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A MICRO-ECONOMETRIC ANALYSIS OF VACATION BEHAVIOUR

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SUMMARY

We present a micro-econometric limited dependent variable model, which simultaneously explains the decision whether to go on vacation or not, the choice of destination and the decision on the level of the vacation expenditures. The model has been estimated on the basis of a cross-section of Dutch households; we find a striking difference in income elasticity between domestic vacations and vacations abroad, and a large impact of owning certain durables (such as a boat) on the choice of destination. To illustrate the potential of the model, some simulations are performed.

1. ECONOMICS AND VACATION BEHAVIOUR

During the past few decades going on vacation has become a common phenomenon in Western countries. Accordingly, the economic significance of tourism has largely increased, both in terms of its impact on GNP and in terms of the number of people employed in the tourist industry. Especially in some Western European countries, such as The Netherlands, tourism substantially influences the current account of the balance of payments.

In the empirical literature on vacation behaviour one can distinguish two types of work. One approach is to analyse aggregate time series of travel flows between countries, using aggregate income, prices and exchange rates as the main explanatory variables. Examples can be found in Gray (1966) and Bond (1979). Alternatively, one may analyse individual (cross-section) data on recreational and vacation behaviour. Most of this literature focuses on modelling the determinants of choices of recreational activities or on examining the demand for recreational sites; see for example Cicchetti (1973) and Morey (1984, 1985).

The present paper is in the spirit of the latter approach. It presents a micro-econometric limited dependent variable model which simultaneously explains the decision whether to go on vacation or not, the choice between a domestic vacation and a vacation abroad as well as the decision on the level of vacation expenditures. The model will be estimated on the basis of a cross-section of 1822 Dutch households.

As has been stressed by Morey (1984, 1985), vacation activities can be seen as household products which are produced by the household using market goods (such as recreational services, food, gasoline and so forth) and the time of the household members as inputs. In this household production approach the household is assumed to maximize a utility function defined over vacation and other activities, subject to the production technology constraints, the time and the income constraints. This determines the demand for market goods as well as time inputs as functions of all input prices (including wage rates) and (non-labour) income.

This approach thus explicitly recognizes the role of time costs in determining vacation decisions. Although we cannot incorporate wage rates directly in our empirical model, due to a lack of information on wages in the available sample, the effect of time costs will be captured by including wage predictors as explanatory variables.

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Section 2 presents the model. In section 3 we discuss the data and estimate the model employing recently developed econometric methodology for the estimation of limited dependent variable models. Section 4 presents some simulation results. Section 5 concludes.

2. A MICRO-ECONOMETRIC MODEL OF VACATION BEHAVIOUR

In this paper we confine ourselves to distinguishing two types of vacations, i.e. vacations spent in one's home country and vacations abroad. Of course, vacations differ in many other respects, such as means of transportation, housing, season in which they take place, duration, etc. The distinction between domestic vacations and vacations abroad, however, is particularly useful from a macro-economic point of view, because of its relevance for the current account of the balance of payments. In The Netherlands, for example, the annual deficit on the travel account amounts to 5 billion guilders approximately, or 1·5 per cent of GNP. For a policy aimed at a reduction of this deficit it is important to know which factors affect households' decisions whether or not to spend a vacation abroad.

To specify the model we start from Working–Leser Engel curves (see Deaton and Muellbauer, 1980):

$$w_i = \alpha_i + \beta_i \log y, \quad i = 1, 2. \tag{1}$$

where y denotes the household's after-tax income minus net savings;* w_1 and w_2 denote expenditures on domestic vacations and vacations abroad as a fraction of y, respectively. The α_i and β_i ($i = 1, 2$) are parameters.† If w_i is positive the corresponding elasticity of expenditures on vacations in destination i with respect to income is given by

$$\eta_y^i = 1 + \frac{\beta_i}{w_i}. \tag{2}$$

Thus, for example, a vacation spent abroad is a luxury if and only if $\beta_2 > 0$.

