THE ECONOMIC DETERMINANTS OF ALCOHOL CONSUMPTION*

K. W. CLEMENTS and S. SELVANATHAN
*Economic Research Centre, The University of Western
Australia; School of Commerce and Administration, Griffith
University*

In this paper is presented an analysis of the consumption patterns of beer, wine and spirits for Australia using data for the period 1955/56–1985/86. The validity of the demand theory hypotheses demand homogeneity and Slutsky symmetry has been tested using recently developed distribution-free procedures. The findings were that (i) beer and wine were necessities and spirits a strong luxury; (ii) beer and spirits are specific complements; and (iii) the homogeneity and symmetry hypotheses are acceptable. Preference for wine consumption seems to be independent of preference for beer and spirits.

Introduction

The consumption of alcoholic beverages is of interest to economists for at least three reasons. First, there is the basic challenge to analyse the extent to which alcohol consumption is amenable to economic analysis. Second, in many countries alcohol is heavily taxed. This raises interesting issues in public finance such as the welfare cost of these taxes, optimal taxation and externalities. Third, in many cases alcohol data are better than most as their basic source is the tax collection records.

The application of the system-wide approach was initiated by Clements and Johnson (1983) who estimated demand equations for beer, wine and spirits. Other studies on this area include Adrian and Ferguson (1987), Clements and E. A. Selvanathan (1987), Duffy (1987), Fuss and Waverman (1987), Heien and Pompelli (1989), Holm (1989), Johnson et al. (1990), Jones (1989), Pearce (1986), Penm (1988), Quek (1988), E. A. Selvanathan (1988) and Wong (1988). In this paper previous research on alcohol is extended in a number of directions. These extensions include the use of new distribution-free procedures (which do not require any asymptotic theory) to test the validity of the hypotheses of demand homogeneity and Slutsky symmetry; the identification of a structure of preferences whereby wine consumption

seems to be in a distinct category, is independent of beer and spirits; and an international comparison of alcohol consumption patterns which reveals some interesting similarities and differences across countries.

For most of the analysis, Theil's (1980) differential approach to consumption theory is used. One of the attractions of this approach is that it does not require the specification of the algebraic form of the utility function. The Rotterdam model (Barten 1964; Theil 1965) is a well-known system of demand equations belonging to the differential approach and a variant of this model is used in the analysis of alcoholic beverages. Other approaches include the AIDS (Deaton and Muellbauer 1980), translog (Christensen *et al.* 1975) and LES (Stone 1954) models. The differential approach is used because of its strong link with economic theory of consumer behaviour, attractive aggregation properties (Barnett 1979; E. A. Selvanathan 1990), generality and simplicity.

The Data

The data used are for Australia (1955/56–1985/86) and come mainly from the Australian Bureau of Statistics; full details are given in Clements and S. Selvanathan (1989).

Let:

p_{it}, q_{it} be the price and per capita quantity consumed of good i ($i = 1,...,n$) in year t;

$M_t = \sum_{i=1}^{n} p_{it}q_{it}$ be total expenditure ('income' for short);

$w_{it} = p_{it}q_{it}/M_t$ be the budget share of i; and

$\overline{w}_{it} = \frac{1}{2}(w_{it} + w_{i,t-1})$ be the arithmetic average of the budget share over the years $t-1$ and t.

If the three alcoholic beverages (beer, wine and spirits) are the first three goods, then

$\overline{W}_{gt} = \sum_{i=1}^{3} \overline{w}_{it}$ is the (arithmetic average of the) budget share for total alcohol and

$\overline{w}_{it}' = \overline{w}_{it}/\overline{W}_{gt}$ is the share of beverage i in total expenditure on alcohol;

this $\overline{w}_{it}'$ is known as the (arithmetic average of the) conditional budget share of i.

Rows 1 and 2 of Table 1 give the sample means of $\overline{w}_{it}'$ and $\overline{W}_{gt}$. As can be seen, on average beer absorbs almost 70 percent of the drinker's

budget and the remaining 30 percent is about evenly split between wine and spirits. Alcohol as a whole accounts for almost 6 percent of income. The first three entries in row 3 of the table contain the means of the log-changes in the prices, defined as $Dp_{it} = \log p_{it} - \log p_{i,t-1}$; when multiplied by 100 these are approximately equal to annual percentage changes. The fourth entry in row 3 is the mean of the Divisia price index of alcohol, $DP_{gt} = \sum_{i=1}^{3} \bar{w}_i' Dp_{it}$. The last row of the table contains the (means of the) quantity log-changes, $Dq_{it} = \log q_{it} - \log q_{i,t-1}$, and the Divisia volume index, $DQ_{gt} = \sum_{i=1}^{3} \bar{w}_i' Dq_{it}$. The rapid growth in wine consumption should be noted.

TABLE 1
Australian Alcohol Data
Means, 1955/56–1985/86

Variable	Beer	Wine	Spirits	Total Alcohol
Conditional budget share ($\bar{w}_{it}'$)	68.56	15.40	16.04	
Budget share ($\overline{W}_{gt}$)				5.82
Log-change in price (Dp_{it}, DP_{gt})	6.68	6.30	6.17	6.43
Log-change in quantity (Dq_{it}, DQ_{gt})	0.29	4.61	1.57	1.25

All entries are to be divided by 100.

Testing Homogeneity and Symmetry

Consider the following conditional demand equation for beverage i

(3.1) $\bar{w}_{it}'(Dq_{it} - DQ_{gt}) = \beta_i' DQ_{gt} + \sum_{j=1}^{3} \pi_{ij}' Dp_{jt} + \varepsilon_{it}$.

In this equation β_i' is the conditional income coefficient of i with $\sum_{i=1}^{3} \beta_i' = 0$; π_{ij}' is the $(i,j)^{\text{th}}$ conditional Slutsky coefficient; and ε_{it} is

a zero-mean error term. The coefficient β_i' is 100 times the change in w_i' resulting from a one percent increase in total alcohol expenditure; and the coefficient π_{ij}' measures the substitution effect of a change in the price of beverage j on the consumption of i. The π_{ij}''s satisfy requirements for demand homogeneity

$$(3.2) \qquad \sum_{j=1}^{3} \pi_{ij}' = 0 \qquad\qquad i = 1,2,3,$$

and Slutsky symmetry,

$$(3.3) \qquad \pi_{ij}' = \pi_{ji}' \qquad\qquad i,j = 1,2,3$$

Model (3.1) and the constraints are attractively simple: everything is linear in the parameters.

