A COHERENCE APPROACH TO ESTIMATES OF PRICE ELASTICITIES IN THE VACATION TRAVEL MARKET

By John H. E. Taplin*

The remarkable growth of vacation travel in recent years can be attributed not only to the rise in disposable incomes but also to the falling real costs of travel and to the price responsiveness of vacation travellers. Air fare innovations and changes in costs have brought about enough variation in real prices for us to make a number of fairly reliable estimates of fare elasticity. Income elasticity has also been estimated on the basis of both cross-section and time series data.

There is, however, a scarcity of estimates of cross-elasticity. This is not peculiar to this field of demand estimation, but may be more serious here than similar deficiencies in other fields. Whereas habit gives the consumer a tendency to ignore substitutes for the things he consumes daily, he often takes virtually the opposite approach when going on vacation. Not only does he tend to look for something new, but also he consciously assesses the relative merits (including prices) of the travel options open to him. The result is that, in aggregate, the cross-elasticities of demand between competing forms of vacation travel are relatively high, and so are the negative cross-elasticities between travel and its main complement, accommodation. Any assessments of either commercial or public policy aimed at the pricing of vacation travel will be severely handicapped if these cross-relationships cannot be taken into account.

What we require, as a minimum, is a set of demand equations for vacation travel, covering overseas air trips, domestic air trips, overseas accommodation, domestic accommodation, and domestic car trips, each being expressed as a function of the corresponding air fares, accommodation charges, and car operating costs, as well as of an index of other consumer prices and income. In fact, estimation has generally been limited, by the data available, to fairly simple equations in which demand for a particular type of travel is expressed as a function of own-price (i.e. the fare), income, and sometimes the price of one close substitute. Thus, estimates of most of the cross-elasticities in our minimal system are lacking, and probably cannot be obtained directly from the data.1

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1 For some purposes, the problem of directly estimating cross-elasticities can be overcome by indirect methods involving the aggregation of consumer goods into groups. Then the cross-elasticities can be derived from the income elasticities. To achieve these results, goods must be grouped to satisfy certain conditions. The most severe condition is Frisch’s (1959) want-independence (or additivity). Techniques have been devised to enable less restrictive separability conditions to be used. Nevertheless, such techniques cannot cope with strongly complementary relationships, nor with relationships between close substitutes, such as classes of travel. Reviews of the topic have been made by Brown and Deaton (1972) and Barten (1977).
The purpose of this paper is to show that the estimates already available may provide the basis for deriving values for the missing cross-elasticities by a method pioneered by Brandow (1961) and others in the field of consumer demand for food. In effect it is argued that, if certain standard propositions of demand theory hold, a limited set of estimated elasticities may enable one to infer the values of the missing elasticities, or at least to limit the range of values these can take. The demand for each of the various categories of vacation travel is seen as part of the complete system of demand functions for all goods and services. Each is expected to satisfy the conditions applying to the elasticities in that system. The following well-known conditions are used:

1. Homogeneity—in each demand equation the own-price, cross-price and income elasticities sum to zero.
2. Symmetry (the Slutsky condition)—if $E_{ij}$ is the cross elasticity of demand for $i$ with respect to the price of $j$ and $E_{ji}$ is defined similarly, then $E_{ij} = (R_i/R_j)E_{ji} + R_j(E_{ij} - E_{iy})$ where $R_i$ and $R_j$ are proportions of total expenditure and $E_{ji}$, $E_{ij}$ are income elasticities of demand. Because vacation travel is only a small part of total expenditure the first term alone is used (the Hotelling-Jureen relationship), because the second term is negligible in magnitude.
3. Cournot column aggregation $\sum_i R_i E_{ij} = -R_j$
4. Engel aggregation $\sum_i R_i E_{iy} = 1$

These restrictions greatly reduce the information necessary to synthesise a coherent set of demand equations.

THE EXAMPLE

Because the interaction between foreign and domestic vacation travel is of primary interest, it is convenient to synthesise a demand system for Australian travellers. The activities are readily distinguished and contrasted for a country where foreign travel is necessarily “overseas” and travel in one’s own car can only be within the country. The majority of the elasticity estimates used are based on Australian data, and so are the expenditure shares. A few estimates have been borrowed from studies of American

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2 Empirical tests of the homogeneity and symmetry conditions are considered in the reviews by Brown and Deaton (1972), pp. 1189–1195, and Barten (1977), pp. 45–47. There is necessarily some doubt what constitutes a satisfactory test, and it is not surprising that workers in the field tend not to accept unfavourable results on the homogeneity condition (based on aggregative models) but tend rather to look for mis-specifications in the estimating models. There is much empirical support for the symmetry condition, and estimates at the specific commodity level have provided general support for the homogeneity condition.

3 A non-mathematical treatment of the conditions and their use is given in Tomek and Robinson (1972), pp. 34–43.

4 This condition follows from the assumption that the demand function is homogeneous of degree zero.

5 Another way in which the restrictions can be applied is to use them as prior constraints in the process of estimating all coefficients. See Goldberger (1964), pp. 256–258.
and Canadian travel overseas, but estimates for European travellers are not used because much of their foreign travel is to nearby countries. Thus this paper is not a review of studies in the whole field of vacation travel.