The prices of market goods and wage rates do not appear explicitly as explanatory variables in equation (1). Given that we use cross-section data in which all households can be assumed to face the same prices of market goods, the effect of different prices for domestic vacations and vacations abroad will be absorbed into the constant terms α_i. Due to the lack of information on working hours, we are unable to calculate the wage rates of the household members. Rather than using wages directly, we will therefore use variables such as education and age which have turned out to be important predictors for wage rates in several wage studies (see, for example, Kiefer and Neumann 1981, and Meyer and Wise, 1983). In particular, we allow the parameters α_i to vary with the wage predictors and other household characteristics. Thus, equation (1) can be seen as a reduced form equation which is obtained by eliminating the wage rate from the original demand equation using a wage equation.

Expenditures on vacation are of a mixed discrete/continuous nature. The decision whether to go on vacation or not, and the decision which destination to choose are discrete, whereas the decision on how much to spend is continuous. This is reflected by the relatively large number of zero expenditure observations; see Table I.

*By using after-tax income minus savings (i.e. total expenditures) rather than income, our model is consistent with a two-stage-budgeting life cycle model; see for example Deaton and Muellbauer (1980), ch. 5. In what follows we will refer to y as 'income'.

†An alternative formulation is to include a dummy variable on the right-hand side of equation (1) which is 1 if the household chooses destination j ($\neq i$) and 0 otherwise. However, only under stringent conditions is such a model logically consistent (see, for example, Schmidt, 1981). Therefore we prefer the 'reduced form' model as described in (1). For a discussion of the capability of this model to account for the simultaneity of the various decisions, see section 3.

Table I. Distribution of expenditures on domestic vacations and vacations abroad (in Dfl)[a]

Vacations abroad	Domestic vacations 0	0–800	800–1600	1600–2400	>2400	Total
0	37·0	8·3	8·2	3·5	1·6	58·7
0–800	2·3	0·7	0·2	0·1	0·0	3·3
800–1600	7·5	1·2	0·8	0·2	0·0	9·6
1600–2400	8·3	0·9	0·7	0·1	0·1	10·1
2400–3200	5·6	0·8	0·4	0·2	0·0	6·9
3200–4000	4·0	0·4	0·1	0·0	0·1	4·7
>4000	5·9	0·6	0·2	0·0	0·0	6·7
Total	70·5	13·0	10·6	4·1	1·8	100

[a]Based on 1822 household observations from the 1981 Consumer Expenditure Survey in The Netherlands.

Most of the households either choose only one of the two destinations ($w_1 = 0$ or $w_2 = 0$) or do not spend anything on vacations at all ($w_1 = 0$ and $w_2 = 0$). Only few of them spend money on both domestic vacations and vacations abroad.

Table I also reveals that there are relatively few households with low positive expenditures on vacations, in particular on vacations abroad. This is mainly due to the definition of a 'vacation' used in the survey from which the data come. Only if one stays away from home for recreation purposes at least four successive nights is it considered a vacation.

To take this selection rule into account we assume that we only observe positive expenditures on vacations if they exceed the minimal (unobserved) costs m_i associated with a 4-day vacation in destination i, i.e. we have

$$\begin{aligned} w^*_i &= \alpha_i + \beta_i \log y \\ w_i &= w^*_i \text{ if } w^*_i > m_i/y \\ w_i &= 0 \text{ if } w^*_i < m_i/y, \\ i &= 1, 2. \end{aligned} \tag{3}$$

The parameters α_i and β_i, as well as the threshold values m_i, may be different for different households. In our specification we allow α_i and m_i to vary with household characteristics, while β_i is assumed to be identical across households.

Furthermore, we add error terms α_i to the budget share equations and error terms β_i to the threshold equations.

Summarizing, the model consists of the following equations:

$$w^*_i = \sum_{k=0}^{K_w} \alpha_{ik} x_k + \beta_i \log y + \varepsilon_i \tag{4a}$$

$$m_i = \sum_{k=0}^{K_m} \gamma_{ik} z_k + \delta_i \tag{4b}$$

$$\begin{aligned} w_i &= w^*_i \text{ if } w^*_i > m_i/y \\ w_i &= 0 \text{ if } w^*_i < m_i/y, \\ i &= 1, 2 \end{aligned} \tag{4c}$$

where $x = (x_0, x_1, \ldots, x_{K_w})'$ and $z = (z_0, z_1, \ldots, z_{K_m})'$ are vectors of household characteristics,* including a constant term. The error terms ε_i and δ_i are assumed to follow a joint normal distribution:†

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \delta_2 \\ \delta_2 \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 & 0 & 0 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 & 0 & 0 \\ 0 & 0 & \tau_1^2 & \psi\tau_1\tau_2 \\ 0 & 0 & \psi\tau_1\tau_2 & \tau_2^2 \end{bmatrix} \right) \tag{5}$$

The parameters α_{ik}, β_{ik}, γ_{ik}, σ_i, τ_i, ρ and ψ have to be estimated.

