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AN EMPIRICAL COMPARISON OF SYSTEMS OF DEMAND EQUATIONS FOR TOURIST EXPENDITURES IN RESORT DESTINATIONS

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In this paper, we employ the systems approach to the estimation of demand equations. We model visitor expenditures on six different categories of goods at a major resort destination, **Hawaii.** This study breaks new ground in several respects: (a) we apply systems estimation techniques to a new area – detailed budget data on visitor expenditures at a given resort destination, (b) we compare elasticities generated by the linear expenditure system and the Rotterdam model with the almost ideal demand system, a new functional form that has not been extensively tested empirically, and (c) we improve on a method suggested by Parks to measure goodness of fit in the Rotterdam model.

1. Introduction

Tourism is an important industry in many areas. For these destinations, accurate forecasts of visitor expenditure patterns are important for tax revenue projections and planning. As well, precise estimates of demand elasticities for different vacation goods are important to policymakers concerned with the effects of potential tourist taxes on the local visitor industry.

In this paper, we estimate systems of demand equations for visitor expenditures at a major tourist destination – Hawaii. Specifically, we analyze visitor expenditures in Hawaii for six different vacation goods: (1) food and drink, (2) lodging, (3) clothing, (4) local transportation, (5) recreation and entertainment, and (6) an aggregate of other goods.

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In empirical studies that employed the systems approach to estimate consumer demand functions (e.g. Klevmarken, 1979; Parks, 1969; Yoshihara, 1977; and Flood, Finke, and Theil, 1984), elasticity estimates have typically been found to be highly sensitive to the choice of functional form. Klevmarken observed, "with these large differences in estimated elasticities, the choice of model may become decisive for forecasting and policy."

Among the models available, the most important in recent use are the linear expenditure system (LES) (Stone, 1954), the translog model (Christensen, Jorgensen, and Lau, 1975), and the Rotterdam model (Barten, 1967 and Theil, 1967). Both the translog model and the Rotterdam model belong to the class of flexible functional forms; i.e., they do not impose any *a priori* restrictions on elasticities. By contrast, the LES requires that every good must be a substitute for every other good (i.e. no two goods may be complements) and goods may not be inferior. As Deaton and Muellbauer (1980a, p. 66) noted, "these restrictions do not mean that the model cannot be applied in practice, only that its application must be restricted to those cases where its limitations are not thought to be serious."

Recently, Deaton and Muellbauer (1980b) proposed a new model, the almost ideal demand system (AIDS), which is comparable in generality with the translog and Rotterdam models but possesses properties that are superior to both. However, for empirical work, the choice of model must depend on which model performs best. To date, there has not been extensive empirical testing of the AIDS model vis-a-vis other models.

The present paper compares our previous estimates of the AIDS model (Fujii, Khaled, and Mak, 1985a & 1985b) with the LES and the Rotterdam models. LES and AIDS were chosen because among the four models above, only two, the LES and AIDS aggregate consistently over individual consumers without requiring all goods to have unitary income elasticities. If the issue of aggregation is ignored, however, as it is in most empirical work, both the translog and the Rotterdam models are as general as AIDS. However, we selected only the Rotterdam model because its estimating equations are linear in its parameters (unlike the translog model) and hence easier to estimate.

Further, in comparing the three models, we improve a procedure suggested by Parks (1969) to measure goodness of fit in the Rotterdam model. We also demonstrate that the model that provides the best fit (i.e. predictions) may not provide the most plausible estimates of the demand elasticities. Finally, we find that different equations in a demand system may be fitted best by different functional forms.

2. Alternative Functional Forms

The Linear Expenditure System

The demand equations of the LES are commonly written as expenditure equations:

$$P_i X_i = P_i \gamma_i + \beta_i (Y - \sum_j P_j \gamma_j)$$

where P_i is the price of good i, X_i is the quantity per capita of good i, Y is the per capita income, β_i is the marginal propensity to consume good i, and the γ_i and γ_j's reflect the own and cross price effects on the expenditure of the i*th* commodity.[1] There is no theoretical reason to require the γ's to be positive, but if they are, they can be interpreted (Samuelson, 1948) as subsistence quantities and correspondingly the β_i's are interpreted as marginal budget shares.

Consumer theory requires that the demand system satisfy the restrictions of homogeneity, adding up, symmetry, and negativity. By its very structure, the LES incorporates homogeneity and symmetry. The other two restrictions are satisfied if $\sum_i \beta_i = 1, 0 < \beta_i < 1$ and $X_i > \gamma_i$.