The variables on the right-hand side of equation (3.1), DQ_{gt} and Dp_{jt} ($j = 1,2,3$), refer to the alcoholic beverages only; consumption of other goods and other prices play no role. Consequently, (3.1) for $i = 1,2,3$ refers to the allocation of the alcohol budget to the three beverages and is known as a system of conditional (i.e., within alcohol) demand equations. These demand equations hold under the conditions of block independence with the alcoholic beverages comprising one block and all other goods another. Under block independence, the marginal utility of any member of the alcoholic beverages group is unaffected by the consumption of other goods (Clements 1987). For evidence in favour of block independence of alcohol, see Clements and E. A. Selvanathan (1988). Constraint (3.2) means that an equiproportional increase in the prices of the three beverages has no effect on the consumption of i, total alcohol consumption remaining unchanged. Constraint (3.3) implies that the substitution effects are symmetric in i and j. Dividing both sides of (3.1) by $\overline{w}_{it}'$ and rearranging, we obtain $1 + \beta_i'/\overline{w}_{it}'$ as the ith conditional income elasticity and $\pi_{ij}'/\overline{w}_{it}'$ as the $(i,j)^{th}$ conditional Slutsky price elasticity.

To test constraints (3.2) and (3.3), Theil's (1987) recently-developed distribution-free procedure is used; this does not require the assumption of normality or asymptotic theory. These tests are based on Barnard's (1963) Monte Carlo simulation procedure. Briefly, this procedure involves drawing error terms to simulate a large number of values of the test statistic under the null hypothesis to construct its empirical distribution. The observed value of the test statistic is then compared to this distribution, rather than its asymptotic counterpart.

Let $\hat{\pi}_{ij}'$ be the least-squares (LS) estimate of π_{ij}' in (3.1). Then the test statistic for the homogeneity of the ith equation is

$$(3.4) \qquad \hat{\tau}^i = \sum_{j=1}^{3} \hat{\pi}_{ij}'$$

and the test statistic for the homogeneity of all three equations jointly is

$$(3.5) \qquad \hat{\tau}^h = \sum_{i=1}^{3} | \hat{\tau}^i | .$$

In column 2 of Table 2 is presented the value of the test-statistics based on the data.[1] To assess the significance of these values the Monte Carlo simulation procedure discussed above with quasi-normal error terms is used.[2] In column 3 of the table is presented the rank of the data-based value among the 99 simulated values. As can be seen from the last entry of this column, the rank of the test statistic for the homogeneity of the system as a whole is 59. As this value lies outside the right-hand tail of the empirical distribution which contains 5 percent of the drawings, homogeneity may not be rejected at the 5 percent level. Similarly, a two-tailed test for the homogeneity of the individual equations shows that this hypothesis is also acceptable at the 5 percent level for each of the three beverages. Reinforcing this finding is the insignificance of the values of the three $\hat{\tau}^i$'s (see column 2).

TABLE 2
Monte Carlo Tests of Homogeneity
(standard errors in parentheses)

Beverage	Data-based Value of the Test Statistic $\hat{\tau}, \hat{\tau}^h \times 10$	Rank of the Data-based Test Statistic	
		Normal Errors	Bootstrap Errors
(1)	(2)	(3)	(4)
Beer	−.374 (.434)	22	11
Wine	.505 (.371)	91	97
Spirits	−.131 (.429)	35	33
All	1.009 (−)	59	78

Let $\hat{\pi}'_{ij}$ be the homogeneity-constrained LS estimate of π'_{ij}.[3] The test statistic for symmetry given homogeneity is

[1] To take account of autonomous trends, we have added constant terms (intercepts) to (3.1). See Clements and S. Selvanathan (1989) for details.
[2] See Clements and S. Selvanathan (1989) and Theil (1987) for details.
[3] Using constraint (3.2) in (3.1) yields

$$\overline{w}_{it}(Dq_{it} - DQ_{gt}) = \beta'_i DQ_{gt} + \sum_{j=1}^{2} \pi'_{ij}(Dp_{jt} - Dp_{3t}) + \varepsilon_{it} .$$

The homogeneity-constrained LS estimate of π'_{ij} is then obtained from this equation.

TABLE 3
First Set of Estimates of Conditional Demand Equations for Alcoholic Beverages

$$\bar{w}_{it}(Dq_{it} - DQ_{gt}) = \alpha_i' + \beta_i'DQ_{gt} + \sum_{j=1}^{3} \pi_{ij}'Dp_{jt}$$

(asymptotic standard errors in parentheses)

Beverage	Constant $\alpha_i' \times 100$			Conditional Income Coefficient β_i'	Conditional Slutsky Coefficients		
	1956/57– *1964/65*	*1965/66–* *1976/77*	*1977/78–* *1985/86*		$\pi_{i1}' \times 10$	$\pi_{i2}' \times 10$	$\pi_{i3}' \times 10$
Beer	0	0	-1.093 (.194)	-.163 (.038)	-.620 (.293)	-.014 (.225)	.635 (.165)
Wine	0	.881 (.122)	.881 (.122)	-.073 (.037)		-.453 (.214)	.467 (.131)
Spirits	0	-.881 (.122)	.212 (.183)	.236 (.039)			-1.102 (.165)

$$(3.6) \qquad \hat{\tau}^s = \sum_{i=1}^{3} \sum_{j=1}^{3} \mid \hat{\pi}_{ij}' - \hat{\pi}_{ji}' \mid$$

The data based value of $\hat{\tau}^s$ (x10) = 0.679.[4] To assess the significance of this value proceed as before and compute the simulated value of the test static (3.6). The rank of the data-based $\hat{\tau}^s$ among the 99 simulated values is 23. Thus symmetry may not be rejected at the 5 percent level.

The above results are based on quasi-normal errors. In order to avoid the normality assumption, Efron's (1979) bootstrap procedure is used. This involves using bootstrap realizations of the residuals of the demand equations under the null hypothesis.[5] Proceeding as before, the simulated values of the test-statistics (3.4), (3.5) and (3.6) for 99 simulations are then obtained. For homogeneity, the ranks of the data-based test statistics are presented in column 4 of Table 2. As can be seen, homogeneity still may not be rejected at the 5 percent level for the three individual beverages as well as for alcohol as a whole; the rank for wine is high, but still not significant (the 5 percent level critical values for two-tail tests are 3 and 97). For symmetry, the rank is 23 (as before). Hence symmetry is also still acceptable at the 5 percent level.[6]

The Utility Interactions Among Beverages

In this section the structure of preferences within the alcoholic beverages group is analysed. The presentation begins with the homogeneity- and symmetry-constrained estimates of demand equation (3.1) for $i = 1,2,3$. The maximum likelihood (ML) estimates under the assumption that the errors are independent, multivariate normal with a constant covariance matrix, are given in Table 3. Based on a preliminary analysis of the data, constant terms were added to the equations to take account of autonomous trends. As can be seen, all the constant terms are significant. It is to be noted that there are three sub-periods for the constants. The data are not incompatible with the restriction that the second constant in the wine equation is equal to the third constant for that beverage. This restriction is imposed in Table 3. As the estimates of β_i' for beer and wine are significantly negative, these two beverages are conditional necessities. Spirits are a conditional luxury as the estimate of β_3' is significantly positive. Regarding

[4] As before, constant terms have been added to the demand equations.