In using the various estimates, one is not only making hazardous inferences from the behaviour of different populations but also combining cross-section and time-series estimates. However, the exercise is, in part, a test of the mutual consistency of the estimates; if they were seriously inconsistent with one another, some of the elasticities inferred from them would take implausible values.

ESTIMATES OF ELASTICITY

A potentially good source of elasticity estimates is offered by studies of disaggregate demand or mode choice. There is a difficulty, however. Whereas mode split elasticities can be derived from ordinary elasticities of demand if the trip shares are known,\(^6\) the ordinary elasticities cannot be derived from mode split elasticities unless a second stage of estimation has been carried out. A second stage estimate would, for example, be the elasticity of demand for all types of vacation trips with respect to overseas air fares.\(^7\) Two-stage estimation makes it possible to estimate ordinary cross-elasticities as well as own-price elasticities, though there is no guarantee that these cross-elasticity estimates will satisfy the symmetry condition.

It is the lack of second-stage estimates that makes it impossible to use the results of a mode choice study for non-business travel, such as the multinomial logit study of Stopher and Prashker (1976). Such studies as this and the multinomial choice study of international air travel by Kanafani and Sadoulet (1977) provide insights into choices between modes and types of travel, but cannot be used in constructing a demand system. Thus one is left with the direct demand models to provide the estimates.

A number of results obtained by estimating direct demand equations are summarised in Table 1. Despite the differing populations studied, the estimated own-price elasticities of demand (i.e. the fare elasticities) for overseas leisure travel are of similar magnitude. This similarity extends to the Jud and Joseph (1974) equation, which includes a variable for prices in countries visited.

The three estimates of the elasticity of demand for spending in countries visited provide some indication of the elasticity of demand for overseas accommodation. Similarly, the cross-elasticity in the Jud and Joseph equation is an initial indicator of the elasticity of demand for overseas trips with respect to the price of tourist accommodation overseas.

Table 2 gives the income elasticity of demand for each of seven leisure travel

\(^6\) Following Quandt (1968), if \(m_{1p}\) is the mode split elasticity for mode 1 with respect to price \(p\) then

\[
m_{1p} = \frac{E_{1p} - E_{2p}}{1 + \frac{T_1}{T_2}}
\]

where \(E_{1p}\) and \(E_{2p}\) are ordinary price elasticities and \(T_1\) and \(T_2\) are numbers of trips.

\(^7\) The ordinary elasticity is obtained by adding the mode split and second-stage elasticities.
### Table 1

**Estimated Elasticities of Demand for Overseas Leisure Travel and Tourist Expenditure Abroad**

<table>
<thead>
<tr>
<th>Type of travel</th>
<th>Dependent variable</th>
<th>Income elasticity</th>
<th>Own-price elasticity</th>
<th>Cross price elasticity</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>International from U.S.</td>
<td>Trips</td>
<td>2.2</td>
<td>-1.4 to -1.7</td>
<td></td>
<td>Newman (1971)</td>
</tr>
<tr>
<td>U.S. mainland to Hawaii</td>
<td>Trips</td>
<td>1.0 to 1.1</td>
<td>-1.6 to -3.3</td>
<td>-1.5</td>
<td>Newman (1971)</td>
</tr>
<tr>
<td>U.S. to Latin America other than Mexico</td>
<td>Trips</td>
<td>2.0</td>
<td>-2.0</td>
<td>-1.5</td>
<td>Newman (1971)</td>
</tr>
<tr>
<td>(1) High discount and promotion</td>
<td>Trips</td>
<td>1.1</td>
<td>-2.7</td>
<td></td>
<td>Straszheim (1978)</td>
</tr>
<tr>
<td>(2) High discount and promotion</td>
<td>Trips</td>
<td></td>
<td>-1.8</td>
<td></td>
<td>Straszheim (1978)</td>
</tr>
<tr>
<td>International from Australia</td>
<td>Trips</td>
<td>2.4</td>
<td>-1.8</td>
<td></td>
<td>Smith and Toms (1978)</td>
</tr>
<tr>
<td>International to Australia</td>
<td>Trips</td>
<td>1.1 to 2.6</td>
<td>-1.9</td>
<td></td>
<td>Smith and Toms (1978)</td>
</tr>
<tr>
<td>International from U.S.</td>
<td>Spending abroad (other than fares)</td>
<td>1.2 to 1.3</td>
<td>-1.4 to -1.6 (ratio of foreign to U.S. prices)</td>
<td></td>
<td>Kwack (1972)</td>
</tr>
<tr>
<td>U.S. and Canada to Europe</td>
<td>Spending in countries visited</td>
<td></td>
<td>-1.0 and -1.6 (ratio of foreign to domestic prices)</td>
<td></td>
<td>Artus (1972)</td>
</tr>
<tr>
<td>U.S. to Latin America</td>
<td>Spending in countries visited</td>
<td>-0.9 to -2.7 (ratio of foreign to U.S. prices)</td>
<td></td>
<td></td>
<td>Jud and Joseph (1974)</td>
</tr>
</tbody>
</table>

### Table 2

**Income Elasticities of Demand for Categories of Vacation Leisure Travel Expenditure: Cross-Section Estimates from Summaries of Australian Household Expenditure Surveys 1974–75 and 1975–76**