Formulas for price and income elasticities implied by the LES (as well as the Rotterdam and AIDS systems described below) are displayed in Table 1. It can be seen that for the LES, the restrictions $0<\beta_i<1$ and $X_i>\gamma_i$ imply that there can be no inferior goods, nor can there be any net complements. This is a consequence of the fact that the preferences underlying the LES are additive, i.e., that the marginal utility of each good is independent of the quantity of any other good. This is a plausible assumption only if choice is being exercised over very broadly defined goods, e.g., food, clothing, and housing.

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[1] Let $E_i = P_i X_i = P_i \gamma_i + \beta_i (Y - \sum_j P_j X_j)$. The interpretation of the LES parameters can be seen from the derivatives:

$$\partial E_i / \partial Y = \beta_i, \ \partial E_i / \partial P_i = \gamma_i (1 - \beta_i), \text{ and } \partial E_i / \partial P_j = - \gamma_j \beta_i$$

Table 1 — Elasticity Formulas*
$(S_i = P_i X_i / Y)$

Elasticity Measure	LES	AIDS	[illegible]
Income	$\frac{B_i}{S_i}$	$\frac{\beta_i}{S_i} + 1$	$\frac{\cdots_i}{S_i}$
Own price Compensated	$-(1-\beta_i)(1-\frac{\gamma_i}{X_i})$	$\frac{\gamma_{ij}}{S_i} + S_i - 1$	$\frac{\gamma_{ij}}{S_i}$
Own price Uncompensated	$-1 + (1-\beta_i)\frac{\gamma_i}{X_i}$	$\frac{\gamma_{ij}}{S_i} - \beta_i - 1$	$\frac{\gamma_{ij}}{S_i} - \beta_i$
Cross price Compensated	$\beta_j(1 - \frac{\gamma_i}{X_i})$	$\frac{\gamma_{ij}}{S_i} + S_j$	$\frac{\gamma_{ij}}{S_i}$
Cross price Uncompensated	$-\beta_i \frac{P_j \gamma_j}{P_i X_i}$	$\frac{\gamma_{ij} - \beta_i S_j}{S_i}$	$\frac{\gamma_{ij} - \beta_i S_j}{S_i}$

*It should be noted that the parameters appearing in the elasticity formulas have different meaning in different models.

The Almost Ideal Demand System

In the AIDS model, the demand equations are usually expressed as a system of budget share equations. Their most commonly estimated form is:

$$S_i = \alpha_i + \beta_i log\,(Y/P) + \sum_j \gamma_{ij}\,log\,P_j \quad i, j = 1, 2, \ldots, n$$

where S_i is the budget share of good *i*, P_j is the price of good *j*, Y is total expenditure per capita, and P is the aggregate price index defined by $logP = \sum_j S_j logP_j$. The slope coefficients of the model β_i and γ_{ij}'s, $i,j,=1,2,\ldots n$ reflect the expenditure and price effects on the demand for the *n* goods.

The general restrictions of demand theory are easily imposed on the AIDS model. Adding up is satisfied if $\sum_i \alpha_i = 1$, $\sum_i \beta_i = 0$ and $\sum_i \gamma_{ij} = 0$. Symmetry requires that $\gamma_{ij} = \gamma_{ji}$. Given adding up, imposition of symmetry implies that $\sum_j \gamma_{ij} = 0$ which is precisely the homogeneity condition in the AIDS.[2] As in other flexible functional forms, the negativity conditions in the AIDS model cannot be imposed by simple parametric restrictions. However, these properties are likely to be satisfied automatically by data set generated by utility maximizing behavior.[3]

The elasticity formulas for the AIDS model are shown in Table 1. Since the β_i and the γ_{ij}'s can take on any sign, goods in the AIDS can either be normal or inferior, and pairs of goods can either be substitutes or complements. Thus in terms of *a priori* flexibility the AIDS is clearly superior to the LES.

The Rotterdam Model

The Rotterdam model is a differential version of the well-known log-linear demand system. The latter specification is not amenable to adding up. This problem is circumvented in the Rotterdam model by weighting the differential of each log-linear specification by their respective budget shares. The resulting form of the demand equations is:

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[2] Since the expenditure share data add up by construction, the adding up property of demand equations is not a testable restriction. However, with adding up as a maintained hypothesis, it is not possible to test symmetry without also imposing homogeneity. Symmetry can, however, be tested given homogeneity.