3. DATA, ESTIMATION METHOD AND RESULTS

The data set we used in estimating the model (4)–(5) stems from a survey held in 1981 as part of the 'Consumer Expenditure Survey' of the Netherlands Central Bureau of Statistics (CBS), containing data on 2896 households. We used only data on households with at least two adult partners. Vacation behaviour of single individuals or incomplete families seemed too different from the behaviour of complete families to be treated within the same model.

Having removed a few households with incomplete or inconsistent information on one or more of the variables, we obtained a data set consisting of 1822 observations. In Table II some sample statistics are presented.

The model has been estimated by maximum likelihood. Details on the likelihood function and its maximization are given in Appendix B. The estimation results are given in Table III. The upper panel of this table contains the parameters in the budget share equations (4a), where budget shares are expressed as a percentage of the household's income. Most of the parameter estimates in these equations significantly differ from zero. In particular, the equation for vacations abroad yields some very large t-values.

The signs of the parameter estimates for α_{ik} are largely in accordance with what one would expect. Large families tend to stay in the home country; older people spend less on vacations and in particular they are not inclined to go abroad. The higher the education level of the family head, the more money the family will spend on vacations abroad. Apparently, a positive direct impact (a shift in preferences) dominates the impact through the wage, which is expected to be negative, since a rise in education level leads to a rise in wage, i.e. larger opportunity costs of spending one's time on a vacation. With respect to the latter effect, it should be borne in mind that, at least in The Netherlands, the number of days available for vacation is fixed for employed wage-earners. People who live in big cities prefer going abroad. If the family head has no job, this keeps the family from having a domestic vacation, but surprisingly it has a negligible (direct) impact on going on vacation abroad. Students feel very much attracted to foreign countries. Farmers and other self-employed individuals are not big vacation spenders, especially not in the home country.

The results with respect to the ownership of durables are also in accordance with intuition. The ownership of a second home, a mobile home or a boat stimulates the family to spend a

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*x includes demographic variables, dummy variables representing the occupational status of the family head and dummy variables indicating whether the household owns durable goods, which are thought to be relevant for vacation behaviour, such as a second home, a boat etc.; z includes a constant term, family size and the same dummies pertaining to durable ownership.

†To keep the computational burden of estimation within manageable proportions, we imposed block diagonality *a priori*.

Table II. Sample statistics

	Mean	Standard deviation
Expenditures on domestic vacations (Dfl)[a]	1078	805
Expenditures on vacations abroad (Dfl)[a]	2657	1909
Total household expenditures	34,150	12,500
Family size	3·21	1·2
Age class family head[b]	4·59	2·9
Education index family head[c]	2·31	1·1
Degree of urbanization[d]	3·86	1·7
Family head inactive[e]	0·371	0·48
Family head full-time student[e]	0·008	0·09
Family head is self-employed[e] (incl. farmer)	0·060	0·24
Car/motorbicycle[f]	0·767	0·39
Tent/trailer[f]	0·187	0·39
Second home/mobile home[f]	0·048	0·21
Boat[f]	0·056	0·23

Explanation

[a]Mean and sample standard deviation are computed for non-zero observations.
[b]1: < 20 years old, 2: 20–24 years old, 3: 25–29 years old, . . . , 12: 70–74 years old, 13: > 74 years old.
[c]Ranging from 1 to 5.
[d]Ranging from 1 (country village) to 6 (big city).
[e]Dummies pertaining to the family head's occupation. If all three dummy values equal 0, then the family head is an employee or manager of a firm he does not own.
[f]Dummies with value 1 or 0, depending on whether or not the household owns (one or more species of) the durable good concerned.

vacation in The Netherlands. For example, for the average household the ownership of a boat changes the domestic participation probability from 0·28 to 0·44, while the participation probability for a vacation abroad decreases from 0·43 to 0·35.

