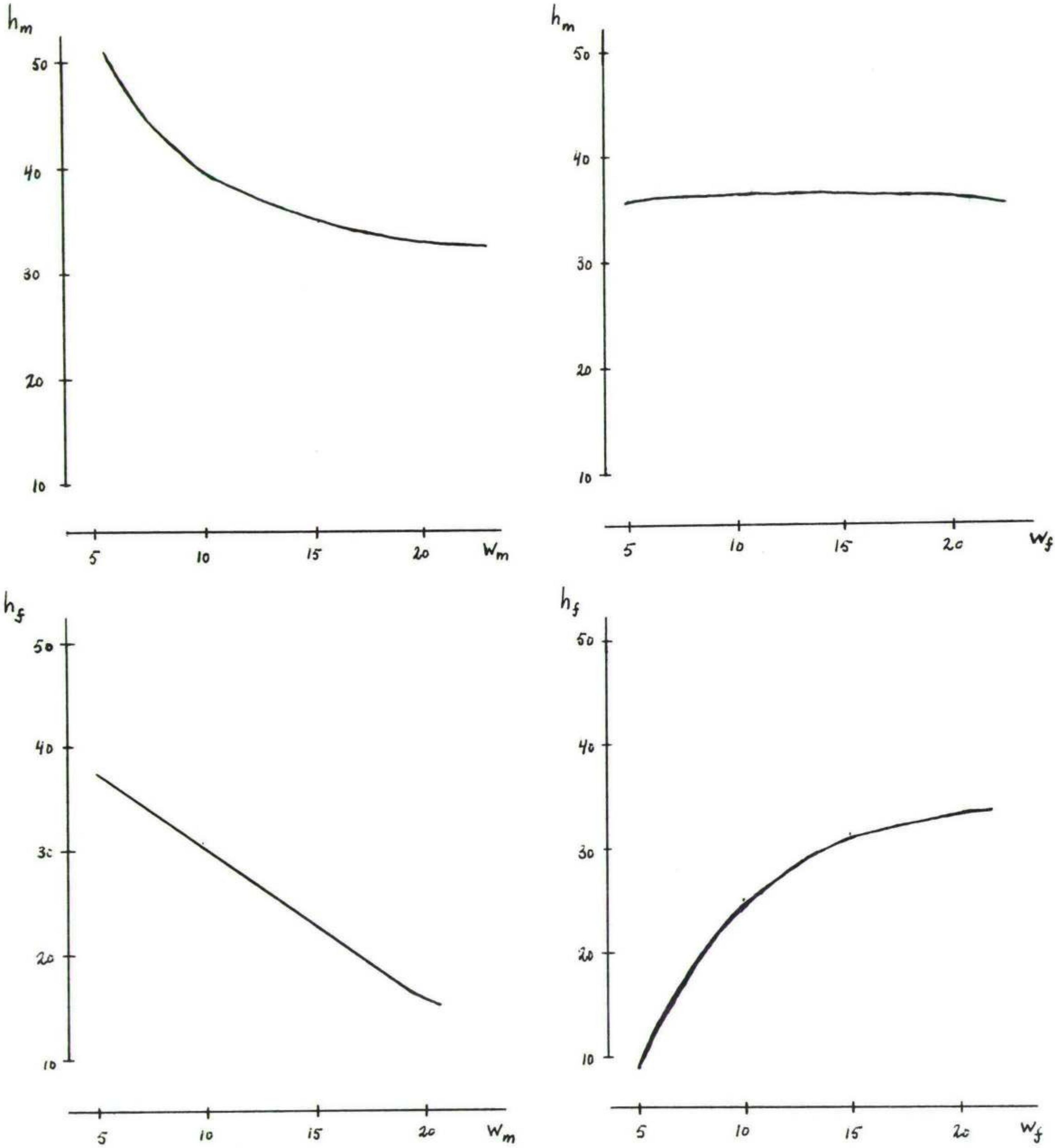

Figure 1. Estimated labor supply functions. (In each diagram all other variables are fixed at their sample means; wage rates are measured in Dfl./hour; hours are per week).