[5] To ensure that these disturbances have the same variances as in the previous simulations, we multiply each realization by $\sqrt{T/(T-K)}$, where T is the sample size and K is the number of independent variables in each demand equation.

[6] As an additional check Laitinen's (1978) exact test for homogeneity and the usual χ^2 test for symmetry (Theil, 1987) were also used. Again, the two hypotheses were not rejected. For details, see Clements and S. Selvanathan (1989).

the estimated Slutsky coefficients, the three diagonal elements of the matrix $[\pi_{ij}']$ are significantly negative, as should be the case.[7]

The Slutsky coefficient π_{ij}' refers to the total substitution effect of a price change. This total effect comprises a specific and general substitution effect; the former, which holds the marginal utility of income constant, is related to the interactions in the utility function among the beverages. Estimates of the specific substitution effects are now obtained by decomposing the Slutsky coefficients. Let:

λ be the marginal utility of income;

$M_g = \sum_{i=1}^{3} p_i q_i$ be total alcohol expenditure;

u^{ij} be the $(i,j)^{th}$ element of the inverse of the Hessian matrix of the utility function pertaining to alcohol; and

$v_{ij}' = (\lambda/M_g)p_i p_j u^{ij}.$

The coefficient v_{ij}' represents the specific substitution effect and is related to π_{ij}' by (Clements 1987)

(4.1) $\pi_{ij}' = v_{ij}' - \eta_{gg}\, \theta_i' \theta_j'$

where η_{gg} is the own-price elasticity of demand for alcohol as a group; and $\theta_i' = \partial(p_i q_i)/\partial M_g$ is the conditional marginal share of beverage i. The coefficients v_{ij}' are symmetric in i and j and satisfy (Clements 1987)

(4.2) $\sum_{j=1}^{3} v_{ij}' = \eta_{gg}\theta_i'$ $i = 1,2,3$

Let $DP_{gt}' = \sum_{i=1}^{3} \theta_i' Dp_{it}$ be the Frisch price index. Then, using (4.1) and (4.2), the substitution term of demand equation (3.1) becomes

(4.3) $\sum_{j=1}^{3} \pi_{ij}' Dp_{jt} = \sum_{j=1}^{3} v_{ij}' (Dp_{jt} - DP_{gt}').$

Accordingly, v_{ij}' is the coefficient attached to the jth relative price in the ith demand equation, or the $(i,j)^{th}$ price coefficient for short.

Consider the marginal utility of beverage i, $\partial u/\partial q_i$. Additional consumption of j causes this marginal utility to change by $\partial^2 u/\partial q_i \partial q_j$. All such changes are given by the 3x3 Hessian matrix of the utility function pertaining to alcohol, $U = [\partial^2 u/\partial q_i \partial q_j]$. Suppose, for example,

---

[7]The characteristic roots of $[\pi_{ij}']$ are -1.67, $-.50$ and 0 (all x 10), which verifies that this matrix is negative semidefinite.

that the marginal utility of wine is independent of the consumption of beer and spirits. As Hessians are symmetric, in this case

$$U = \begin{array}{c} beer \\ wine \\ spirits \end{array} \begin{array}{ccc} beer & wine & spirits \\ \left[\begin{array}{ccc} \partial^2 u/\partial q_1^2 & 0 & \partial^2 u/\partial q_1 \partial q_3 \\ 0 & \partial^2 u/\partial q_2^2 & 0 \\ \partial^2 u/\partial q_3 \partial q_1 & 0 & \partial^2 u/\partial q_3^2 \end{array} \right] \end{array}$$

Here the beverages can be reordered so that U and U^{-1} are both blocked diagonal with beer and spirits in one block and wine in another. This can be described as block independence within alcohol or, more simply, wine independence. In this case, all the off-diagonal v_{ij}''s involving wine vanish and, according to (4.3), the relative price of wine has no effect on the consumption of the other two beverages.

Equation (4.1) is used in the form $v_{ij}' = \pi_{ij}' + \eta_{gg}\theta_i'\theta_j'$ to obtain estimates of the price coefficients from the Slutsky coefficients given in Table 3. The price elasticity of alcohol η_{gg} is set equal to -0.6, a value obtained in preliminary analysis.[8] Regarding the marginal shares θ_i', these take the form $\beta_i' + \overline{w}_{it}'$ under model (3.1). Column 2 of Table 4 contains the estimates of the θ_i''s, obtained using the income coefficients of Table 3 and means of the $\overline{w}_{it}'$'s. These indicate that an additional \$1 of spending on alcohol results in beer expenditure increasing by 52 cents, wine by 8 cents and spirits by 40 cents. Columns 3-5 of Table 3 contain the upper triangle of the $[v_{ij}']$ matrix.

TABLE 4

Conditional Marginal Shares and Price Coefficients
(asymptotic standard errors in parentheses)

Beverage	Conditional Marginal Share θ_i'	Price coefficients x 10		
		v_{i1}'	v_{i2}'	v_{i3}'
(1)	(2)	(3)	(4)	(5)
Beer	.523 (.038)	-2.260 (.317)	-.268 (.213)	-.609 (.191)
Wine	.081 (.037)		-.492 (.229)	.275 (.159)
Spirits	.396 (.039)			-2.045 (.260)

[8]This value is obtained by regressing the log change in alcohol consumption relative to real income on the change in the relative price. See Clements and S. Selvanathan (1989).