β_i reflects the impact of income on the budget share for vacations with destination i. We notice that this impact is slightly negative for domestic vacations and largely positive for vacations abroad. Clearly a vacation abroad is a luxury, whereas a domestic vacation turns out to be a necessity.

Figures 1 to 3 show the participation probability, expected expenditures conditional on participation and expected expenditures as a function of income y; see Appendix A for mathematical details. Other variables in the equations are set equal to their sample means. Again, vacations abroad turn out to be much more sensitive to changes in income than domestic vacations.

The impact of an income increase on the probability of a domestic vacation is the result of two opposite effects. If income is already high, an income rise will lead to a substitution of a domestic vacation by a vacation abroad, resulting in a smaller probability, whereas if income is low an income rise will result in a larger probability of going on vacation.

Figure 3 reveals a positive relationship between income and expected expenditures on both domestic vacations and vacations abroad, and thus shows that both goods are normal. The convexity of the curve for vacations abroad again illustrates that a vacation abroad is a luxury, whereas a domestic vacation is a necessity.

The estimates $\hat{\sigma}_1 = 4{\cdot}3$ and $\hat{\sigma}_2 = 6{\cdot}8$ for the standard deviations of w_1^* and w_2^* imply that, for

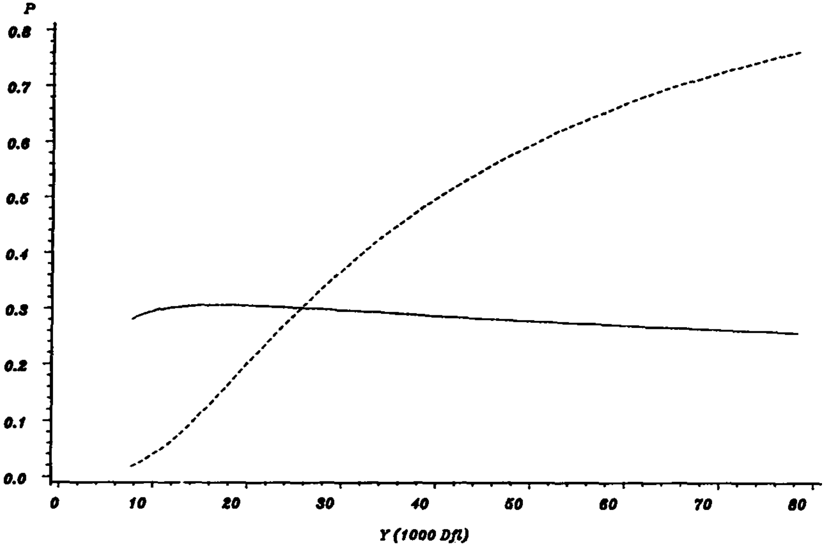

Figure 1. Participation probabilities (P) for the mean household as a function of family income (Y) —— domestic vacation; ---- vacation abroad

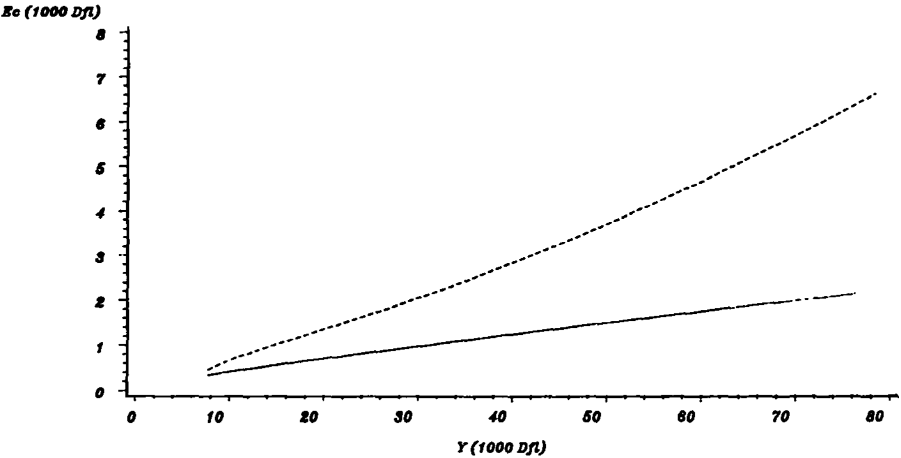

Figure 2. Expected amount spent given participation (Ec) for the mean household as a function of family income (Y) —— domestic vacation; ---- vacation abroad