Actual hours

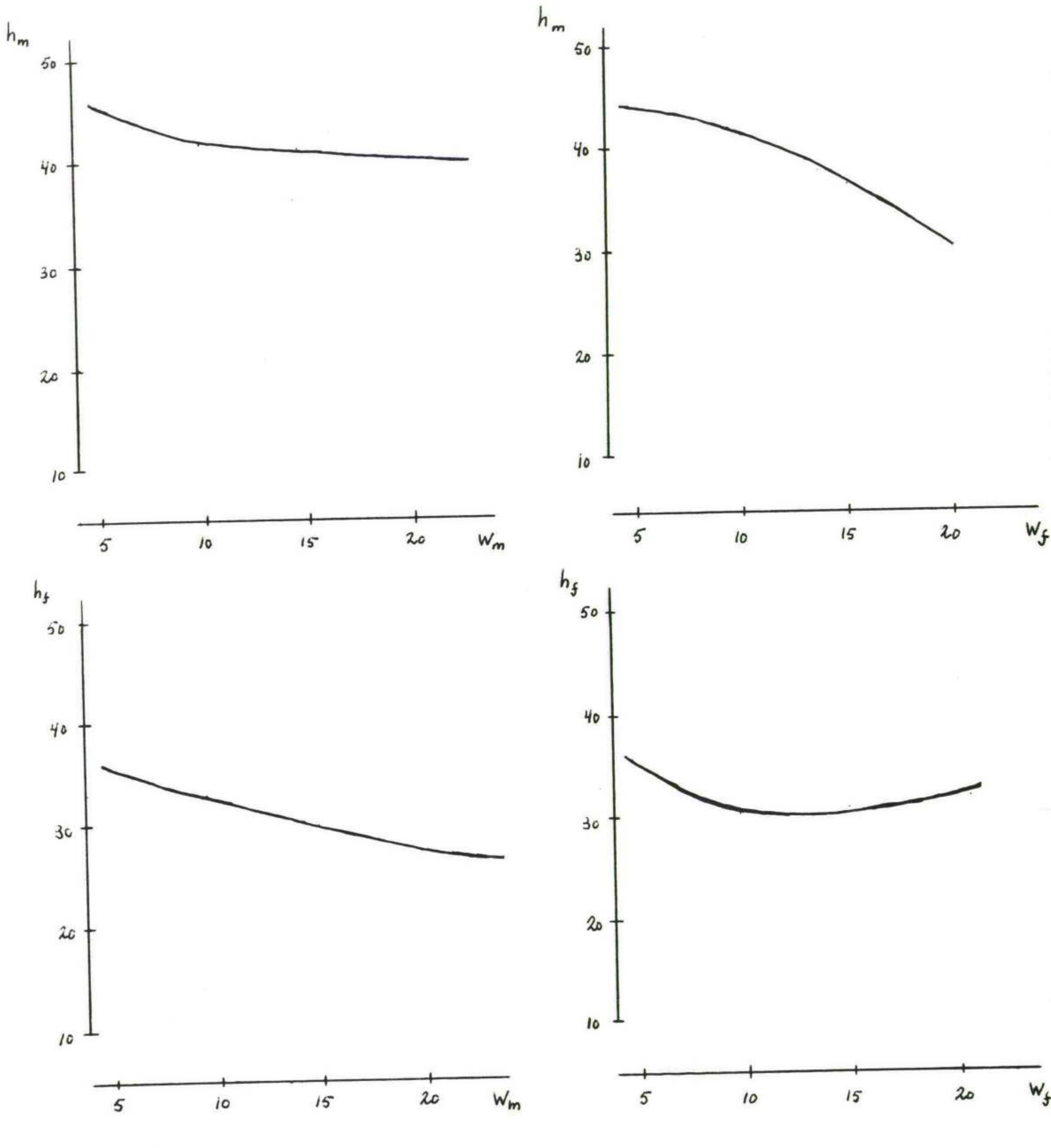

Figure 1. (continued).