<table>
<thead>
<tr>
<th>Category (as defined in the Surveys)</th>
<th>1974–75 Weekly Expenditure ($)</th>
<th>Income Elasticity $^b$ (t-value in brackets)$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holiday fares—overseas</td>
<td>1.15</td>
<td>1.5 (3.9)</td>
</tr>
<tr>
<td>Holiday accommodation—overseas</td>
<td>0.36</td>
<td>2.6 (2.9)</td>
</tr>
<tr>
<td>Holiday package tour—overseas</td>
<td>1.20</td>
<td>0.7 (2.2)</td>
</tr>
<tr>
<td>Holiday fares—Australia</td>
<td>0.47</td>
<td>0.8 (4.3)</td>
</tr>
<tr>
<td>Holiday petrol—Australia</td>
<td>0.30</td>
<td>0.7 (4.1)</td>
</tr>
<tr>
<td>Holiday accommodation—Australia</td>
<td>0.81</td>
<td>1.0 (12.8)</td>
</tr>
<tr>
<td>Holiday package tour—Australia</td>
<td>0.36</td>
<td>1.2 (3.4)</td>
</tr>
</tbody>
</table>

**Source:** See Appendix 1.

$^a$ Total expenditure (other than income tax, superannuation, life insurance and capital for housing) was $157.04.

$^b$ The dependent variable is expenditure on vacation travel (i.e. of four or more nights away from home), not trips.

$^c$ See the second paragraph of Appendix 1.
sectors, estimated from cross-section data in the summaries of the Australian Household Expenditure Surveys, 1974–75 and 1975–76 (Australian Bureau of Statistics). The estimates were made by expressing expenditure as a function of disposable income and the age of the head of the household.\textsuperscript{8} Other independent variables were not included because they are fairly highly correlated with the age of the head of the household. The estimated equations are shown in Appendix 1.

THE PRE-DETERMINED ELASTICITIES

The estimates shown in Tables 1 and 2, together with Hutton's (1979) estimates for internal air travel, provide the basis for the demand system for the five sectors of the vacation travel market. Nine initial values have been inferred from the sources. They are shown in Table 3 (marked \(a\) to \(d\)), and reasons for selecting the specific values are given in Appendix 2.

Clearly, the set of data is less than adequate, and the results are presented only as a first approximation. Furthermore, it should be recognised that the author's judgement of what is plausible has influenced the values selected. Appendix 2 indicates the nature of the particular judgements.

Probably the least reliable of the nine estimates are the two which relate overseas travel to the price of overseas accommodation. These are marked \(b\) and \(d\) in Table 3 and are discussed in Appendix 2. The source estimates refer to the general level of prices in overseas countries rather than to the price of overseas accommodation. For the general price level to be a satisfactory proxy for accommodation costs it is necessary to assume that costs in a service sector, with a high wage content, move in step with prices generally. This may not be true.

The validity of inferring the own-price elasticity of demand for overseas accommodation from the own-price elasticity of demand for spending in countries visited depends upon accommodation taking a large proportion of such spending. This is probably true for trips to distant countries but not for trips to those nearby, which are partly short-term shopping trips. Consequently, estimates referring to travel between nearby countries have not been taken into account.

Of the two fare elasticities (marked \(a\) and \(f\)), the one for overseas travel is taken directly from the work of Smith and Toms, 1978 (the \(t\)-value being 19.9). The domestic elasticity is derived from Hutton's (1979) estimate for all air travel in Australia of \(-1.45\) (\(t = 25.9\)). On the basis of other information (see Appendix 2), an elasticity for vacation travel of \(-2.1\) is inferred from Hutton's estimate.

The five income elasticities are based on the estimates shown in Table 2 and, for three of them, on the estimates of Smith and Toms (1978), Kwack (1972) and Hutton (1979). The nature of the compromise between the sources in each of these three cases is explained in Appendix 2.

\textsuperscript{8} From the nature of the data, these are elasticities of demand for expenditure. Because they are cross-section estimates, these expenditure elasticities would be over-estimates of the normal income elasticities only if a higher income household tended to pay a higher price for a given service. Empirical evidence suggests that the two types of estimates are generally similar. This paper deals with demand for trips, but expenditure elasticities are used where it is unavoidable.
## Table 3

**Synthesised Matrix of Elasticities of Demand for Categories of Vacation Travel and Tourist Accommodation: Australian Travellers**

<table>
<thead>
<tr>
<th>Demand for</th>
<th>Overseas air fares</th>
<th>Price of overseas accommodation</th>
<th>Internal air fares</th>
<th>Price of domestic accommodation</th>
<th>Car operating costs</th>
<th>Prices of other consumer goods and services</th>
<th>Income</th>
<th>Share of Expenditure(x) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacation air trips overseas</td>
<td>-1.8*</td>
<td>-1.2*</td>
<td>+0.4</td>
<td>+0.4</td>
<td>+0.1</td>
<td>+0.0(f)</td>
<td>+2.1(c)</td>
<td>1.114</td>
</tr>
<tr>
<td>Overseas tourist accommodation</td>
<td>-2.2*</td>
<td>-0.9(d)</td>
<td>+0.2</td>
<td>+0.4</td>
<td>+0.1</td>
<td>+0.2(f)</td>
<td>+2.2(d)</td>
<td>0.611</td>
</tr>
<tr>
<td>Internal vacation trips by air</td>
<td>+1.7*</td>
<td>+0.5*</td>
<td>-2.1(e)</td>
<td>-1.7</td>
<td>+0.3</td>
<td>+0.2(f)</td>
<td>+1.1(e)</td>
<td>0.255</td>
</tr>
<tr>
<td>Internal tourist accommodation</td>
<td>+0.7*</td>
<td>+0.4*</td>
<td>-0.7*</td>
<td>-1.2</td>
<td>-0.4</td>
<td>+0.2(d)</td>
<td>+1.0(d)</td>
<td>0.630</td>
</tr>
<tr>
<td>Vacation car trips (internal)</td>
<td>+0.5*</td>
<td>+0.3*</td>
<td>+0.3*</td>
<td>-1.1*</td>
<td>-1.4</td>
<td>+0.7(f)</td>
<td>+0.7(f)</td>
<td>0.223</td>
</tr>
</tbody>
</table>