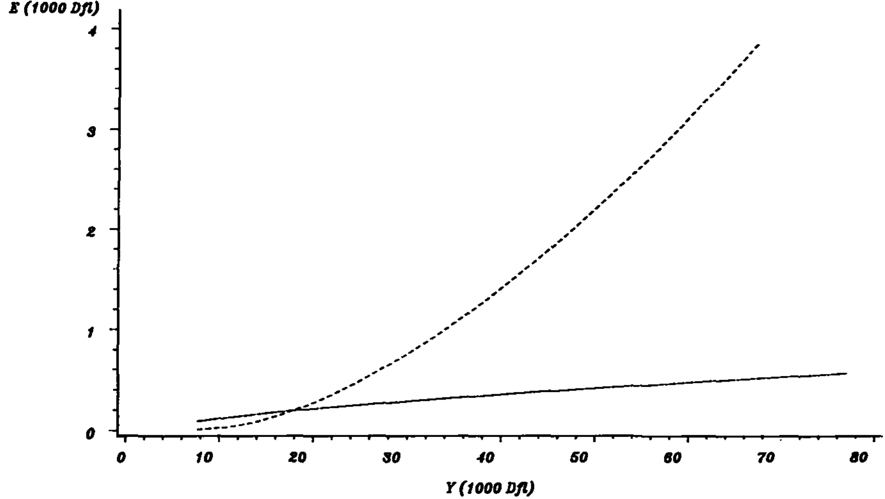

Figure 3. Expected amount spent (E) for the mean household as a function of family income (Y) —— domestic vaction; ---- vacation abroad

the average household, the standard deviation of ε_1, given participation on a domestic vacation equals 2·23, and the standard deviation of ε_2, given participation on a vacatic 1 abroad, equals 3·95. The values of $\hat{\sigma}_1$ and $\hat{\sigma}_2$ can be used to compute a goodness-of-fit measure for each budget share equation separately, given by

$$R_i = \sqrt{\left[\sum_{t=1}^{1822} (z_{it} - \bar{z}_{i.})^2 \bigg/ \left(\sum_{t=1}^{1822} (z_{it} - \bar{z}_{i.})^2 + 1822\, \hat{\sigma}_i^2\right)\right]} \quad (i = 1, 2)$$

where

$$z_{it} = \sum_{k=0}^{K_w} \alpha_{ik} x_{kt} + \beta_i \log y_t, \quad i = 1, 2; t = 1, 1822.$$

So, R_i^2 is the explained variance in $w^*_i \Gamma$ as a fraction of the sum of the explained variance in w^*_i and the variance due to the error term. This sum is an approximation to the unobservable total variance in w^*_i which would be exact if there were only non-zero observations. This measure seems to be the appropriate substitute for the ordinary multiple correlation coefficient in an OLS estimation. The computed values are $R_1 = 0{\cdot}19$ and $R_2 = 0{\cdot}40$ for domestic vacations and vacations abroad respectively.

The lower panel of Table III concerns the parameters in the threshold equations (4b), where threshold values are expressed in Dfl. Due to large constant terms the threshold values are positive for almost all observations. The negative estimate (though small and insignificant) for the impact of family size on the threshold value contradicts our intuition, but it should be borne in mind that not every member of the household has to participate in a vacation. The ownership of a car or motor bicycle makes it cheaper to travel abroad, and thus leads to a lower threshold value. The ownership of a second home (which is usually located in the home country) turns out to involve a significant amount of fixed costs and thus seems to decrease the