For male labor supply the elasticities have opposite signs, although the absolute values of all elasticities are rather small. For female labor supply the signs are the same, but our biggest estimate, for preferred hours, is only about half the values found by Renaud and Siegers. Although any explanation of the differences will have to rest on guesses to some extent, Figure 1 is suggestive. The female labor supply curve for preffered hours is strongly curved, so the value of the elasticity depends very much on the point where it is evaluated. Presumably, our sample mean of w_f is relatively high, because we only consider households where both partners work at least 15 hours. Thus the difference between the elasticity estimates may be partly explained by the particular point at which these are evaluated. A correct comparison should take into account the complete labor supply functions.

5. Policy Simulations

By assuming that household labor supply is consistent with the maximization of a well-behaved utility function, one can investigate both the welfare effects and the behavioral effects of certain policy measures. We shall successively pay attention to a family allowance system and its effect on labor supply and to the effect of rationing of male labor supply on female labor supply and household consumption.

Under the assumption that family composition is exogenous to our model,[1] the cost function immediately gives an answer to the question how much income compensation a family with a certain number of children needs to be as well off as a family without children. Denote the cost function by $c(u,p,w_m,w_f,N)$, i.e. given a price of total consumption p, wage rates w_m and w_f and family size N, it takes full income equal to c to reach utility level u. Then two families of sizes N_1 and N_2 are equally well off if their full incomes Y_1 and Y_2 satisfy

$$\frac{Y_1}{Y_2} = \frac{c(u,p,w_m,w_f,N_1)}{c(u,p,w_m,w_F,N_2)} \;. \qquad (5.1)$$

That is, the family of size N_1 needs Y_1/Y_2 as much full income as the family of size N_2 to reach the same utility level. The ratio (5.1) is usually referred to as a (full income) equivalence scale. In general the equivalence scale depends on u, the reference level of utility chosen.[2]

Let us take as our reference utility level, the utility of a family of four which is facing wages and unearned income equal to the mean values in our sample. The cost function corresponding to AIDS is given in Appendix A. Using the parameter estimates of the model, we have computed the equivalence scale values for various family sizes. These are given in Tables 5 and 6.

1) This is a rather doubtful assumption (see Siegers, 1980, Siegers and Zandanel, 1981, Linssen and Siegers, 1983). Still, the assumption underlies all of the modern literature on family equivalence scales. We maintain the assumption here, but further research into its validity is definitely needed.

2) The same approach as used here, was employed before by Blundell (1980) in a more elaborate model.

Table 5. Full income equivalence scales (preferred hours version).

Family size	Equivalence scale	Effect on male labor supply[a)]		Effect on female labor supply[a)]	
		with compensation	without compensation	with compensation	without compensation
2	0.96	0.86	0.89	1.15	1.05
3	0.98	0.94	0.95	1.06	1.02
4	1.00	1.00	1.00	1.00	1.00
5	1.01	1.04	1.04	0.95	0.99
6	1.02	1.08	1.07	0.91	0.97
7	1.03	1.11	1.09	0.88	0.97
8	1.04	1.14	1.11	0.85	0.96

Table 6. Full income equivalence scales (actual hours version).

Family size	Equivalence scale	Effect on male labor supply[a)]		Effect on female labor supply[a)]	
		with compensation	without compensation	with compensation	without compensation
2	0.82	1.14	0.98	0.81	1.23
3	0.92	1.06	1.00	0.92	1.10
4	1.00	1.00	1.00	1.00	1.00
5	1.07	0.95	1.01	1.06	0.92
6	1.13	0.92	1.02	1.11	0.85
7	1.18	0.89	1.02	1.15	0.80
8	1.23	0.86	1.03	1.19	0.75

a) Keeping wage constant, these columns present relative changes in number of hours supplied when family size changes, relative to size = 4, both when the changes are compensated and when they are not.

Especially for the preferred hours version (Table 5), the equivalence scale values are surprisingly close to each other, but also for actual hours the difference in cost of living between a two-person family and one with six children is lower than usually found with alternative methods (e.g. Kapteyn and Van Praag, 1976, Blokland, 1976). If we accept the model at face value, an interpretation might be that the presence of more children makes leisure more enjoyable. As a result, the cost of reaching a certain utility level does not increase proportionally with the extra expenditures to be made on behalf of the children.