The two off-diagonal price coefficients involving wine (v_{12}' and v_{23}') are both insignificant, which indicates that the marginal utility of this beverage is independent of the other two. Wine by itself satisfies a basic want of the consumer. Note also that the estimate of v_{13}' (beer/spirits) is significantly negative; a rise in the relative price of spirits *decreases* beer consumption, indicating complementarity. There are some reasons to expect complementarity. At a formal dinner it is not unusual for beer to be consumed beforehand, to have wine during dinner and for spirits to be served afterwards. Additional consumption of one beverage consequently reinforces the pleasure of drinking the other two, provided consumption remains within the usual tolerance levels. In this sense the beverages are complements, rather than being competitive or substitutes. Even if some do not drink all three beverages sequentially, another line of argument establishes the presumption of complementarity. The utility at the margin of, say, a beer drinker may well be enhanced by additional consumption by spirits drinkers (and vice versa) due to the increased social interaction facilitated by the larger intake of alcohol as a whole. The finding that wine is an independent beverage implies that wine consumers tend not to mix their drinks, or that they talk only to other wine drinkers at social occasions.

The Second Version of the Demand Model

In the previous section it was concluded that the data are not inconsistent with the proposition that the marginal utility of wine is independent of the consumption of the other two beverages. In this section this restriction is imposed and formally tested.

Equation (3.1) is a demand equation in absolute prices. Substituting (4.3) in (3.1) the following demand equation for i in terms of relative prices is obtained

$$(5.1) \qquad \overline{w}_{it}'(Dq_{it} - DQ_{gt}) = \beta_i'DQ_{gt} + \sum_{j=1}^{3} v_{ij}'(Dp_{jt} - DP_{gt}') + \varepsilon_{it}.$$

This is the second version of the demand model, while (3.1) is the first. When wine is preference independent, the 3x3 symmetric matric $[v_{ij}']$ takes the form

$$(5.2) \qquad
\begin{array}{c}
beer \\
wine \\
spirits
\end{array}
\begin{bmatrix}
v_{11}' & 0 & v_{13}' \\
 & v_{22}' & 0 \\
 & & v_{33}'
\end{bmatrix}$$

As $\theta_i' = \beta_i' + \overline{w}_{it}'$, constraint (4.2) becomes

$$(5.3) \qquad \sum_{j=1}^{3} v_{ij}' = \eta_{gg}(\beta_i' + \overline{w}_{it}'), \qquad i = 1,2,3$$

TABLE 5

Second Set of Estimates of Conditional Demand Equations
$$\overline{w}_{it}'(Dq_{it} - DQ_{gt}) = \alpha_i' + \beta_i'DQ_{gt} + \eta_{gg}z_{it} + \kappa_i c_t$$
(asymptotic standard errors in parentheses)

Beverage	Constant $\alpha_i' x\ 100$			Conditional Income Coefficient β_i'
	1956/57–1964/65	1965/66–1976/77	1977/78–1985/86	
Beer	0	0	−.963 (.189)	−.187 (.035)
Wine	0	.801 (.117)	.801 (.117)	−.054 (.030)
Spirits	0	−.801 (.117)	.162 (.183)	.241 (.039)
	$\kappa = -.142\ (.048)$		$\eta_{gg} = -.6$ (specified)	

TABLE 6

Means of Conditional Income and Slutsky Price Elasticities

Beverage	Conditional Income-Elasticity η_i'	Conditional Price Elasticities		
		η_{i1}'	η_{i2}'	η_{i3}'
Beer	.73	−.15	.04	.11
Wine	.61	.18	−.32	.15
Spirits	2.51	.46	.15	−.61

$\eta_i' = \partial(\log q_i)/\partial(\log M_g)$; $\eta_{ij}' = \partial(\log q_i)/\partial(\log p_j)$ with total alcohol consumption held constant.

Constraint (5.3) means that the price coefficients cannot be constants; following Clements and E. A. Selvanathan (1987), v_{13}' in (5.2) is specified to take the form

$$(5.4) \qquad v_{13}' = \kappa \sqrt{\overline{w}_{1t}' \, \overline{w}_{3t}'}$$

where κ is a constant.[9] As $v_{13}' < 0$ in Table 4, κ is expected to be negative. It follows from (5.2)–(5.4) that

$$(5.5) \qquad \begin{cases} v_{11}' = \eta_{gg}(\beta_1' + \overline{w}_{1t}') - \kappa\sqrt{\overline{w}_{1t}'\overline{w}_{3t}'} \\ v_{22}' = \eta_{gg}(\beta_2' + \overline{w}_{2t}') \\ v_{33}' = \eta_{gg}(\beta_3' + \overline{w}_{3t}') - \kappa\sqrt{\overline{w}_{1t}'\overline{w}_{3t}'} \end{cases}$$

To derive the estimating equations, (5.2), (5.3) and (5.5) are substituted for v_{ij}' in (5.1). After rearrangements, this yields the following conditional demand equation for beverage i:

$$(5.6) \qquad \overline{w}_{it}'(Dq_{it} - DQ_{gt}) = \beta_i' DQ_{gt} + \eta_{gg}z_{it} + \kappa_i c_t + \varepsilon_{it}$$

where
$$z_{it} = (\beta_i' + \overline{w}_{it}')[(Dp_{it} - Dp_{3t}) - \sum_{j=1}^{2}(\beta_j' + \overline{w}_{jt}')(Dp_{jt} - Dp_{3t})];$$

$$c_t = -\sqrt{\overline{w}_{1t}'\,\overline{w}_{3t}'}(Dp_{1t} - Dp_{3t}); \text{ and}$$

$$\kappa_2 = 0, \ \kappa_1 = -\kappa_3 = \kappa.$$

To estimate (5.6) for $i = 1,2,3$ constant terms are added, as before, and the ML estimation applied. The results are contained in Table 5. As can be seen, the estimates of the constants and income coefficients are quite similar to those in Table 3. The estimate of κ is negative, as expected, and significant. The value of η_{gg}, the own-price elasticity for alcohol, is fixed in the table as initial results indicated that it was not possible to obtain a precise estimate of this parameter. This elasticity is set at –0.6, as before.[10] An analysis of the residuals indicates that autocorrelation is not a problem. Furthermore, simulation experiments show that the ML estimators have a satisfactory small-sample performance.[11]

To test the hypothesis that wine is a preference independent beverage, the unrestricted model (3.1) is used for $i = 1,2$ (one equation of the three is redundant) with restricted constant terms and homogeneity and symmetry imposed. The restricted model is (5.6) for $i = 1,2$ with restricted constant terms. Let L_u and L_r be the log-

---

[9]Let F_{ij} be the $(i,j)^{th}$ Frisch elasticity, i.e., the elasticity of beverage i with respect to the relative price of j when the marginal utility of income is held constant. The coefficient κ is then interpreted as the negative of the geometric mean of F_{13} (beer/spirits) and F_{31} (spirits/beer). See Clements and E. A. Selvanathan (1987).

[10]Most of the estimates are fairly insensitive to the use of different values of η_{gg}. See Clements and S. Selvanathan (1989) for details.