* The cross-elasticities below the diagonal have been obtained by applying the Hotelling–Jureen relationship (an abbreviated form of the Slutsky or symmetry relationship) to the corresponding cross-elasticities above the diagonal. Thus, \(E_{ij} = (R_j/R_i)E_{ii}\) where \(R_j\) and \(R_i\) are the expenditure shares of \(j\) and \(i\).  

Note: The items marked \(a\) to \(k\) are discussed in Appendix 2.
PRICE ELASTICITIES IN VACATION TRAVEL

John H. E. Taplin

FORMATION OF THE COMPLETE SYSTEM

To form the matrix of 35 elasticities (Table 3) for the system of five demand equations, we have:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior estimates of elasticities</td>
<td>9</td>
</tr>
<tr>
<td>Homogeneity constraints</td>
<td>5</td>
</tr>
<tr>
<td>Symmetry constraints</td>
<td>10</td>
</tr>
<tr>
<td>Combined column and symmetry constraints</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

This means that, if values can be assigned to an appropriate six of the undetermined elasticities, then all values are determined.

There are constraints also on the signs of the undetermined elasticities, so that the effect of all the constraints is to put limits on the ranges of values these elasticities can take. Because the system has been constructed for five services which are reasonably close substitutes or complements, it is assumed that no cross-elasticity relating any two of the five is smaller in absolute magnitude than 0.1.

The first row of Table 3 contains more pre-determined elasticities than any other, so the first step is to complete this row. From the fact that the sum of the pre-determined elasticities is −0.9 it is inferred that the unknown elasticities sum to +0.9 (the homogeneity condition). There is an added constraint: if the cross-elasticity with respect to internal air fares \( E_{13} \) were to exceed 0.4 the first element in row three \( E_{31} \), which is 4.37 times as large (by symmetry), would too closely approach the magnitude of the own-price elasticity \( E_{13} \) in row three.\(^9\) With \( E_{13} \) set at 0.4, the remaining sum of elasticities in row one is allocated on the grounds of plausibility, 0.4 to \( E_{14} \) and 0.1 to \( E_{15} \).

The conclusion that \( E_{16} \), the elasticity with respect to other prices, is less than 0.1 is finally reached by applying the Cournot column aggregation condition and the full Slutsky relationship in the manner set out in Appendix 2 (note \( j \)). This can only be done after provisional values have been assigned to all elasticities in column one. The other cross-elasticities in the sixth column are obtained similarly. The whole process is iterative, because it is necessary to make some small adjustments to the elasticities in the first five columns in order to simultaneously satisfy the homogeneity condition for all the rows.

As values are assigned to the elements in each successive row, the applications of symmetry leave fewer to be determined in the subsequent rows. Thus in the fourth row, for example, the first three elements are determined by symmetry. This leaves a residual sum of −1.4 to be allocated between the own-price elasticity and one cross-elasticity, as well as the cross-elasticity with respect to other prices (which is determined in the manner already discussed).

\(^9\) The application of symmetry depends on the relative expenditures. These are provided by the Household Expenditure Survey data (Table 2). For the purposes of this paper expenditure on package tours is allocated between trips and accommodation. Details are given in Appendix 2, note \( k \).
### Table 4

**Sensitivity Test: Effect on the Elasticity Matrix of Reducing the Cross-Elasticity of Demand for Vacation Air Trips Overseas with respect to the Price of Overseas Accommodation**

<table>
<thead>
<tr>
<th>Demand for</th>
<th>Overseas air fares</th>
<th>Price of overseas accommodation</th>
<th>Internal air fares</th>
<th>Price of domestic accommodation</th>
<th>Car operating costs</th>
<th>Prices of other consumer goods and services</th>
<th>Income</th>
<th>Share of Expenditure %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacation air trips overseas</td>
<td>−1.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−0.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>+0.3</td>
<td>+0.2</td>
<td>+0.1</td>
<td>+0.0</td>
<td>+2.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.114</td>
</tr>
<tr>
<td>Overseas tourist accommodation</td>
<td>−1.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−0.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+0.1</td>
<td>+0.1</td>
<td>+0.0</td>
<td>+0.2</td>
<td>+2.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.611</td>
</tr>
<tr>
<td>Internal vacation trips by air</td>
<td>+1.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−2.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>−0.9</td>
<td>+0.2</td>
<td>+0.2</td>
<td>+1.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.255</td>
</tr>
<tr>
<td>Internal tourist accommodation</td>
<td>+0.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−0.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−1.0</td>
<td>−0.3</td>
<td>+0.2</td>
<td>+1.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.630</td>
</tr>
<tr>
<td>Vacation car trips (internal)</td>
<td>+0.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>−1.3</td>
<td>+0.7</td>
<td>+0.2</td>
<td>+0.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.223</td>
</tr>
</tbody>
</table>

<sup>a</sup> The cross-elasticities below the diagonal have been obtained by applying the Hotelling-Jureen relationship (an abbreviated form of the Slutsky or symmetry relationship) to the corresponding cross-elasticities above the diagonal. Thus $E_{ij} = (R_j/R_i)E_{ji}$ where $R_j$ and $R_i$ are the expenditure shares of $j$ and $i$.