A more realistic explanation may lie in the sample used for the estimation. The 139 households with two income earners that are used in estimation do not show very much variation in family size.[1)] This is so because by definition, the households for which the presence of (young) children is an impediment fot female labor force participations are left out. Although, in principle, our estimation method takes the selective nature of the sample into account, this lack of variation in family size is bound to lead to unrealiable estimates of family size effects. And that is probably what Tables 5 and 6 show.

The effects on labor supply are also somewhat erratic. In Table 5 the compensated and uncompensated effects run parallel. If family size increases, the female works less and the male works more. In Table 6 the uncompensated effects run counter to the compensated effects. The uncompensated effects are in the same direction as in Table 5. But if we compensate for differences in family size, it is the husband who works less when family size increases and the wife who starts working more.

Only by incorporating one earner families into the sample we will be able to obtain more reliable estimates of family composition effects.

Over the last few years there have been various proposals in The Netherlands to reduce unemployment by restricting the number of hours in a full-time job, the idea being that if present employees work fewer hours, employers will hire extra people to make up for the loss of production. It is not our purpose to discuss the merits of this proposal here, but it is of interest to investigate the effects of a rationing of the number of hours supplied by the male partner on the labor supply of the female partner and on

1) Number of children: 0 1 2 3 4 5
Number of observations: 86 10 32 7 3 1.

total family consumption. Once again, all variables not involved in the simulation are fixed at their sample means. Some details of the computation are given in Appendix C.

Table 7. Effect of rationing on female labor supply and total family consumption

Percentage reduction	Actual hours					Preferred hours				
number of working hours of male	h_m	h_f	% change in h_f	v	% change in h_f	h_m	h_f	% change in h_f	v	% change in v
0	41.0	30.3	0	874	0	36.2	25.4	0	760	0
5	39.0	33.6	+10.9	882	+0.9	34.4	27.2	+ 7.1	755	−0.7
10	36.9	36.2	+19.5	881	+0.8	32.6	29.2	+15.0	751	−1.2
20	32.8	40.2	+32.7	867	−0.8	29.0	32.8	+29.1	741	−2.5

The results in Table 7 suggest that a rationing of male working hours will lead the female partner to increase her labor supply to such an extent that total family consumption will almost remain unchanged. Because the average value of the female wage is lower than the average male wage rate, the increase in female labor supply needed to keep consumption unchanged is higher than the corresponding reduction of male working hours.

An anomaly in Table 7 would seem to be that the 10% rationed case for the actual hours version corresponds to a working week which is still slightly longer than the preferred working week without rationing. We have argued in Section 3, however, that the preferred hours reported are probably underestimates. Hence it does not make much sense to compare the preferred number of hours to the actual number of hours.

6. Conclusions

This paper is mainly a methodological exploration of the applicability of AIDS to Dutch individual household survey data on labor supply. The system has proved its flexibility and tests of the household utility maximization hypothesis turn out favorably. The firm rooting in neoclassical demand theory makes the system ideally suited for policy analysis. As two examples, we have dealt with compensations for differences in family size and the possible effects on female labor supply and total household consumption of rationing of male labor supply.

Having established its potential, considerable efforts will have to go into refining and extending the model. These improvements include

- Using a larger sample by also including one earner families. This requires the estimation of a wage equation.
- A more sophisticated model for the effects of family composition.
- A more appropriate modelling of sample selectivity for the preferred hours version.

If longitudinal data were available, we could add to this list:

- Dynamizing the model by incorporating habit formation, so that long run and short run labor supply responses can be disentangled.

Appendix A. AIDS and the Incorporation of Family Size Effects

Consider a household with utility function $U(q_1,\dots,q_n)$ which maximizes this utility function subject to a budget constraint:

$$\sum_{i=1}^{n} p_i\, q_i = Y, \tag{A.1}$$

where p_i and q_i are the price and quantity of the i-th good, $i = 1,\dots,n$, and Y is income. The result of the utility maximization subject to the budget constraint is a set of demand functions.