[11]See Clements and S. Selvanathan (1989) for details.

likelihood values of the unrestricted and restricted models, respectively. The test statistic chosen was $-2(L_r - L_u)$ which has a data-based value of 6.59. To assess the significance of this value, the Monte Carlo procedure of Section 3 was used. A data set was simulated with quasi-normal error terms under the null hypothesis. The restricted and unrestricted models were estimated and the simulated value of the test statistic computed. This procedure is repeated 999 times and the data-based value of the test statistic ranked among the 999 simulated values. The null hypothesis is rejected at the 5 percent level if the rank of the data-based test statistic is greater than 950. As this rank is 620, the hypothesis that wine is preference independent was not rejected.[12]

The means of the elasticities implied by the estimates in Table 5 are given in Table 6.[13] Beer and wine are conditional necessities, while spirits is a strong luxury. The own-price Slutsky elasticities are -0.2, -0.3 and -0.6 for beer, wine and spirits, respectively; most of the cross elasticities are small.

The Demand for Alcohol as a Whole

The conditional demand equations relate to the allocation of total expenditure on alcohol to the three beverages; total alcohol consumption is held constant in these equations. In this section the analysis is extended by presenting estimates of the demand equation for alcohol as a whole, which shall be referred to as the composite demand equation.

The Divisia volume index for alcohol is a budget-share weighted mean of the three quantity log-changes, $DQ_{gt} = \sum_{i=1}^{3} \bar{w}_{it}'Dq_{it}$. For simplicity, DQ_g is expressed as a linear function of the log-change in per capita real income DQ and the relative price of alcohol DP_g–DP^*, where DP_g is the Divisia price index of alcohol and DP^* is the log-change in the price index of all goods,

$$(6.1) \qquad DQ_{gt} = \eta_g DQ_t + \eta_{gg}(DP_{gt} - DP_t^*) + \mu_t,$$

with η_g the income elasticity for alcohol; η_{gg} the own-price elasticity; and μ_t an error term. Equation (6.1) is an approximation to the composite demand equation implied by block-independent preferences.[14]

---

[12]As an additional check, the normality assumption was relaxed for the error vectors and data sets generated using bootstrap errors. This involves using bootstrap realizations of the ML-residuals of equation (5.6) for $i = 1,2$ with restricted constant terms. The rank of the data-based test statistic is now 701 in the 999 simulations, again insignificant at the 5 percent level. See Clements and S. Selvanathan (1989) for details.

[13]For derivations, see Clements and S. Selvanathan (1989).

[14]The approximation involves (i) treating the elasticities as constants; and (ii) replacing the Frisch price indexes with their Divisia counterparts. See Clements (1987)

TABLE 7

Estimates of Composite Demand Equation for Alcohol

$$DQ_{gt} = \alpha + \eta_g DQ_t + \eta_{gg}(DP_{gt} - DP_t^*)$$

(standard errors in parentheses)

	Constant $\alpha \times 100$	Income Elasticity η_g	Price Elasticity η_{gg}	R^2	SEE x 100	DW
1956/57- 1964/65						
	—	1.004 (.087)	-.592 (.069)	.84	1.13	1.84
1965/66- 1976/77						
-1.101 (.416)						
1977/78- 1985/86						
-1.573 (.406)						

The LS estimates of (6.1) are presented in Table 7. As before, constant terms have been added to take account of trends of residuals. The income elasticity for alcohol as a whole is 1.0, while the price elasticity is −0.6. Note that these elasticities are estimated precisely and that the estimate of η_{gg} is consistent with the value used previously.

Suppose the price of beverage i increases when real income and all other prices remain unchanged. This has two effects on the consumption of i. The first is a reallocation of a given total expenditure on alcohol. The increase in the relative price of i causes consumption of i to fall. This direct effect is given by the conditional demand equation for i. In addition, the price increase causes alcohol as a whole to become relatively more expensive. Total alcohol consumption thus falls. This reduction is real total expenditure then causes consumption of i to change, which is an indirect effect given by a combination of the composite and conditional demand equations. In the following the direct and indirect effects are combined to obtain estimates of the total impact of all income and price changes.

The ith conditional demand equation is given by (5.6). To simplify, a double-log approximation was used and the error term omitted, leaving

$$(6.2) \qquad Dq_{it} = \eta_i' DQ_{gt} + \sum_{j=1}^{3} \eta_{ij}' Dp_{jt} ,$$

where η_i' is the conditional income elasticity of demand for i; and η_{ij}' is the $(i,j)^{th}$ conditional Slutsky price elasticity. The relative price of alcohol, $DP_g - DP^*$, in the composite demand equation (6.1) is the difference between the Divisia price index for alcohol and the log-change in the price index of all goods (including alcohol). The former index is defined as

$$(6.3) \qquad DP_{gt} = \sum_{i=1}^{3} \overline{w}_{it}' Dp_{it} ,$$

with $\overline{w}_{it}'$ the arithmetic average of the conditional budget share of i. The latter price index is expressed as a budget-share weighted average of the changes in the prices of all n goods,

$$(6.4) \qquad DP_t' = \sum_{i=1}^{n} \overline{w}_{it} Dp_{it},$$

where $\overline{w}_{it}$ is the arithmetic average of the (unconditional) budget share of good i.

Recalling that the n goods are ordered such that the alcoholic beverages are the first three goods, $DP_{ot} = \sum_{i=4}^{n} \overline{w}_{it}' Dp_{it}$ is defined as an

index of the price of all other (i.e. nonalcoholic) goods. As the conditional budget share of beverage i is defined as $\overline{w}_{it}' = \overline{w}_{it}/\overline{W}_{gt}$, it follows from equations (6.3) and (6.4) that DP_i^* can be expressed as a weighted average of DP_{gt} and DP_{ot}, $DP_i^* = \overline{W}_{gt} DP_{gt} + (1 - \overline{W}_{gt})DP_{ot}$, so that

(6.5) $DP_{gt} - DP_i^* = (1-\overline{W}_{gt})(DP_{gt} - DP_{ot})$.

The time-dependent budget shares $(\overline{W}_{gt}, \overline{w}_{it}')$ are approximated with their sample means $(\overline{\overline{W}}_g, \overline{\overline{w}}_i')$, so that (6.5) becomes

(6.6) $DP_{gt} - DP_i^* = (1 - \overline{\overline{W}}_g)\left[\sum_{i=1}^{3} \overline{\overline{w}}_i' Dp_{it} - DP_{ot}\right]$.