<sup>b</sup> Pre-determined elasticities as in Table 3.

<sup>c</sup> Pre-determined value changed from −1.2 to −0.9
A TEST OF SENSITIVITY

No systematic sensitivity tests have been done, but the importance and questionable derivation of the cross-elasticity of demand for vacation air trips overseas with respect to the price of overseas accommodation \( E_{12} \) makes it desirable to test the effects of a change in its value. As indicated in Appendix 2, note \( b \), a larger absolute value would imply implausibly large values of other cross-elasticities, but a smaller absolute value is conceivable. Again there is a limit: a change from \(-1.2\) to \(-0.8\) would result in \( E_{23} \), \( E_{24} \) and \( E_{25} \) going to zero. Thus, the test is made at a value of \(-0.9\).

The resulting system of demand elasticities is shown in Table 4. As in the construction of Table 3, judgements have been made about the allocation of residual sums of elasticities. The cross-elasticities with respect to other prices (column 6) do not change. The largest change is in \( E_{34} \), the elasticity of demand for internal vacation trips by air with respect to the price of domestic accommodation, from \(-1.7\) to \(-0.9\). Several others are altered appreciably.\(^{10}\) Owing to compensating changes, there is little change in the two own-price elasticities determined within the system, those for internal tourist accommodation and for vacation car trips.

The only parts of the resulting demand system that appear somewhat implausible are the low elasticities of demand for overseas tourist accommodation with respect to internal air fares and with respect to the price of domestic accommodation. On the assumption that many people going on vacation weigh up the domestic and overseas alternatives, one might expect these cross-elasticities to be larger. Nevertheless, the significance of the test is in showing the degree to which the internally determined elasticities are changed by shifting the value of \( E_{12} \) from one apparent limit to the other.

THE IMPORTANCE OF THE CROSS-ELASTICITIES

To have some idea of the size of previously unknown cross-elasticities is important in at least two ways. First, one's confidence in the estimates already available is somewhat enhanced if they can be seen as parts of a coherent demand system. This is only a limited advance, because other values might appear to fit just as well; furthermore, the initial estimates may be biased because the other variables in the system have been omitted from the estimating procedure.

A second, and possibly the more important, consideration is that without some knowledge of these cross-elasticities the outcome of pricing policies can be unpredictable, even when good estimates are available of own-price elasticities. It is true that under \textit{ceteris paribus} conditions there would be no need to know the cross-elasticities in order to predict the effect of a fare change; but we live in a world of interacting decisions where such an effect is rarely left to work itself out in isolation.

To take a simple but relevant example, overseas airlines might reduce the fares of vacation travellers by one per cent in the expectation of a 1.8% increase in patronage (i.e. using \( E_{11} \) in Table 3). At the same time, domestic airlines might independently

\(^{10}\) The rule adopted in the construction of Table 3, that no cross-elasticity relating any two of the five sectors should be less than 0.1, has been relaxed here.
Table 5
Change in Vacation Air Trips

<table>
<thead>
<tr>
<th></th>
<th>Overseas</th>
<th>Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of 1% reduction in overseas fare</td>
<td>+1.8</td>
<td>-1.7</td>
</tr>
<tr>
<td>Effect of 1% reduction in internal air fare</td>
<td>-0.4</td>
<td>+2.1</td>
</tr>
<tr>
<td>Net effect</td>
<td>+1.4</td>
<td>+0.4</td>
</tr>
</tbody>
</table>

reduce fares for vacation travellers by one per cent on the expectation of a 2.1% increase in patronage (using $E_{31}$). That neither expectation would be fulfilled would be no surprise to airline managements, but their problem would be to predict the separate effects of the simultaneous fare changes. They would be seriously wrong if, for example, they assumed that patronage would increase by percentages proportional to the separate own-price elasticities. This is illustrated by the simple calculation shown in Table 5 (made on the assumption that the elasticities in Table 3 are correct). This shows net effects of +1.4 for overseas and +0.4 for internal vacation air trips. If Table 4 were assumed correct the net effects would be +1.5% and +0.8%.\(^\text{11}\)

Thus, the application of the set of elasticities for vacation travellers strongly suggests that the service with the slightly higher own-price elasticity would experience a much smaller percentage response to a uniform fare change across both services. This seemingly paradoxical result is firmly based on the symmetry of the two cross-elasticities involved, which follows directly from the known expenditure shares. The result follows so long as the cross-elasticities are of some significant magnitude; this can be fairly confidently asserted on the basis of homogeneity.