Dual to the utility function is the cost function $c(u,p_1,\dots,p_n)$, representing the minimum amount of money required to reach utility level u, given prices $p_1,\dots,p_n$. It is well-known that differentiation of the cost function with respect to prices directly gives the demand functions corresponding to utility maximization. Deaton and Muellbauer (1980a, b) propose the following cost function:

$$\log c(u,p) = a(p) + u\, b(p), \tag{A.2}$$

where $p = (p_1,\dots,p_n)^1$ and where a(p) and b(p) are specified as follows:

$$a(p) = a_0 + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_k \sum_j \gamma_{kj} \log p_k \log p_j \tag{A.3}$$

$$b(p) = \log a(p) + \beta_0 \prod_k p_k^{\beta_k}, \tag{A.4}$$

where a_0, α_k, γ_{kj}, β_0, β_k are parameters. The parameters satisfy

$$\sum_k \alpha_k = 1,\ \sum_k \beta_k = 0,\ \gamma_{kj} = \gamma_{jk},\ \sum_k \gamma_{kj} = 0 \tag{A.5}$$

Since the cost function is quadratic in prices it can serve as a local second order approximation to an arbitrary cost function. Hence, the cost function has a so-called flexible form.

Differentiating the cost function with respect to prices leads to the compensated (Hicksian) demand functions for the utility level u. By next solving (A.2) for u and substituting the solution for u into the compensated demand functions we obtain the uncompensated demand functions. In share from these look as follows:

$$s_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log y - \beta_i . a \quad i = 1,\dots,n \tag{A.6}$$

where $s_i = p_i\, q_i/Y$.

In this model the effect of family composition can be introduced quite naturally by following an approach due to Barten (1964). Let the family utility function be redefined in per capita terms:

$$U = U(\frac{q_1}{m_1}, \frac{q_2}{m_2}, \dots, \frac{q_n}{m_n}) \equiv U(x_1,\dots,x_n) , \tag{A.7}$$

where $x_i \equiv q_i/m_i$, $i = 1,\dots,n$, and where m_i is the number of equivalent adults in the household with respect to the i-th good. The budget constraint can be rewritten as

$$\sum_i p_i\, q_i = \sum_i p_i\, m_i \frac{q_i}{m_i} = \sum_i p_i^* x_i = Y , \tag{A.8}$$

with $p_i^* = p_i\, m_i$. Thus family size effects are introduced as pseudo-price effects. The incorporation of family size effects into the AIDS-model simply takes place by replacing all p_i in (A.3) and (A.4) by p_i^*.

The last step to be taken is to find a reasonable specification for m_i as a function of family composition. We propose the following simple form

$$m_i = N^{\theta_i} , \tag{A.9}$$

where N is the number of family members.

For the case considered in this paper there are three goods, female leisure with price w_f, male leisure with price w_m and total consumption with price equal to one. Taking this into account, model (2.2)-(2.11) is equivalent with the model discussed here.

In Section 4 a check of the negativity conditions per observation is reported. The negativity conditions refer to the fact that the matrix of derivatives of Hicksian demand functions with respect to all prices must be negative semidefinite. This condition is equivalent to concavity of the cost function. Concavity of the cost function is necessary since household utility maximization is equivalent with (dual to) minimization of expenditures for a given utility level. (See e.g. Deaton and Muellbauer 1980a, p. 39). The cost function is concave if and only if the matrix with elements

$$c_{ij} = \gamma_{ij} + \beta_i \beta_j \{\log(Y)-a\} - s_i \delta_{ij} + s_i s_j \qquad i,j = m,f,y \quad (A.10)$$

where δ_{ij} is one if $i = j$ and zero otherwise, is negative semidefinite. A necessary condition for negativity is that the own compensated (Hicksian) price elasticity is negative.

For the concavity checks reported in Section 4 we have used (A.10) with the observed values of s_i and s_j inserted. We might also have used predicted values of s_i and s_j, but since we are checking the consistency of actual choices (or preferred ones) with utility maximization, it is more natural to use the observed values.