Table III. Estimation results (asymptotic standard errors in parentheses)

w^* equation (in percentages)	Domestic vacations		Vacations abroad
Constant term	6·0 (4·6)		−59·3 (7·6)
Log total expenditures	−0·9 (0·5)		5·9 (0·7)
Family size	0·4 (0·1)		−0·9 (0·2)
Age class family head	−0·1 (0·06)		−0·5 (0·09)
Education class family head	0·0 (0·1)		0·4 (0·2)
Degree of urbanization	0·1 (0·08)		0·6 (0·1)
Family head is inactive	−0·8 (0·4)		−0·1 (0·6)
Family head is student	0·4 (1·4)		5·2 (1·9)
Family head is self-employed	−1·6 (0·6)		−0·4 (0·8)
Car/motorbike	−0·3 (0·3)		0·2 (0·5)
Tent/trailer	0·4 (0·3)		0·8 (0·5)
Second home/mobile home	0·6 (0·6)		−3·5 (1·1)
Boat	1·9 (0·5)		−1·4 (0·9)
σ	4·3 (0·2)		6·8 (0·2)
ρ		−0·4 (0·03)	

m equations (in Dfl)	Domestic vacations		Vacations abroad
Constant term	155 (61)		989 (119)
Family size	−16 (13)		−46 (32)
Car/motor bicycle	51 (37)		−168 (85)
Tent/trailer	−2 (42)		−127 (99)
Second home/mobile home	169 (74)		−93 (239)
Boat	57 (65)		187 (170)
τ	97 (28)		339 (49)
ψ		0·4 (0·7)	

probability of a domestic vacation. This counterintuitive result might merely indicate, however, that a second home is mainly used for vacations shorter than 4 days. The other effects are all insignificant.

The small t-values for many parameters—both in budget share equations and threshold value equations—concerning durables may suggest that the ownership of some durables does not have a significant impact on vacation behaviour. This hypothesis (each of the parameters $\alpha_{1k}, \alpha_{2k}, \gamma_{1k}$, and γ_{2k}, equals zero), however, is rejected by a Wald test with size 0·10 for all four groups of durables.*

The correlation coefficient ρ differs significantly from zero, which justifies our simultaneous treatment of domestic vacations and vacations abroad. To test the independence assumptions between the error terms ε_i ($i = 1, 2$) and δ_j ($j = 1, 2$) we performed a Lagrange multiplier test. The value of the test statistic was 2·92 (critical value: $\chi^2_{4;0\cdot10} = 7\cdot78$), so that the independence assumptions cannot be rejected.†

*The values of the Wald-statistic are 7·93 for a car or motor bicycle, 9·19 for a tent or trailer, 19·06 for a second home or mobile home and 15·57 for a boat, whereas the corresponding critical value $\chi^2_{4;0\cdot10} = 7\cdot78$.

†All correlation coefficients are identified if at lease one of the explanatory variables in the budget share equations is not included in the threshold equations; cf. Maddala (1983, ch. 8).

The capability of the model to account for the simultaneity of the decisions to go on vacation abroad and/or in The Netherlands is borne out by the following conditional probabilities (calculated for the average household):

$$P(w_1 > 0 | w_2 > 0) = 0{\cdot}174 \quad P(w_1 > 0 | w_2 = 0) = 0{\cdot}379$$

$$P(w_2 > 0 | w_1 > 0) = 0{\cdot}254 \quad P(w_1 > 0 | w_1 = 0) = 0{\cdot}496$$

This result reflects the large negative estimated value of ρ. Loosely speaking, it says that the probability of choosing destination j decreases substantially if one decides to go on vacation in destination i. This is in accordance with the empirical finding that most families choose only one destination.

In general, the estimates for parameters in the threshold equations seem to be less precise than the ones in the budget share equations. This can be explained by the fact that threshold values are never observed, whereas w^*_i is observed directly if expenditures on vacations in destination i are positive (see also Nelson, 1977).

4. SIMULATIONS

To illustrate the macro-economic implications of the estimated micro-economic model, some simulations are performed on the sample of 1822 households we used for the estimation.

Table IV shows the impact of a change of all family incomes by the same factor on the sample means of participation probabilities and (conditional and unconditional) expected expenditures on vacations. Domestic vacations show only a slight dependency on family income: a rise of 1 per cent in income results in a fall of only 0·1 per cent in the domestic participation probability, while the expected amount spent on domestic vacations rises with 0·7 per cent. Vacations abroad are much more sensitive to family income. An income rise of 1 per cent causes a rise of 1·0 per cent of the participation probability and a rise of 2·1 per cent of the expected expenditures, indicating that vacations abroad are a luxury. These macroeconomic elasticities are largely in accordance with the microeconomic elasticities for the 'mean household' which can be derived from Figures 1 through 3; see Table V.