[3] The negativity conditions require that the matrix of substitution effects be negative semidefinite. One subset of these conditions is that all the compensated own price elasticities must be negative.

$$S_i dlnX_i = \beta_i dln\overline{Y} + \sum_i \gamma_{ij}\, dlnP_j \quad i, j = 1, 2, \ldots, n$$

where $dln\overline{Y} = \sum_j S_j dlnX_j = dlnY - \sum_j S_j dlnP_j$. Since the price and income coefficients in the log-linear system are the elasticities, the coefficients in the Rotterdam model are:

$$\beta_i = S_i \in_{iY} \text{ and } \gamma_{ij} = P_i P_j S_{ij}/Y$$

where $\in_{iY}$ is the income elasticity of demand for good i and S_{ij} is the compensated price derivative for good i with price j.[4]

As in the AIDS, consumer theory is easily imposed on the Rotterdam equations. For adding up, $\sum_i \beta_i = 1$ and $\sum_i \gamma_{ij} = 0$. Homogeneity is satisfied if $\sum_j \gamma_{ij} = 0$ and symmetry if $\gamma_{ij} = \gamma_{ji}$. Here again, given adding up, symmetry also imposes homogeneity but not vice versa. One attractive feature of the Rotterdam model is that the negativity condition involves the matrix of the γ_{ij}'s only. This matrix must be negative semidefinite, which includes the requirement that all γ_{ii}'s be negative.

The elasticity formulas for the Rotterdam model can be seen in Table 1. As in the AIDS, there are no undue restrictions on the income and substitution effects. Substitutability or complementarity is reflected directly in the sign of the γ_{ij}'s. It is clear that in terms of empirical flexibility, the AIDS and Rotterdam models are rated as even competitors. The AIDS (like the LES) has an edge over the Rotterdam model only theoretically, i.e., it can be derived explicitly from utility maximizing behavior and involves no aggregation error[5].

3. Data

The data required to estimate the models are per capita visitor expenditures by commodity groups and their respective prices.

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[4]The assumption that the elasticities are constant in the log-linear model implies that the coefficients in the Rotterdam model are variable. These are, however, treated as constants in estimation. The resulting estimates are, therefore, average values of the corresponding variables.

[5]The significance of this advantage is debatable. Most applied econometricians simply ignore the issue of aggregation. For example, Houthakker and Taylor (1970, p. 200) are of the opinion that "of all the errors likely to be made in demand analysis, the aggregation error is the least troublesome."

The data on the annual number of visitors to Hawaii were obtained from the Hawaii Visitors Bureau (*Annual Research Report, 1981*).

Data on aggregate visitor expenditures and all prices (except the price of lodging) were obtained from *Hawaii's Income and Expenditure Accounts:* 1958-1980 (HIE), published by the State of Hawaii, Department of Planning and Economic Development (DPED). Since visitor spending comprises a large percentage (25% in 1980) of Hawaii's gross state product, DPED published separate time series estimates of personal consumption expenditures for visitors and residents for the period 1958-1980. Estimates of visitor spending were largely constructed from information contained in visitor surveys conducted by the Hawaii Visitors Bureau.[6] The surveys rely heavily on detailed diaries completed by visitors while in Hawaii.

Thirty-seven separate categories of visitor expenditures were listed in the HIE. We reduced them to six categories: (1) food and drink (hereafter referred to as "food"), (2) clothing, accessories and jewelry (hereafter referred to as "clothing"), (3) lodging, (4) local transportation, including interisland airfare (hereafter referred to as transportation"), (5) recreation and entertainment (hereafter referred to as "entertainment"), and (6) other, which comprise everything else. Clothing is treated separately in our analysis as Polynesian wear and locally produced jewelry comprise a very large percentage (12.8 per cent in 1980) of total visitor spending in Hawaii. Our expenditure categories and their equivalent HIE definitions are displayed in Table 2. HIE expenditure categories have the same definitions as the U.S. National Income and Product Accounts.

Prices, except for lodging, were also obtained from the HIE accounts. They were derived from the relevant component series from the Honolulu Consumer Price Index for all urban consumers. The aggregation of detailed categories of visitor expenditures to form two broader expenditure categories (food and other) required the construction of two new price indices. For aggregating the component price indices, we used the Tornqvist (1936) price index. An advantage of this index is that it allows for moving weights. Moreover, Diewert (1976), 1978) has shown that this index is 'superlative' (i.e. corresponds to a

[6]For a brief description of the methodologies and data used in constructing these estimates, see the Appendices in the HIE. A Procedure Manual, describing the estimating methodology for each item is held in the DPED's Research and Economic Analysis Division file record.