Appendix B. Details of Estimation

The budget shares s_m and s_f in (2.2) and (2.3) are bounded from below and from above. The lower bound (i.e. zero leisure, or working 168 hours per week) is never achieved, so we neglect it. The upper bound is achieved whenever a male or female decides not to work in a paid job. In the empirical analysis we only use observations on households where the male works full time and the female works at least 15 hours per week (cf. Section 3). In the estimation procedure we have to take this sample selection rule into account.

Since there are not many households where the female partner works more than 15 hours a week and the male does not work full-time, we only take into account the more stringent sample selection rule for female labor supply. Thus we consider a system of two equations and a sample selection rule according to which a household is only observed if the dependent variable of the second equation falls within a certain range. Without loss of generality we can describe that situation as follows[1)]

$$Y_i = X'\beta_i + \varepsilon_i \,, \qquad i = m,f. \tag{B.1}$$

where we assume ε_i to be normally distributed with mean zero and variance σ_i^2. In (2.2) and (2.3) there are restrictions on the elements of β_i. The restriction on the budget share of female leisure is expressed as $Y_f > 0$, and we only observe households if $Y_f > 0$.

There holds

$$E(\varepsilon_i | Y_f > 0) = E[\varepsilon_i | \varepsilon_f > -X'\beta_f] = \lambda\, \sigma_{if}/\sigma_f \,, \quad i = m,f \tag{B.2}$$

with $\lambda = n(L)/(1-N(L))$, where $L = -X'\beta_f/\sigma_f$ and $n(.)$ and $N(.)$ are the standard normal density and distribution function respectively. If λ were known we could estimate β_i consistently by means of joint restricted[2)] maximum likelihood applied to

1) The exposition closely resembles the one given by Blundell and Walker (1982).

2) Because of the restrictions on the elements of β_i.

$$Y_i = X'\beta_i + \delta_i\ \lambda, \qquad i = m,f \tag{B.3}$$

where $\delta_i = \sigma_{if}/\sigma_f$. Since λ is unknown it has to be estimated. We employ the estimation method developed by Amemiya (1973).

He observes that

$$E[Y_f^2 | \varepsilon_f > -X'\beta_f] = X'\beta_f\ E[Y_f | \varepsilon_f > -X'\beta_f] + \sigma_f^2 \tag{B.4}$$

Amemiya therefore estimates β_f from

$$Y_f^2 = Y_f\ X'\beta_f + \sigma_f^2 + \eta\ , \tag{B.5}$$

with $\eta = \varepsilon_f^2 - \sigma_f\ L\ \varepsilon_f - \sigma_f^2$, using $(X\hat{Y}_f,1)'$ as instruments; $\hat{Y}_f$ is the least squares prediction of Y_f from (B.1). He shows that this procedure produces a consistent estimate of β_f and σ_f^2. Consequently, one can derive L and next λ. This estimate of λ is used in (B.3) and the parameters in (B.3) are next estimated by means of maximum likelihood. In the first step we have ignored the restrictions on the elements of β_i. This entails a possible loss of efficiency in the estimation of λ, but it does not impair consistency of the estimates in the second step.

The standard errors of the parameter estimates presented in Tabel 1 are based on the ML-procedure applied to (B.3), but we have ignored the extra uncertainty caused by the fact that λ in (B.3) has to be estimated first. The standard errors presented are therefore underestimates of the true standard errors.

For the preferred hours version the cut-off point has been taken to be equal to twelve hours, being the lowest number of hours any female respondent preferred to work. As indicated in Section 3, the sample selection model presented does not quite apply to the preferred hours version, because there are <u>two</u> sample selection rules: the number of preferred hours should exceed twelve and the number of actual hours should exceed fifteen. In the estimation of the preferred hours version the second selection rule has been ignored.