Table IV. Effects of a change of all total expenditures by the same factor

Factor	$P(w_1 > 0)$	$P(w_2 > 0)$	$E(w_1 y \mid w_1 > 0)$	$E(w_2 y \mid w_2 > 0)$	$E(w_1 y)$	$E(w_2 y)$
0·90	0·2978	0·3571	995·9	2153·1	305·3	903·2
0·99	0·2952	0·3951	1078·0	2398·5	327·3	1102·9
1·00	0·2949	0·3992	1087·0	2426·3	329·7	1126·0
1·01	0·2946	0·4032	1096·1	2454·2	332·1	1149·3
1·10	0·2919	0·4378	1177·3	2710·2	353·3	1366·7

Table V. Income elasticities

	Macro elasticity	Micro elasticity
$P(w_1 > 0)$	−0·1	−0·1
$P(w_2 > 0)$	1·0	1·0
$E(w_1 y)$	0·7	0·7
$E(w_2 y)$	2·1	2·2

The advantage of using a micro-economic model is that not only the impact of an overall change in income level can be measured, but also the effect of a change in the distribution of incomes. We have investigated this latter impact by redistributing incomes in such a way that the sample standard deviation of the logarithm of incomes decreases with 10 per cent, keeping the average income constant.* As a result the ratio of the maximum and minimum income in the sample falls from 8·4 to 6·8. The impact on domestic vacations proves to be negligible. The participation probability and the expected expenditures rise with only 0·03 per cent and 0·04 per cent respectively. The effects on vacations abroad are larger. An egalitarian redistribution of 10 per cent results in an increase of the participation probability with 1·2 per cent, whereas expected expenditures fall by 1·5 per cent. The explanation is clear: Reduction of inequality allows more people to 'cross the threshold', but high-income families—who already had a high probability of participation—will spend less.

5. SUMMARY AND CONCLUSIONS

In this paper we have estimated a micro-econometric model of vacation behaviour which simultaneously explains the decision whether to go on vacation or not, the choice of destination and the decision on the level of the vacation expenditures. The estimation of the model reveals a number of interesting results such as a striking difference in income elasticity between domestic vacations and vacations abroad and a large impact of owning certain durables (such as a boat) on the choice of destination. To illustrate the macro-economic potential of the model we have performed some simulations.

The model has been estimated on the basis of a cross-section of Dutch households. If longitudinal data become available the model can be extended to take into account the effects of time-varying explanatory variables, such as exchange rates, prices and weather conditions.

APPENDIX A: DERIVATION OF ELASTICITIES

We derive expressions for the probability of going on vacation, the conditional expectation of the amount spent given participation and the (unconditional) expectation of the amount spent. Define

$$p_i \equiv \sum_{k=0}^{K_w} \alpha_{ik} x_k + \beta_i \log y \tag{A1}$$

$$q_i \equiv \sum_{k=0}^{K_m} \gamma_{ik} z_k \tag{A2}$$

$$\xi_i = \sqrt{(\sigma_i^2 y^2 + \tau_i^2)} \quad (i = 1, 2) \tag{A3}$$

and denote the standard normal density and distribution function by ϕ and Φ respectively. Using well-known formulae for conditional expectations for the binormal distribution (see, for example, Johnson and Kotz, 1972), the following expressions can be derived:

$$P(w_i > 0) = \Phi((p_i y - q_i)/\, \xi_i) \tag{A4}$$

$$E(w_i y \mid w_i y > 0) = p_i y + (\sigma_i^2 y^2/\xi_i)\varphi((p_i y - q_i)/\xi_i)\Phi((p_i y - q_i)/\xi_i) \tag{A5}$$

$$E(w_i y) = p_i y \cdot \Phi((p_i y - q_i)/\xi_i) + \sigma_i^2 y^2/\xi^i \cdot \varphi((p_i y - q_i)/\xi_i) \tag{A6}$$

*This was achieved by replacing each income $y_i (i = 1, \ldots, 1822)$ by $y_i' = \exp(0{\cdot}9(\log y_i - \log y))/\Sigma \exp(0{\cdot}9(\log y_j - \log y)) \,\Sigma y_j$ where $\log y = (1/1822)\, \Sigma \log y_j$.