Table 2 — Visitor Expenditure Categories and Their Equivalent Hawaii Income and Expenditure Account Categories

Visitor Expenditure Category	Category Name	HIE Expenditure Categories
Food and Drink	Food	Food Purchase for Off-Premise Consumption, and Purchased Meals and Beverages
Lodging	Lodging	Housing
Clothing, Accessories, and Jewelry	Clothing	Clothing, Accessories, and Jewelry
Local (including interisland) Transportation	Transportation	Transportation
Recreation and Entertainment	Entertainment	Recreation
Other	Other	Tobacco, Personal Care, Household Operation, and Medical Care Expenses

Source: State of Hawaii, Department of Planning and Economic Development, *Hawaii's Income and Expenditure Accounts: 1958-1980* (Honolulu: DPED, 1982), Tables 6-4 (Visitor Personal Consumption Expenditures by Type of Expenditures: 1958-1980), pp. 178-179

Table 3 — Real Per Capita Visitor Expenditures and Average Budget Shares

	Average Per Capita Expenditures (in 1972 $)	Average Budget Shares
Food	$ 192.06	40.40%
Lodging	117.94	26.68
Clothing	61.60	12.96
Transportation	38.77	8.40
Entertainment	25.26	5.52
Other	26.89	6.05

flexible aggregator function) and is approximately 'consistent in aggregation' (the value of the index based on sub-indices is the same as the value calculated in a single stage from all the basic commodities.)[7]

A hotel room (i.e. lodging) price index was constructed for 1961-1980 by splicing together two separate weighted price indices using the method of proportions described in Yamane (1973, p. 321). Each series is an index of the weighted average of posted room rates (double occupancy) for a selected number of Hawaii hotels, using the total number of rooms in each hotel as weights. The first series consists of room rates at 22 hotels (1961-1974); and the second series, 38 hotels (1974-1980). Data on the number of rooms and room rates at each hotel are published in the Hawaii Visitors Bureau's annual *Member Accommodation Guide, 1961-1980*. Our analysis of visitor spending in Hawaii was confined to the 20-year period, 1961-1980, because our lodging price index covers a shorter period (1961-1980) than the available series on visitor expenditures (1958-1980). Table 3 presents the mean values of the real per capita visitor expenditures by individual goods and their respective budget shares.

4. Empirical Results

In the static theory of consumer behavior, prices and income are the only explanatory variables. In the real world, ex-

[7] Laspeyres and Paasche indices are consistent in aggregation but not superlative.

penditure patterns can change, due to factors other than changes in price and income. In Hawaii's visitor industry, a likely additional source of change, *among others,* is the shift in the mix of visitors. Between 1960 and 1980, Japanese visitors increased from less than 5 per cent of total visitors to 14.5 per cent. Correspondingly, U.S. visitors declined from 80 to 65 per cent of total visitors. To capture the steady change in the visitor mix as well as other influences (e.g. change in the proportion of first time vs. repeat visitors) *in a simple manner,* we included a trend variable *(t)* in our estimating equations. Failure to account for such dynamic aspects of consumer behavior may lead to rejection of consumer theory. Deaton and Muellbauer (1980a, p. 322) state "...the introduction of (arbitrary) time trends removes much of the conflict between the data and the hypothesis of a representative consumer maximizing a conventional static utility function."

The Estimating Equations

For the purpose of estimation we express the LES as a set of share equations:

$$S_i = \gamma_i \overline{P}_i + \beta_i (1 - \sum_j \gamma_j P_j) + \tau_i t + \epsilon_i$$

where $\overline{P}_i = P_i / Y$ is the normalized price of good i and ϵ_i is a disturbance term representing the random elements in the observed share of i.. The estimating equations in the AIDS and Rotterdam model are, respectively,

$$S_i = \alpha_i + \beta_i ln(Y/P) + \sum_j \gamma_{ij} lnP_j + \tau_i t + \epsilon_i$$

and

$$S_i \Delta lnX_i = \tau_i + \beta_i \Delta ln\overline{Y} + \sum_j \gamma_{ij} \Delta lnP_j + \epsilon_i$$

The differentials in the Rotterdam equations are approximated by the corresponding first differences. It should be noted that the trend coefficients (τ_i) in each equation[8] must sum to zero to satisfy the adding up property of demand equations. Since the dependent variables in all the three equations involve deflation by total expenditure, it can reasonably be assumed that the disturbances are homoskedastic. The problem of serial correlation is also largely eliminated in the Rotterdam model as it is already formulated in terms of first differences. However, initial experimentation with the LES and AIDS specifications

[8]Since the Rotterdam model involves first differencing, the trend coefficient in the underlying log-linear equation appears as an intercept in the Rotterdam formulation.

revealed substantial first order serial correlation in the disturbance term. Therefore, we assume that the random errors are contemporaneously correlated in each demand system and that each disturbance is correlated with its own value in the previous time period in the LES and AIDS models. Finally, we assume that the disturbances are multivariate normally distributed with zero mean vector and constant covariance matrix.