**SUMMARY**

The focus of this paper is on the most price-responsive group in the travel market, vacation travellers. In order to bring the analysis to bear on substitution between overseas and domestic air travel and on the complementarity of travel and accommodation, vacation travel is divided into five sectors. Domestic vacation car travel is included as the fifth sector to take account of significant relationships with the other four. This degree of disaggregation is necessary in order to examine the interactions of prices and pricing policies between the sectors. The system is defined for Australian travellers, but estimates based on overseas travel from North America are also used.

Initially, the matrix of coefficients of this five-equation demand system is only sparsely filled by previous estimates. Income elasticities are available for all five classes of vacation expenditure, while own-price elasticities are available or can be inferred for the two overseas vacation sectors (air trips and accommodation) and for internal vacation trips by air. One cross-elasticity can also be inferred. This leaves to

\(^{11}\) The implied elasticity of demand for vacation air trips in aggregate, i.e. the expenditure-weighted mean of the two net effects, is $-1.2$ based on Table 3 or $-1.4$ based on Table 4.
be determined not only two own-price elasticities but also twenty-four cross-
elasticities, some of the latter being indispensable in the assessment of interacting price
policies. Even though the deficiencies are partly due to the need for more estimation
work, it is probable that many of the cross-elasticities will remain inaccessible to
econometric techniques.

The solution employed here depends upon theoretical restrictions, the elements of
the system being subject to row sum (homogeneity), proportionality (symmetry) and
column constraints to a total of twenty, as well as constraints on the signs of all
twenty-six of the unknown elasticities. Thus, it is possible to limit the range of feasible
values and even to determine specific values within these ranges by making plausible
allocations of certain residual sums of elasticities.

Nevertheless, the pre-determined values, several of which depend upon doubtful
inferences, are a less than adequate basis for the system, and the results can only be
treated as indicative of orders of magnitude. One sensitivity test has been made by
varying the least reliable of the prior estimates from one apparent limit to the other.
The effect on the internally determined elasticities is considerable, but not so great as
to upset general inferences that can be drawn from some of them.

As an illustration, it is shown that, within wide limits, the relevant cross-elasticities
are such that a uniform percentage fare change across the two vacation air travel
sectors would result in a much smaller percentage response in the sector with the
slightly higher own-price elasticity. Such a conclusion would appear paradoxical if the
own-price elasticities were considered alone, and indicates the advantage of having
even an imperfect indication of the size of the cross-elasticities.

APPENDIX 1

Regression equations: categories of “holiday” expenditure as a function of disposable
income and age of head of household: Australia 1974–75 and 1975–76

75 and Household Expenditure Survey 1975–76, Preliminary.

Households are grouped into six income categories. The survey was repeated with a
fresh sample in the second year, so that there are twelve grouped data observations.
Incomes and expenditures for 1975–76 have been deflated by the ratio of average
1974–75 household income to average 1975–76 household income.

The t-values of estimates obtained from grouped data are normally overstated by a
few per cent (Cramer, 1964). In cases such as overseas travel, where many house-
holds have zero observations, the t-values may be overstated by 50% or more.12 The
calculated value of $R^2$ refers only to the grouped data.

The “holiday” expenditure recorded in the surveys refers to trips involving four or
more nights away from home. Expenditure in the various categories (dependent
variables $X_1$ to $X_4$) is expressed in cents per week. The independent variables are:

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12 The author is indebted to A. Fischer of the University of Adelaide for drawing his attention to this
point.
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\[ Y \text{ household disposable income in dollars per week} \]
\[ Z \text{ age of household head in years} \]

The \( t \)-values are shown in brackets (nine degrees of freedom). Common logarithms are used.

**Holiday fares—overseas** \((X_1)\)
\[ \log X_1 = -5.6195 + 1.4686 \log Y + 2.6399 \log Z \quad R^2 = 0.707 \\
(3.920) \quad (1.649) \]

**Holiday accommodation—overseas** \((X_2)\)
(Because a zero observation on \( X_2 \) was recorded for the "under \$80" income class in 1975–76, this observation was excluded—leaving eleven, i.e. eight degrees of freedom)
\[ \log X_2 = -12.3986 + 2.6115 \log Y + 4.7721 \log Z \quad R^2 = 0.546 \\
(2.871) \quad (1.176) \]

**Holiday package tour—overseas** \((X_3)\)
\[ \log X_3 = -0.6858 + 0.7407 \log Y + 0.6267 \log Z \quad R^2 = 0.519 \\
(2.181) \quad (0.432) \]

**Holiday fares—Australia** \((X_4)\)
\[ \log X_4 = -2.1746 + 0.7893 \log Y + 1.3015 \log Z \quad R^2 = 0.701 \\
(4.262) \quad (1.644) \]

**Holiday petrol—Australia** \((X_5)\)
\[ \log X_5 = 0.7144 + 0.6886 \log Y - 0.4581 \log Z \quad R^2 = 0.873 \\
(4.147) \quad (0.646) \]

**Holiday accommodation—Australia** \((X_6)\)
\[ \log X_6 = -2.5573 + 1.0019 \log Y + 1.3758 \log Z \quad R^2 = 0.968 \\
(12.789) \quad (4.109) \]

**Holiday package tour—Australia** \((X_7)\)
\[ \log X_7 = -3.5979 + 1.2213 \log Y + 1.4951 \log Z \quad R^2 = 0.696 \\
(3.428) \quad (0.982) \]