The right-hand side of (6.6) is substituted for the relative price in the composite demand equation (6.1) and the error term omitted to give

(6.7) $DQ_{gt} = \eta_g DQ_t + \sum_{j=1}^{3} \eta_{gj} Dp_{jt} + \eta_{go} DP_{ot}$,

where

(6.8) $\eta_{gj} = \eta_{gg} (1-\overline{\overline{W}}_g)\overline{\overline{w}}_j'$, $\eta_{go} = -\eta_{gg}(1 - \overline{\overline{W}}_g)$

are price elasticities of demand for total alcohol. Using the values of $\overline{\overline{W}}_g$ and $\overline{\overline{w}}_i'$ given in Table 1, together with $\eta_{gg} = -0.592$ (from Table 7) in equation (6.8) for $j = 1,2,3$, and the following results are obtained.

	Good j	Elasticity of demand for total alcohol with respect to price of good j η_{gj}
(6.9)	beer	−0.382
	wine	−0.086
	spirits	−0.089
	all other goods	0.558

Equation (6.7) is used to substitute for DQ_{gt} in (6.2) to give

$Dq_{it} = \eta_i DQ_t + \sum_{j=1}^{3} \eta_{ij} Dp_{jt} + \eta_{io} DP_{ot}$,

where

(6.10) $\eta_i = \eta_i' \eta_g$, $\eta_{ij} = \eta_{ij}' + \eta_i' \eta_{gj}$, $\eta_{io} = \eta_i' \eta_{go}$

are the total (or unconditional) income and price elasticities. The values of these elasticities are contained in Table 8 and are computed using equation (6.10) for i,j = 1,2,3, η_g = 1.004 (from Table 7) and the elasticity values given in (6.9) and Table 6. A comparison of Tables 6 and 8 reveals that the unconditional income elasticities are almost exactly equal to their conditional counterparts (as $\eta_g \approx 1$). Also, the own-price elasticities in Table 8 are all larger (in absolute value) than those in Table 6 because of the indirect effects of the price changes. The negative cross-price elasticities in Table 8 indicate complementarity.

TABLE 8
Unconditional Income and Slutsky Price Elasticities

Beverage	Unconditional Income-Elasticity η_i	Unconditional Price Elasticities			
		η_{i1}	η_{i2}	η_{i3}	η_{io}
Beer	.73	−.43	−.02	.05	.41
Wine	.61	−.05	−.37	.10	.34
Spirits	2.52	−.50	−.07	−.83	1.40

$\eta_i = \partial(\log q_i)/\partial(\log M)$; $\eta_{ij} = \partial(\log q_i)/\partial(\log p_j)$ with real income held constant.

On Substitutes and Complements

In the previous section titled 'The Utility Interactions Among Beverages', it was shown that there is complementarity amongst the alcoholic beverages (see Table 4). However, all the cross-price elasticities in Table 6 are positive, indicating that the three beverages are pairwise substitutes. The occurrence of negative cross-price elasticities in Table 8 adds to the apparent contradiction. In this section these findings are reconciled.

The explanation lies in different variables being held constant in the three tables. The measures based on the Hessian matrix of the utility function (Table 4) deal with only the specific part of the substitution effect and thus hold constant the marginal utility of income. By contrast, the conditional elasticities in Table 6 refer to both the specific and general components; as they are conditional, they hold constant total consumption of alcohol. Finally, the elasticities in Table 8 are unconditional and hold constant income rather than alcohol expenditure. Let $F_{ij} = v'_{ij}/w'_i$ be the elasticity of demand for beverage i with respect to the price of beverage j when the marginal utility of income is held constant (the F is for Frisch); v'_{ij} here is the $(i,j)^{th}$ price coefficient defined in 'The Utility Interactions Among Beverages' and w'_i is the conditional budget share of beverage i. The conditional

Slutsky elasticity η'_{ij} is the same elasticity when real total expenditure on alcohol remains unchanged. It can then be shown that the relationship between η'_{ij} and F_{ij} is

(7.1) $$\eta'_{ij} = F_{ij} - \eta_{gg} w_i \eta_i \eta_j,$$

where η_{gg} is the own-price elasticity of demand for alcohol as a whole; and η'_i is the conditional income elasticity of demand for i. As $\eta_{gg} < 0$ and w_i, η_i, η_j are all positive, it is shown in equation (7.1) that the conditional Slutsky elasticity is algebraically larger than the corresponding Frisch elasticity. This explains why substitutability is revealed in Table 6 ($\eta'_{ij} > 0$ for $i \neq j$), whereas complementarity is indicated in Table 4 ($v'_{12}, v'_{13} < 0$).

The relationship between the unconditional elasticity (η_{ij}) and its conditional counterpart is given in the middle part of equation (6.10), $\eta_{ij} = \eta'_{ij} + \eta_i \eta_{gj}$, where η_{gj} is the elasticity of total alcohol with respect to the price of beverage j. As $\eta_{gj} < 0$, $j = 1,2,3$, it is shown in this equation that $\eta_{ij} < \eta'_{ij}$, which explains the negative cross elasticities in Table 8. Take, for example, $i = 3$ (spirits) and $j = 1$ (beer). From Tables 6 and 8, $\eta'_{31} = 0.5$ (substitutes) and $\eta_{31} = -0.5$ (complements). Here an increase in beer prices causes total alcohol to fall to such an extent that the indirect effect overwhelms the substitution effect, so that the total effect of the beer price increase is for consumption of spirits to fall.

Comparison with Other Studies

Alcohol consumption patterns in several other countries have also been analysed recently at The University of Western Australia using a similar method to that employed in this analysis. The findings of these studies are summarised in Table 9. Note that beer is always a (conditional) necessity and, in ever case except one, spirits a luxury. New Zealanders are the median drinkers. Similarities and differences between the previous elasticities (as summarized by the medians) and those derived in this study are recorded in the last two rows of Table 9. The major differences involve the income elasticities for wine and spirits and the price elasticity for spirits. The other three pairs of elasticities are similar. Note also that the earlier estimates of elasticities for alcohol demand for Australia (given in the first row of the table) agree well with the more recent estimates (last row).