By the adding up requirement, the random disturbances in the system must sum to zero at each observation making the covariance matrix of errors singular[9]. We handled this problem by estimating the system of equations by the method of maximum likelihood, after arbitrarily dropping one of the six share equations, namely "other" goods. Barten (1969) has proved that the results are invariant to the equation deleted. The coefficients of the deleted equation are easily calculated, since they are linear combinations of the parameters in the included equations.

Parameter and Elasticity Estimates

The estimated parameters of the three models are presented in Tables 4-6. It can be seen that in all the three systems, most of the trend coefficients are significantly different from zero.[10] Thus leaving the trend variable out would have resulted in specification error and biased coefficients of the remaining variables. Over the period 1961-1980, the consumption of lodging, transportation, entertainment, and other increased while that of food decreased. No clear trend was present in the expenditure for clothing.

The estimated expenditure elasticities at the average budget shares are shown in Table 7. The AIDS and Rotterdam estimates indicate that the expenditure elasticities for all six goods are approximately unity. Food is usually found to be a necessity (i.e. its expenditure elasticity is typically less than one). However, for visitors, it must be emphasized that food expen-

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[9] Adding up also requires that if we specify first order serial correlation in each equation as $\in_{it} = \rho_i \in_{it-1} + u_t$, then we must have $\rho i = \rho$ for all *i*. See Berndt and Savin (1975). Our estimated ρ is .730 in the AIDS and .808 in the LES. The respective asymptotic λ^2 statistics are 25.42 and 69.63. The critical λ^2 value at the 1% level is 6.63.

[10] These coefficients represent trends in budget shares in the LES and AIDS. However, in the Rotterdam model, these are the share weighted values of the trends in logarithms of quantities.

Table 4 — Estimated Parameters of the LES Model (Standard Errors in Parentheses)

Commodity i	α_i	β_i	τ_i
1. Food	29.097*	.478*	− .008*
	(9.586)	(.019)	(.001)
2. Lodging	3.126	.265*	.003*
	(4.326)	(.015)	(.001)
3. Clothing	7.504*	.131 *	− .0003
	(3.178)	(.016)	(.0007)
4. Transportation	3.821	.070*	.002*
	(2.388)	(.009)	(.0004)
5. Entertainment	2.492	.027 *	.002*
	(2.074)	(.010)	(.0005)
6. Other	− .393	.029 *	.002 *
	(1.561)	(.011)	(.0004)

An (*) indicates that the parameter is significant at the 5 per cent level by the asymptotic normal distribution.

ditures consist mainly of restaurant meals and beverages that are more in the nature of luxuries. On the other hand, entertainment and "other" goods (consisting in part of gifts and souvenirs) normally appear to be luxuries (i.e. the expenditure elasticities are typically greater than one). Our results here indicate that perhaps the luxury aspect of these commodities is neutralized by some visitors' attitude that these goods are an integral part of any vacation, independent of total expenditure. Given this interpretation, our finding of unitary expenditure elasticities seems to be a reasonable finding. When this result is imposed on AIDS (i.e. $\beta_i=0$ for all i), AIDS reduces to the homothetic version of the translog model.

Although caution must be exercised in classifying goods as luxuries or necessities based solely on visitor spending, which is but a fraction of total consumer spending, the LES estimates are clearly counterintuitive. The expenditure elasticities of

Table 5 — Estimated Parameters of the AIDS
(Standard Errors in Parentheses)

Commodity i	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	α	β	τ
1. Food	.033	.050*	-.012	.007	-.042	-.036*	.509*	-.001	-.009*
	(.062)	(.022)	(.038)	(.024)	(.029)	(.017)	(.119)	(.019)	(.001)
2. Lodging	.	.015	-.044*	.013	-.027*	-.006	.209*	.008	.001
		(.019)	(.014)	(.009)	(.013)	(.008)	(.091)	(.015)	(.001)
3. Clothing			.025	--.011	.032	.009	.193*	-.012	.001
			(.024)	(.015)	(.019)	(.011)	(.076)	(.012)	(.001)
4. Transportation				-.013	.008	-.003	.048	.004	.001*
				(.012)	(.012)	(.008)	(.051)	(.008)	(.0006)
5. Entertainment					.016	.014	-.055	-.006	.003*
					(.016)	(.008)	(.066)	(.010)	(.0008)
6. Other						.022	—0.14	.007	.003*
						(.011)	(.041)	(.007)	(.0005)

An (*) indicates that the parameter is significant at the 5% level by the asymptotic normal distribution.