**APPENDIX 2**

**Notes on the formation of Table 3**

*a. Own-price elasticity of demand for vacation air trips overseas*

Own-price elasticity of \(-1.78\) \((t = 19.9)\) estimated from combined time series and cross-section data by Smith and Toms (1978) in a demand equation for Australian leisure trips (per head of population) to seven overseas countries. A similar equation
estimated for leisure travel to Australia from the seven countries gave an estimated price elasticity of $-1.85$ ($t = 13.6$). Estimates made in various studies of U.S. travel overseas (Table 1) range from $-1.4$ to $-3.3$.

b. Cross-elasticity of demand for vacation air trips overseas with respect to price of overseas accommodation

Based on an estimate by Jud and Joseph (1974) relating to tourist trips by U.S. residents to Latin America other than Mexico (Table 1, third reference). Their estimating equation includes a cross-elasticity of demand for trips with respect to the ratio of prices in countries visited to U.S. prices of $-1.53$. This is taken as an indicator of the cross-elasticity with respect to accommodation costs, on the assumption that accommodation costs move in step with the general level of prices. This assumption is wrong to the extent that costs in this service sector, with a high wage content, move independently. The elasticity has been reduced to $-1.2$ to satisfy the homogeneity constraint. If this elasticity were larger in absolute magnitude, one or more of the other cross-elasticities would be implausibly large.

c. Income elasticity of demand for vacation air trips overseas

This income elasticity estimate of 2.1 is a compromise between the estimate of 2.36 ($t = 12.3$) by Smith and Toms (1978) and the estimate of 1.47 ($t = 3.9$) based on the 1974–75 and 1975–76 Household Expenditure Surveys (Appendix 1). These can be compared with estimates for the U.S. of 2.0 and 2.2 (Table 1). In view of this comparison and the narrower confidence limits associated with the Smith and Toms estimate, the chosen figure is closer to 2.36 than to 1.47 (being 1.4 standard errors below the former and 1.7 standard errors above the latter).

d. Own-price elasticity of demand for overseas tourist accommodation

Based on estimates of the elasticity of expenditure in countries visited with respect to the ratio of prices there to prices in the country of origin (Table 1). This is taken to be a reasonable indicator of the magnitude of the own price elasticity of demand for accommodation, on the ground that accommodation accounts for a considerable proportion of tourist expenditure in distant countries. Artus (1972) obtained estimates for U.S. and Canadian visitors to Europe of $-1.02$ ($t = 2.0$) and $-1.56$ ($t = 13.0$). His other estimates tend to be higher, but refer to neighbouring countries and hence include the effect of short-term shopping trips. Kwack (1972) made estimates for U.S. tourist spending abroad of $-1.36$ to $-1.57$. However, these estimates are biased upward by the effect of short-term trips to adjoining countries (Canada and Mexico), which accounted for 57% of U.S. travel spending abroad. Jud and Joseph (1974) made estimates for U.S. tourist expenditure in Latin America of $-0.92$ to $-2.68$. On the grounds that these elasticity estimates reflect some transport components, for which demand is known to be more elastic, the lowest estimate ($-0.9$) was selected as the most likely own-price elasticity for accommodation.

e. Income elasticity of demand for overseas tourist accommodation

Based primarily on the income elasticity estimate of 2.61 ($t = 2.9$) obtained from the 1974–75 and 1975–76 Household Expenditure Surveys (Appendix 1). The estimate
has been reduced to 2.2 in view of the estimated income elasticity of demand for spending abroad of 1.2 to 1.3 obtained by Kwack, 1972 (see Table 1). The reduction is equivalent to 0.44 of the standard error of the Australian estimate.

\[ f. \text{ Own-price elasticity of demand for internal vacation trips by air} \]

Based primarily on Hutton's (1979) estimate of $-1.45$ ($t = 25.9$) for all air travel in Australia. Preliminary unpublished work had given elasticities of $-0.86$ for business travel and $-1.26$ for non-business, the (historically) weighted mean being $-0.98$. When these two component elasticities are scaled up to Hutton's estimate they become $-1.27$ for business and $-1.86$ for non-business. The latter is still an underestimate of the elasticity of demand for vacation travel, because non-business travel includes activities which are less price responsive. The Preliminary Statistical Summary of the National Travel Survey (Aplin and Hirsch, 1978) shows the following composition of non-business travel by air within Australia in the September quarter of 1977:

<table>
<thead>
<tr>
<th></th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visiting friends</td>
<td>32</td>
</tr>
<tr>
<td>Recreation</td>
<td>15</td>
</tr>
<tr>
<td>Holiday</td>
<td>24</td>
</tr>
<tr>
<td>Personal affairs</td>
<td>21</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
</tbody>
</table>

Of these, "personal affairs" generally involve non-discretionary travel with a low price elasticity. Of the remainder, vacation travel ("Australian holiday" of four nights or more, as defined in the Household Expenditure Survey) would be the most price-responsive type of travel. On these grounds the non-business elasticity of $-1.86$ has been increased to $-2.1$ for the elasticity of vacation travel.

\[ g. \text{ Income elasticity of demand for internal vacation trips by air} \]