There are some similarities and some differences among the elasticities for different countries. To a certain extent, differences are to be expected for such finely-defined commodities as beer, wine and spirits. Presumably, if the three beverages were aggregated into total alcohol, there would be fewer differences. This matter is pursued by E. A. Selvanathan and Clements (1988) who analysed annual per capita alcohol data for Australia (1956–77), the UK (1955–75) and the US (1949–82). The change in alcohol consumption relative to income, $DQ_g - DQ$, against the change in the relative price, $DP_g - DP^*$, is shown

TABLE 9
Conditional Demand Elasticities for Alcohol from Recent Studies

Author	Country	Period	Income Elasticities			Own-price Slutsky Elasticities		
			Beer	Wine	Spirits	Beer	Wine	Spirits
Clements and E. A. Selvanathan (1987)	Australia	1956-1977	.73	.62	2.50	-.12	-.34	-.52
———(1987)	U.K.	1955-1975	.41	1.91	1.81	-.19	-.23	-.24
———(1987)	U.S.	1949-1982	.75	.46	1.34	-.09	-.22	-.10
Pearce (1986)	New Zealand	1966-1982	.85	1.14	1.31	-.15	-.35	-.32
Quek (1988)	Canada	1953-1982	.77	1.12	1.20	-.28	-.58	-.30
E. A. Selvanathan (1988)	U.K.	1955-1985	.55	1.23	1.82	-.13	-.37	-.32
Wong (1988)	U.K.	1920-1938	.94	1.62	.94	-.25	-.99	-.51
Median			.75	1.14	1.34	-.15	-.35	-.32
Current Study	Australia	1956-1986	.73	.61	2.51	-.15	-.32	-.61

Figure
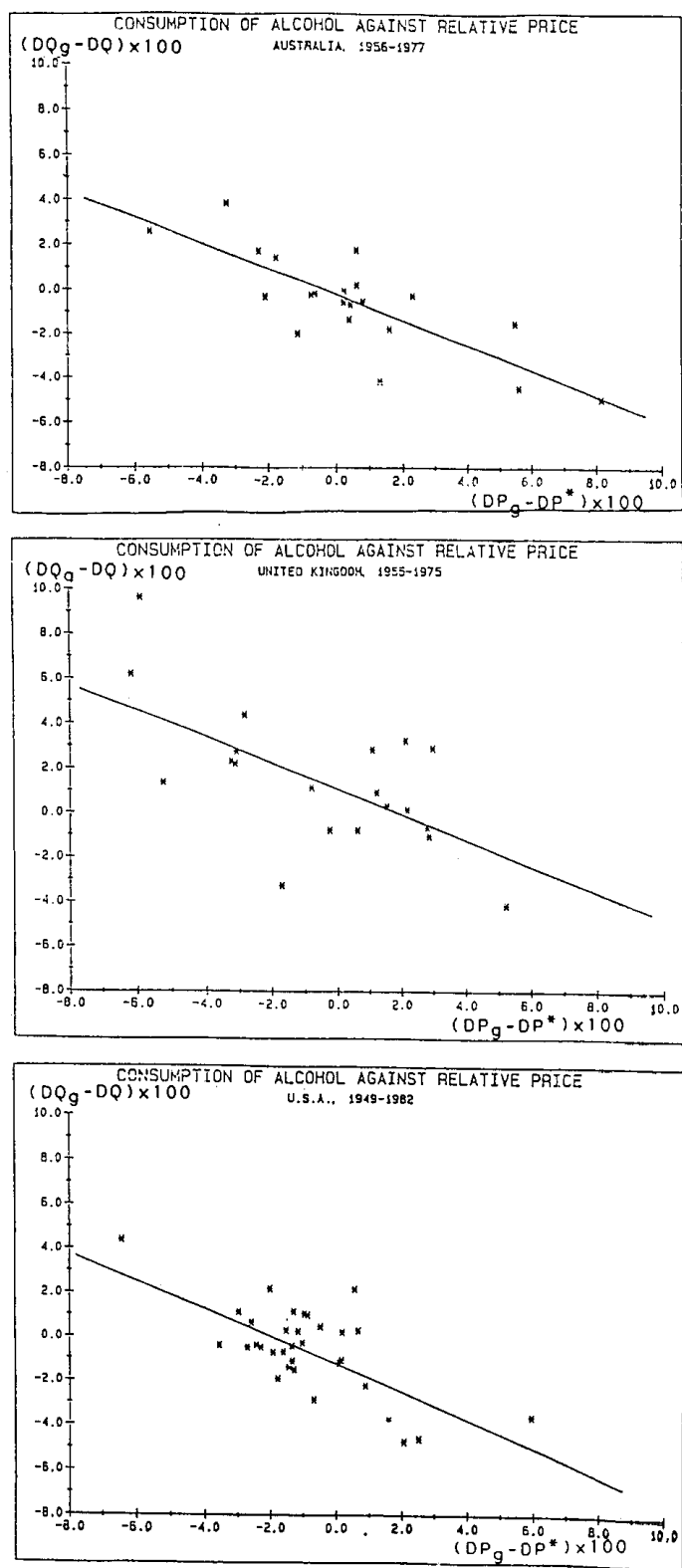
in Figure 1.[15] The solid lines are the LS regression lines. There is a distinct negative relationship between consumption and price in each country. The slopes of the regression lines are (standard errors in parentheses) are Australia –0.56 (0.10), UK –0.61 (0.17) and US –0.63 (0.12). The slopes, which were all highly significant, were interpreted as estimates of the own-price elasticity of demand for alcohol under the assumption of a unitary income elasticity. Note that these elasticities were very similar in the three countries. E. A. Selvanathan and Clements, using formal methods, concluded that the elasticities were identical in the three countries. Their three-country pooled estimates were 0.81 (0.10) for the income elasticity and –0.59 (0.07) for the price elasticity. These values are consistent with those given in Table 7.

This similarity of elasticities across countries points towards tastes being identical. It could be argued this implies that tastes are a fundamental constant which transcend national boundaries. In other words, if adjustments are made for differences in real incomes and relative prices, then consumption patterns are approximately the same internationally. Such an interpretation would appeal to economists who emphasize the universal applicability of microeconomic theory and eschew ad hoc 'special case' explanations, such as Stigler and Becker (1977).

Concluding Comments

An extensive analysis of the consumption patterns of beer, wine and spirits has been presented in the paper. The hypotheses of demand homogeneity and Slutsky symmetry were tested. The results indicated that drinkers do not suffer from money illusion and are consistent in their choice of beverage, i.e., the substitution effects are symmetric. A feature of this hypothesis testing was the use of new Monte Carlo techniques which do not rely on the usual assumption of normality or asymptotic theory. Next, and contrary to popular belief, it was shown that there was evidence of complementarity among the three beverages. In particular, the results indicated that beer and spirits are specific complements in the sense that the marginal utility of beer increases with additional consumption of spirits. The marginal utility of wine, however, is independent of the consumption of the other two beverages, indicating that wine by itself satisfies a basic want of the consumer.