Table 6 — Estimated Parameters of the Rotterdam Model
(Standard Errors in Parentheses)

Commodity	γ_{i1}	γ_{i2}	γ_{i3}	γ_{i4}	γ_{i5}	γ_{i6}	β	τ
1. Food	-.284* (.057)	.156* (.019)	.062* (.030)	.012 (.020)	.001 (.023)	.018 (.025)	.420* (.015)	-.008* (.001)
2. Lodging		-.191* (.021)	.003 (.011)	.026* (.010)	-.005 (.011)	.011 (.013)	.264* (.015)	.003* (.001)
3. Clothing			-.097* (.019)	.004 (.012)	.032* (.013)	-.003 (.013)	.125* (.009)	-.00003 (.001)
4. Transportation				-.128* (.011)	.037* (.010)	.049* (.011)	.078* (.008)	.003* (.0006)
5. Entertainment					-.060* (.011)	-.005 (.012)	.050* (.009)	.002* (.001)
6. Other						-.070* (.020)	.063* (.010)	.001 (.001)

An (*) indicates that the parameter is significant at the 5% level by the asymptotic normal distribution.

Table 7 — Expenditure Elasticities: LES, AIDS, and Rotterdam Models (at mean budget shares)

	LES	AIDS	Rotterdam
Food	1.183*+	.998*	1.040*
	(.047)	(.046)	(.037)
Lodging	.993*	1.030*	.989*
	(.056)	(.055)	(.057)
Clothing	1.010*	.910*	.961*
	(.113)	(.091)	(.070)
Transportation	.838*	1.045*	.923*
	(.111)	(.094)	(.094)
Entertainment	.497*+	.896*	.914*
	(.187)	(.191)	(.165)
Other	.481*+	1.109*	1.046*
	(.186)	(.110)	(.170)

Notes: (1) Standard errors are enclosed by parentheses.
(2) An asterisk(*) indicates the elasticity is significantly different from zero at the 5% level.
(3) The superscript (+) indicates that the elasticity is significantly different from +1 at the 5% level.

entertainment and other goods are substantially below unity. This is likely to be a consequence of the unduly restrictive nature of the functional form of the LES[11] rather than a characteristic of the data. We therefore reject the LES estimates. Nonetheless, expenditure elasticities for lodging, clothing, and transportation are similar in all three models.

Our estimates of uncompensated own price elasticities are given in Table 8. In the LES estimates, visitor demand for lodging, transportation, entertainment, and other goods is price inelastic, although the price elasticity of demand for lodging is close to unity. It is notable that these are precisely the same commodities that have the lowest income elasticity estimates.

[11] The LES requires the Engel curves to be (piecewise) linear and the "specific" cross-substitution effect to be zero. For an exposition of the latter see Phlips (1983, p. 63).

Table 8 — Uncompensated Own Price Elasticities: LES, AIDS, and Rotterdam Models (at mean budget shares)

	LES	AIDS	Rotterdam
Food	–1.033*	–.917*	–1.035*
	(.027)	(.162)	(.149)
Lodging	–.921*+	–.953*	–.979*
	(.026)	(.067)	(.079)
Clothing	–.920*	–.793*	–.878*
	(.046)	(.181)	(.143)
Transportation	–.770*+	–1.156*	–1.604*+
	(.058)	(.147)	(.140)
Entertainment	–.453*+	–.707*	–1.139*
	(.080)	(.282)	(.207)
Other	–.449*	–.644*	–1.219*
	(.057)	(.177)	(.333)

Notes: (1) Standard errors are enclosed by parentheses.
(2) An asterisk(*) indicates the elasticity is significantly different from zero at the 5% level.
(3) The superscript (+) indicates that the elasticity is significantly different from –1 at the 5% level.

This is a consequence of the fact that the LES belongs to a class of additive utility functions which constrain the price elasticities of goods to be proportional to their respective income elasticities.[12] Since some of the LES income elasticity estimates are not plausible, we also reject the corresponding LES estimates of the price elasticities.

By contrast, most of the AIDS and Rotterdam elasticity estimates are not significantly different from unity. The two exceptions are that in the AIDS, the "other" commodity is price inelastic, while in the Rotterdam model, the demand for transportation is price elastic. Thus, although the AIDS and the Rotterdam models are equally flexible in terms of elasticity

[12] For a proof, see Phlips (1983, p. 62).

measures, the actual estimates may differ depending on the system chosen. It should, however, be noted that all three models estimate similar price elasticities of demand for food, lodging, and clothing.