From (A4)–(A6) it is straightforward to derive income elasticities of the probability of going on vacation and the expected amount spent on vacation.

APPENDIX B: THE LIKELIHOOD FUNCTION

In deriving the likelihood function four different cases have to be distinguished.

I. $w_1 > 0, w_2 > 0$

(implying $\varepsilon_1 = w_1 - p_1, \varepsilon_2 = w_2 - p_2, \delta_1 \leq yw_1 - q_1, \delta_2 \leq yw_2 - q_2$)

$$L = (2\pi\sigma_1\sigma_2)^{-1} \exp\left[\{2(1-\rho^2)\}^{-1}\left\{\left(\frac{w_1 - p_1}{\sigma_1}\right)^2 + \left(\frac{w_2 - p_2}{\sigma_2}\right)^2 - 2\rho\left(\frac{w_1 - p_1}{\sigma_1}\right)\left(\frac{w_2 - p_2}{\sigma_2}\right)\right\}\right] \cdot \mathrm{Bin}\left(\frac{yw_1 - q_1}{\tau_1}, \frac{yw_2 - q_2}{\tau_2}, \psi\right).$$

II. $w_1 > 0, w_2 = 0$

(implying $\varepsilon_1 = w_1 - p_1, \delta_1 \leq yw_1 - q_1, -\delta_2 + y\varepsilon_2 < -yp_2 + q_2$)

$$L = (\sqrt{(2\pi)}\sigma_1)^{-1} \exp(-\tfrac{1}{2}z_1^2)\mathrm{Bin}\left(\frac{yw_1 - q_1}{\tau_1}, \frac{-yp_2 + q_2 - y\rho z_1\sigma_2}{\{\tau_2^2 + y^2\sigma_2^2(1-\rho^2)\}^{\frac{1}{2}}}, \frac{-\psi\tau_2}{\{\tau_2^2 + y^2\sigma_2^2(1-\rho^2)\}^{\frac{1}{2}}}\right)$$

where $z_1 = (w_1 - p_1)/\sigma_1$

III. $w_1 = 0, w_2 > 0$

(implying $\varepsilon_2 = w_2 - p_2, \delta_2 \leq yw_2 - q_2, -\delta_1 + y\varepsilon_1 < -yp_1 + q_1$)

$$L = (\sqrt{(2\pi)}\sigma_2)^{-1} \exp(-\tfrac{1}{2}z_2^2)\mathrm{Bin}\left(\frac{yw_2 - q_2}{\tau_2}, \frac{-yp_1 + q_1 - y\rho z_2\sigma_1}{\{\tau_1^2 + y^2\sigma_1^2(1-\rho^2)\}^{\frac{1}{2}}}, \frac{-\psi\tau_1}{\{\tau_1^2 + y^2\sigma_1^2(1-\rho^2)\}^{\frac{1}{2}}}\right)$$

where $z_2 = (w_2 - p_2)/\sigma_2$.

IV. $w_1 = 0, w_2 = 0$

(implying $-\delta_1 + y\varepsilon_1 < -yp_1 + q_1$ and $-\delta_2 + y\varepsilon_2 < -yp_2 + q_2$)

$$L = \mathrm{Bin}\left(\frac{-yp_1 + q_1}{\xi_1}, \frac{-yp_2 + q_2}{\xi_2}, \frac{\psi\tau_1\tau_2 + \rho\sigma_1\sigma_2 y^2}{\xi_1\xi_2}\right).$$

Here $\mathrm{Bin}(x,y,\rho)$ is the probability $P(X \leq x$ and $Y \leq y)$ for a stochastic vector $(X,Y)'$ with

$$\begin{bmatrix} X \\ Y \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}\right).$$

The calculation of $\mathrm{Bin}(x,y,\rho)$ was performed using an algorithm based upon an approximating formula given by Abramowitz and Stegun (1970), p. 940.

The likelihood was maximized using a quasi-Newton algorithm, as provided by the NAG Library (EO4KBF), requiring analytical first-order derivatives. Standard errors were obtained from the inverse of the (numerically calculated) information matrix.

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