The conditional (i.e. within the alcoholic beverages group) income elasticities show that beer and wine are necessities, while spirits is a strong luxury. The conditional own-price Slutsky elasticities are –0.2, –0.3, and –0.6 for beer, wine and spirits, respectively. The demand equation for alcohol as a whole reveals that the income and own-price

[15]Both variables are multiplied by 100 in the figure so they are approximately percentage changes.

elasticities are 1 and –0.6, respectively. There are several other recent studies which apply a similar methodology to other countries. A systematic review of these highlights some intriguing similarities and differences in elasticities across countries. Beer is always a (conditional) necessity and, in every case except one, spirits always a luxury. Also, the income and price elasticities for alcohol as a whole are not significantly different in Australia, the UK and the US, implying that tastes are the same for the broader aggregates.

Based on the usual criteria of plausibility of the results, hypothesis testing and compatibility of the findings with previous studies, overall the approach of explaining alcohol demand in terms of the utility-maximising theory of the consumer must be judged to be fairly successful. However, it must be acknowledged that there are still some important aspects of alcohol consumption patterns that remain unexplained in this work. In particular, constant terms are needed in all the demand equations to account for residual trends in consumption. These trends could reflect changing demography, immigration, new packaging and so on. More research is required to explore systematically the role of these factors.

References

Adrian, M. and Ferguson, B. S. (1987), 'Demand for Domestic and Imported Alcohol in Canada', *Applied Economics* 19, 531-40.

Barnard, G. A. (1963), 'Comment', *Journal of the Royal Statistical Society*, Series B, 25, 294.

Barnett, W. A. (1979), 'Theoretical Foundations for the Rotterdam Model', *Review of Economic Studies* 46, 109-30.

Barten, A. P. (1964), 'Consumer Demand Functions Under Conditions of Almost Additive Preferences', *Econometrica* 32, 1-38.

Christensen, L. R., Jorgenson, D. W. and Lau, L. J. (1975), 'Transcendental Logarithmic Utility Functions', *American Economic Review* 65, 367-83.

Clements, K. W. (1987), 'The Demand for Groups of Goods and Conditional Demand', in H. Theil and K. W. Clements, *Applied Demand Analysis: Results from System-Wide Approaches*, Ballinger Publishing Company, Cambridge, Mass., 163-84.

Clements, K. W. and Johnson, L. W. (1983), 'The Demand for Beer, Wine and Spirits: A System-Wide Analysis', *Journal of Business* 56, 273-304. Reprinted in T. J. Coyne, ed. (1985), *Reading in managerial Economics* 4th ed., Business Publications, Inc., Plano Texas, 127-55.

Clements, K. W. and Selvanathan, E. A. (1987), 'Alcohol Consumption', in Theil and Clements, *Applied Demand Analysis: Results from System-Wide Approaches*, Ballinger Publishing Company, Cambridge, Mass., 185-264.

Clements, K. W. and Selvanathan, E. A. (1988), 'The Rotterdam Demand Model and its Application in Marketing', *Marketing Science* 7, 60-75.

Clements, K. W. and Selvanathan, S. (1989), 'The Economic Determinants of Alcohol Consumption'. Discussion Paper 89.35, Department of Economics, The University of Western Australia.

Deaton, A. S. and Muellauer, J. (1980), 'An Almost Ideal Demand System', *American Economic Review* 70, 312-26.

Duffy, M. H. (1987), 'Advertising and the Inter-Product Distribution of Demand: A Rotterdam Model Approach', *European Economic Review* 31, 1051-70.

Efron, B. (1979), 'Bootstrap Methods: Another Look at the Jackknife', *Annals of Statistics* 7, 1-26.

Fuss, M. and Waverman, L. (1987), 'The Demand for Alcoholic Beverages in Canada: An Application of the Almost Ideal Demand System'. Working Paper No. 8714, Department of Economics and Institute for Policy Analysis, University of Toronto.

Heien, D. and Pompelli, G. (1989), 'The Demand for Alcoholic Beverages: Economic and Demographic Effects', *Southern Economic Journal* 55, 759-70.

Holm, P. (1989), 'Advertising, Alcohol Content and Demand for Alcoholic Beverages: A System Approach'. Unpublished, Department of Economics, University of Helsinki.

Johnson, J. A., Oksanen, E. H., Veall, M. R. and Fretz, D. (1990), 'Alternative Approaches to the Measurement of Consumption and Price of Alcoholic Beverages, Canada, 1957-1983', *Journal of Studies on Alcohol* 51, 82-5.

Jones, A. M. (1989), 'A Systems Approach to the Demand for Alcohol and Tobacco', *Bulletin of Economic Research* 41, 82-101.

Laitinen, K. (1978), 'Why is Demand Homogeneity So Often Rejected?', *Economics Letters* 1, 187-91.

Pearce, D. (1986), 'The Demand for Alcohol in New Zealand'. Discussion Paper No. 86.02, Department of Economics, The University of Western Australia.

Penm, J. H. (1988), 'An Econometric Study of the Demand for Bottled, Canned and Bulk Beer', *Economic Record* 64, 268-74.

Quek, K. E. (1988), 'The Demand for Alcohol in Canada: An Econometric Study', Discussion Paper No. 88.08, Department of Economics, The University of Western Australia.

Selvanathan, E. A. (1988), 'Alcohol Consumption in the UK, 1955-85: A System-Wide Analysis', *Applied Economics* 20, 1071-86.

Selvanathan, E. A. (1991), 'Further Results on Aggregation of Differential Demand Equations', *Review of Economic Studies* 35, 799-805.

Selvanathan, E. A. and Clements, K. W. (1988), 'Is the Elasticity of Demand for Alcohol an International Constant?'. Unpublished paper, Economic Research Centre, Department of Economics, The University of Western Australia.

Stigler, G. J. and Becker, G. S. (1977), 'De Gustibus Non Est Disputandum', *American Economic Review* 67, 76-90.

Stone, R. (1954), 'Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand', *Economic Journal* 64, 511-27.

Theil, H. (1965), 'The Information Approach to Demand Analysis', *Econometrica* 33, 67-87.

Theil, H. (1980), *The System-Wide Approach to Microeconomics*, The University of Chicago Press, Chicago.

Theil, H. (1987), 'The Econometrics of Demand Systems', in H. Theil and K. W. Clements, *Applied Demand Analysis: Results from System-Wide Approaches*, Ballinger Publishing Company, Cambridge, Mass., 101-62.

Wong, A. Y-T. (1988), 'The Demand for Alcohol in the UK 1920-1938: An Econometric Study'. Discussion Paper No. 88.13, Department of Economics, The University of Western Australia.