The second step of the estimation procedure also produces estimates of δ_i in (B.3). For the two versions of the model these turn out to be (asymptotic values in parentheses):

	preferred hours	actual hours
δ_1	-0.10	0.19
	(-1.1)	(2.3)
δ_2	-0.29	-0.11
	(-3.2)	(-1.5)

Appendix C. The Computation of Rationed Supply Functions

We closely follow the expositions in Blundell and Walker (1982) and Deaton and Muellbauer (1980a). Let male leisure be restricted: $\ell_m = \bar{\ell}_m$. Then we want to derive the demand for female leisure, with price w_f, and total consumption, with price p. The unrestricted cost function is defined as

$$c(u,p,w_m,w_f) = \min_{y,\ell_f,\ell_m} (w_f\ \ell_f + w_m\ \ell_m + y|u). \tag{C.1}$$

The restricted cost function is defined as

$$\bar{c}(u,p,w_f\ \bar{\ell}_m) = \min_{y,\ell_f} (w_f\ \ell_f + w_m\ \bar{\ell}_m + y|u,\bar{\ell}_m) =$$

$$= \min_{y,\ell_f} (w_f\ \ell_f + y|u,\bar{\ell}_m) + w_m\ \bar{\ell}_m \tag{C.2}$$

Let $\bar{w}_m$ be the wage rate that would induce the household to choose $\ell_m = \bar{\ell}_m$ in the unrationed case. Then there holds

$$c(u,p,\bar{w}_m,w_f) = \bar{c}(u,p,w_f|\bar{\ell}_m). \tag{C.3}$$

because at $\bar{w}_m$ the rationing would not affect the cost of achieving utility level u. Combining (C.2) and (C.3) yields

$$c(u,p,\bar{w}_m,w_f) = \min_{y,\ell_f} (w_f\ \ell_f + y|u,\bar{\ell}_m) + \bar{w}_m\ \bar{\ell}_m =$$

$$= \min_{y,\ell_f} (w_f\ \ell_f + y + w_m\ \bar{\ell}_m|u,\bar{\ell}_m) + \bar{w}_m\ \bar{\ell}_m - w_m\ \bar{\ell}_m$$

$$= \bar{c}(u,p,w_f|\bar{\ell}_m) + \bar{\ell}_m(\bar{w}_m - w_m). \tag{C.4}$$

So, we can express the restricted cost function in the unrestricted cost function as follows:

$$\bar{c}(u,p,w_f\ \bar{\ell}_m) = c(u,p,\bar{w}_m,w_f) + \bar{\ell}_m(w_m-\bar{w}_m) \tag{C.5}$$

The restricted demands for female leisure and total consumption are found by partial differentiation of the restricted cost function with respect to w_f and p. In the differentiation one has to take into account the dependence of $\bar{w}_m$ on w_f and p, because $\bar{w}_m$ is found by setting $\ell_m = \bar{\ell}_m$ in the compensated demand function for male leisure and next solving for $\bar{w}_m$.

So we have for the restricted compensated demand for female leisure:

$$\ell_f = \frac{\partial c(u,p,\bar{w}_m,w_f)}{\partial w_f} + \frac{\partial c(u,p,\bar{w}_m,w_f)}{\partial \bar{w}_m} \cdot \frac{\partial \bar{w}_m}{\partial w_f} - \bar{\ell}_m \cdot \frac{\partial \bar{w}_m}{\partial w_f}$$

$$= \frac{\partial c(u,p,\bar{w}_m,w_f)}{\partial w_f} + \bar{\ell}_m \cdot \frac{\partial \bar{w}_m}{\partial w_f} - \bar{\ell}_m \cdot \frac{\partial \bar{w}_m}{\partial w_f} = \frac{\partial c(u,p,\bar{w}_m,w_f)}{\partial w_f} . \tag{C.6}$$

This is just the unrestricted compensated demand function at $w_m = \bar{w}_m$. The uncompensated demand function is found by solving u from

$$Y = c(u,p,\bar{w}_m,w_f) + \bar{\ell}_m(w_m-\bar{w}_m) \tag{C.7}$$

and substituting the solution for u into the compensated demand function (C.6).

Since u can not be solved from (C.7) explicitly, a numerical procedure has to be used.

Note, incidentally, that the cost functions can be used to assess how much extra full income it takes to reach a utility level u in the rationed case, compared to the unrationed case.

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