Based primarily on Hutton's (1979) estimate of the income elasticity of demand for all internal Australian air travel of 1.22 ($t = 7.9$). Although this embraces business travel there is evidence (Newman, 1971) that leisure travel is no more, and may even be less, income elastic than business travel (even though leisure travel is more price elastic). The figure has been reduced to 1.1 because the estimated income elasticity of demand for internal vacation travel expenditure on public transport (Appendix 1) obtained from the 1974–75 and 1975–76 Household Expenditure Surveys is 0.79 ($t = 4.3$). The Preliminary Statistical Summary of the National Travel Survey (Aplin and Hirsch, 1978) shows that some 39% of internal vacation travel was by air. If the air travel component is assumed to have an elasticity of 1.1, this implies that the remaining 61% of such travel (by train and bus) has an income elasticity of 0.6. This figure is consistent with the estimated income elasticity of demand for holiday petrol of 0.69 (Appendix 1) on the assumption that train and bus travel is somewhat inferior to car travel.

\[ h. \text{ Income elasticity of demand for internal vacation car trips} \]

See Appendix 1 and Table 2: "holiday accommodation—Australia".
i. Income elasticity of demand for internal vacation car trips

See Appendix 1 and Table 2: “holiday petrol—Australia”. An independent check can be made from the income elasticity estimate of 0.7 (t = 9.0) obtained when Aplin and Hirsch’s (1978) estimate of all internal Australian trips (of more than 100 km from home) as a function of income is converted to an elasticity at the mean. This latter estimate can be regarded as the weighted mean of the income elasticities of demand for car trips (83% of all trips as defined), air trips (6.6%), train trips (3.7%), truck trips (3.0%), bus trips (2.7%), and other trips (0.7%). If these weights are applied to income elasticities of 1.1 for air (see note g), 0.7 for car and 0.6 (see note g) for train, bus and other, the implied average income elasticity is 0.716, which approximates to the estimate of 0.7 based on the Household Expenditure Survey (Table 2).

j. Calculation of the cross-elasticities with respect to other prices

Each of the cross-elasticities with respect to the prices of all other goods and services had been calculated by the following two steps:

1. Calculate (for column j) the cross-elasticity of demand for other goods and services with respect to the price of j using the Cournot aggregation condition (as it applies to this case):

\[ R_1 E_{ij} + R_2 E_{2j} + \cdots + R_6 E_{6j} = -R_j \]

where \( R_1, \cdots, R_j, \cdots, R_6 \) are the shares of total expenditure (\( R_i \) being the proportion of “all other expenditure” in the total), and \( E_{ij} \) (\( i = 1, \cdots, 6 \)) is the cross-elasticity of demand for \( i \) with respect to the price of \( j \).

The elasticity calculated by this method (\( E_{6j} \)) is very small (except for \( E_{66} \) which approximates to -1.0, and is of no interest).

2. Calculate the cross-elasticity of demand for \( j \) with respect to the prices of all other goods and services, using the Slutsky relationship, which in this case becomes:

\[ E_{ij} = \frac{R_j}{R_i} E_{6i} + R_6 (E_{6j} - E_{ij}) \]

where \( E_{ij} \) is the income elasticity of demand for all other goods and services, having the value 0.98 (obtained by applying the Engel aggregation condition: the weighted sum of income elasticities is unity) and \( E_{ij} \) is the income elasticity of demand for \( i \).

In calculating the cross-elasticities in this sixth column the full Slutsky relationship is used because \( R_6 \) is large (97.2%) and hence the second term (the income effect) is comparable in magnitude to the first (the substitution effect). In calculating cross-elasticities in other columns only the first term (the Hotelling-Jureen relationship) is used, because the second is negligible in magnitude.

k. Shares of expenditure

The expenditure weights were obtained from the Australian Household Expenditure Survey 1974–75. The “holiday” expenditure recorded in the survey refers to trips involving four or more nights away from home. This definition differs appreciably from the one used for trips in the B.T.E. National Travel Survey (more than 100 km from home). Expenditure has been allocated as follows:
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(1) “holiday package tour—overseas”, divided equally between “vacation air trip overseas” and “overseas tourist accommodation”.
(2) “holiday package tour—Australia”: half to “internal tourist accommodation”; one quarter to “internal vacation trips by air”; one quarter to bus fares (therefore omitted from this tabulation).
(3) “holiday fares—Australia”: two-thirds to “internal vacation trips by air”; one-third to train and bus fares (therefore omitted from this tabulation).

Thus, the following expenditures are obtained:

<table>
<thead>
<tr>
<th>Vacation air trips overseas</th>
<th>Overseas tourist accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Holiday fares overseas”</td>
<td>“Holiday accommodation—overseas”</td>
</tr>
<tr>
<td>From “holiday package tour—overseas”</td>
<td>From “holiday package tour—overseas”</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>$1.15</td>
<td>$0.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal vacation trips by air</th>
<th>Internal tourist accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>From “holiday fares—Australia”</td>
<td>“Holiday accommodation—Australia”</td>
</tr>
<tr>
<td>From “holiday package tour—Australia”</td>
<td>From “holiday package tour—Australia”</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>$0.31</td>
<td>$0.81</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vacation car trips (internal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>“Holiday petrol—Australia”</td>
<td>0.30</td>
</tr>
<tr>
<td>Add other direct operating costs (not recorded in survey)</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>0.35</td>
</tr>
</tbody>
</table>

To obtain the shares, these expenditures have been expressed as percentages of $157.04 (1974–75 total weekly expenditure other than income tax, superannuation, life insurance and capital for housing).

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