We now present (in Table 9) our estimates of the Allen (1938) partial elasticities of substitution (σ_{ij}) given by the relation:

$$\in^*_{ij} = S_j \sigma_{ij}$$

where $\in^*_{ij}$ is the compensated price elasticity of good i with j.[13] The Allen elasticity (σ_{ij}) is a normalization of the price elasticity ($\in^*_{ij}$) so that $\sigma_{ij} = \sigma_{ji}$. None of the LES elasticities are negative, indicating that this functional form does not allow goods to be complements. However, this may not be a serious restriction when broad commodity aggregates are being used as indicated by the more general AIDS and Rotterdam estimates in the present case. Although a few of the latter estimates are negative, none is significantly different from zero. However, it is clear that cross elasticity estimates may differ substantially depending on the choice of functional form. Even if we compare only the more general AIDS and Rotterdam estimates, it can be seen that the estimated elasticity of substitution between transportation and entertainment (8.06) and transportation and other goods (9.64) is significantly different from zero in the Rotterdam model, but not in the AIDS model. By contrast, the elasticity between entertainment and other goods (5.21) is significant in the AIDS but not in the Rotterdam representations. Comparing all the models, whereas the estimated elasticity between clothing and entertainment is large in the AIDS (5.49) and the Rotterdam system (4.46), it is much smaller in the LES (0.44).

5. Measures of Goodness of Fit

Since all three models mentioned above are not tested, we cannot employ the classical testing procedures to determine the best fitting model. Recently, Berndt, Darrough, and Diewert

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[13] The uncompensated cross price elasticities ($\in_{ij}$) can be computed by utilizing the relation, $\in_{ij} = S_j\ (\sigma_{ij} - \in_{iY})$. The income elasticities ($\in_{iY}$) are presented in Table 7 and the elasticities of substitution (σ_{ij}) in Table 9. When the above computation is made, it can be seen that most of the cross price effects are rather small.

Table 9 — Allen Partial Elasticities of Substitutions: LES, AIDS, and Rotterdam Models (at mean budget shares)

Elasticity Between	LES	AIDS	Rotterdam
F,L	1.057* (.064)	1.466* (.199)	1.447* (.176)
F,C	1.073* (.100)	.764 (.718)	1.181 (.579)
F,T	.893* (.107)	1.190 (.714)	.345 (.595)
F,E	.525* (.163)	-.888 (1.286)	.036 (1.014)
F,O	.513* (.165)	-.463 (.694)	1.375 (1.025)
L,C	.903* (.116)	-.262 (.409)	.077 (.324)
L,T	.750* (.107)	1.559* (.405)	1.155* (.440)
L,E	.435* (.181)	-.870 (.870)	.344 (.779)
L,O	.430* (.182)	.612 (.513)	.694 (.843)
C,T	.762* (.095)	.036 (1.381)	.381 (1.083)
C,E	.435* (.181)	5.489* (2.609)	4.456* (1.830)
C,O	.430* (.165)	2.166 (1.455)	-.364 (1.703)

Table 9 (Continued)

Elasticity Between	LES	AIDS	Rotterdam
T,E	.362*	2.627	8.061*
	(.163)	(2.645)	(2.156)
T,O	.364*	.364	9.640*
	(.165)	(1.488)	(2.216)
E,O	.215	5.208*	–1.521
	(.182)	(2.497)	(3.505)

Notes: (1) Commodities are denoted by F (Food), L (Lodging), C (Clothing), T (Transportation, E (Entertainment), and 0 (Other goods).
(2) Numbers in parentheses are standard errors.
(3) An (*) indicates that the coefficient is significant at the 5% level.

(1977) employed a Bayesian discrimination technique which compares the sample maximum values of the logarithm of the likelihood function of the alternative models. However, this method requires all the systems to have the same dependent variables. Thus, in the present case, we can compare only the LES and the AIDS. We find that the AIDS (logL=541) is more likely to have generated the observed data than the LES (logL=525).

In order to compare all three models *on a systemwide basis,* we utilized Theil's (1965) index of information inaccuracy of predictions *(I)* defined as:

$$I = \sum_i S_i ln(S_i/\widehat{S}_i)$$

where S_i is the observed share of good i and $\widehat{S}_i$ is the predicted share. An attractive feature of this measure is that it gives appropriate weight to each commodity in determining goodness of fit. Prediction is perfect when $I=0$. Therefore, the smaller the value of I, the better the fit provided by the model.

For computing the above index, we require the shares predicted by the different models. We obtain these values directly from the estimated equations of the LES and AIDS, while taking account of the information provided by presence of serial correlation in the residuals. However, it can be seen that the Rotterdam model predicts changes in shares, not the shares themselves. Predictions of the latter are obtained in an indirect manner. Dividing the estimated value of dependent variable by S_i we obtain the predicted change in quantity:

$$\Delta ln\widehat{X}_{it} = ln\widehat{X}_{it} - ln\widehat{X}_{i,t-1}$$

The predicted quantities are then obtained by applying the recursive formula:

$$\widehat{X}_{it} = exp(\Delta ln\widehat{X}_{it} + ln\widehat{X}_{i,t-1})$$

where we assume that for the *first observation only* the observed and predicted quantities are the same. The estimated shares are then obtained as:

$$\widehat{S}_i = P_i\widehat{X}_i / \sum_j P_j\widehat{X}_j$$

Our method of computing predicted shares is superior to the method adopted by Parks (1969) in which each year's predicted value is obtained as the last year's actual value plus the predicted change over the last year. This method suffers from the disadvantage of overstating the predictive ability (or goodness of fit) of the different models.

Since the I index varies from observation to observation, we can compare our models on the basis of the average value of I over the sample period:

LES	.0017459
AIDS	.0037439
Rotterdam	.0015657

Thus predictive accuracy is greatest in the Rotterdam model, which is marginally superior to the LES. It is interesting to note that although the AIDS possesses more flexibility than the LES in terms of price coefficients, in the present case, the LES outperforms the AIDS in terms of predictive ability.

We now turn to a comparison of the alternative models on an equation by equation basis. For each commodity we have computed R^2, which is the proportion of the total variation in the share of a commodity explained by the model in question, i.e.:

$$R^2 = 1 - \sum_t (S_{it} - \widehat{S}_{it})^2 / \sum_t (S_{it} - \overline{S}_i)^2$$

These values are shown in Table 10. Note that R^2 values are well defined only in the case of a simple linear regression with an intercept term. Our present methods of estimation (seemingly unrelated nonlinear regression for LES and AIDS

Table 10 — "Proportion of Explained Variation" in Alternative Demand Models

Commodity	LES	AIDS	Rotterdam	Best Fitting Model
Food	.714	.440	.946	Rotterdam
Lodging	.686	.860	.108	AIDS
Clothing	.795	.693	.165	LES
Transportation	.814	.761	.840	Rotterdam
Entertainment	.708	–.056	.745	Rotterdam
Other	.272	–.434	.168	LES

and seemingly unrelated linear regression for the Rotterdam system) do not guarantee that R^2 measures are positive. Indeed, there are two negative R^2 values in our estimated AIDS model.

From Table 10, it appears that the Rotterdam system provides the best fit for three commodities (food, transportation, and entertainment) out of a total of six. It gives a very poor fit for the other three goods. Budget shares for clothing and others are best explained by the LES, while AIDS furnishes the best explanation for only one good (lodging). Thus, our equation by equation fits correspond closely with our evaluation of the models based on Theil's *I* index.

6. Conclusion

In this paper, we have considered three alternative functional forms for estimating elasticities of visitor demand for vacation goods in Hawaii over the period 1961-1980. Two of the three functional forms (AIDS and Rotterdam) are highly general. Only one (LES) imposes more restrictions on elasticities than are warranted by consumer theory.

Our results indicate that some of the elasticity estimates based on the LES may be distorted due to the unnecessary restrictions imposed by its functional form. Policy conclusions based on elasticity estimates from the LES model alone can, therefore, be misleading.

Expenditure and own price elasticity estimates provided by the AIDS and the Rotterdam model are more plausible and are, with few exceptions, similar in magnitude. However, no such similarity is present in estimates of cross price elasticities. Thus, in formulating policies based on the latter, one should consider several alternative functional forms in order to establish a reliable range for policies.

Since none of the estimated expenditure elasticities in both the AIDS and the Rotterdam models are significantly different from unity, it appears that visitor preferences in Hawaii over the period 1961-1980 were homothetic. Another result supported by all three models is that visitor demand for food, lodging, and clothing have approximately unitary price and expenditure elasticities. This agreement among all the three models is remarkable in the present case because, on average, food, lodging, and clothing together accounted for 80 per cent of total visitor expenditures in Hawaii.

When we consider measures of goodness of fit, the Rotterdam model seems to be the best for the present sample. One curious result in this connection is that while the AIDS is better than the LES on the basis of the Bayesian criterion of being more likely to have generated the observed data, the LES outperforms AIDS based on Theil's index of information inaccuracy. From this, we make two observations. One, although AIDS has a theoretical edge over the Rotterdam model, the latter may have an empirical edge over AIDS in situations of forecasting. Two, while LES may not be entirely reliable for policy formulation based on its estimated elasticities, it may nevertheless be acceptable for forecasting budget shares of aggregate expenditures.

Finally, it should be pointed out that in the context of a system of demand equations, different equations may be fitted best by different functional forms. For example, in predicting lodging expenditures by visitors in Hawaii, the AIDS functional form appears to be the best, although on an overall forecasting basis, it is dominated by the LES and Rotterdam models.

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