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The Demand for Wine and Beer*

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In this paper annual data series covering 1955–56 to 1978–79 are used to estimate the elasticity of demand for both wine and beer. These are first estimated using a flexible functional form. The habit formation hypothesis and the role of social and demographic factors are also examined. The demand for wine in aggregate is estimated to be relatively price inelastic in the short run, while in the long run it is relatively price elastic. With respect to income, the demand for wine is shown to be relatively highly elastic. For beer, demand with respect to price and income is found to be relatively inelastic in the short run as well as in the long run. These results can be used to evaluate the impact of changes in patterns of consumption and of government taxation policies on the industry.

1. Introduction

The basic task of the demand analyst is to find out how the quantity of a commodity consumed varies as certain pre-specified variables change. As Brown and Deaton (1972, p. 1150) suggest, in most instances this means that an attempt should be made to formulate a model to account for the effect of changes in per person income, the structure of relative prices and income distribution on quantity demanded. In time-series framework, introduction of new commodities and changes in tastes may also be quite significant, in which case it becomes important to select a model that incorporates these features.

In this paper, two approaches are used to obtain own-price and income elasticity estimates for wine and for beer. The first approach is based on the static theory of consumer behaviour. The static theory is often used as the basis for formulating empirical demand functions. The results from this approach are used as a basis for comparison with results from other studies which have employed the static theory. However, in this analysis, particular emphasis is given to the choice of the most appropriate functional form which we show is an important aspect of the specification in demand analysis.

The second approach introduces dynamic aspects into the model of consumer behaviour. Because consumers often react with some delay to price and income changes, this approach introduces a more realistic description of consumer's behaviour. The hypothesis that wine and beer consumption is not determined solely by price and income but that consumption habits are also influential is tested. Results from the dynamic approach give information about longer term effects on consumption which are of particular importance in policy evaluation.

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These results could help dissipate some of the uncertainty concerning the impact of excise taxes upon consumption of alcoholic beverages and the revenue consequences of changing rates of levy. The importance of this is illustrated by the fact that duties on beer and spirits yielded approximately $5 800 million between 1970 and 1978, (17 per cent of total revenue from all indirect taxes). Apart from a brief period during the early 1970's, wine has been free from excise. While decisions on levels of taxation on alcoholic beverages must reflect more extensive social considerations, the results of an economic analysis which throws light upon the factors influencing consumption can be of assistance in policy formulation.

The following section provides a brief description of Australian and overseas research into the demand for alcoholic beverages. A description of the data follows, and in the fourth and fifth sections the models and estimates from the static and dynamic approaches are described. Some results regarding the effect of socio-demographic variables on the demand for wine and beer are presented in section 6. The conclusions from the analysis complete the paper.

2. Previous Research

A number of fairly recent studies have examined Australian demand for alcohol, most often wine. Taplin and Ryan (1969) concluded that wine demand is price elastic and the income elasticity lies between 1 and 2. Miller and Roberts (1972) arrived at estimates of price elasticities for fortified wine of −0.96 and for table wine of −1.8. Wills (1972) concluded that the demand for wine is inelastic in the short run. All these studies made only limited use of statistical analysis.

More recently, Owen (1979), using ridge regression to overcome multicollinearity problems, estimated wine to be price and income inelastic in the short run. He found wine to be price inelastic and income elastic in the long run. Clements and Johnson (1982), using a system-wide analysis which included all three major alcoholic beverages (beer, wine and spirits), found all these beverages to be price inelastic in the short run. Income elasticities were estimated close to 1 for beer and wine, while spirits were found to be income elastic.

Table 1 summarises the results of these studies. Some results from overseas studies, from consumer expenditure surveys and from analysis of national accounts are also presented. They appear for comparative purpose only.

3. Data Source

The data set used in this paper was an annual series covering 1955–56 to 1978–79. Australian Bureau of Statistics (ABS) figures on wine makers' wholesale sales were used as a proxy for consumption of Australian-produced wine on the assumption that wine makers' stocks average out over time. Imports were added to the sales figures to obtain total consumption. The quantity of beer on which excise was paid was used as a proxy for consumption of beer. Consumption figures per person were obtained by using ABS estimates of the population aged 20 and over.

While it was at least possible to get a proxy from a published source for alcohol consumption, the same could not be said for price. The wine price used is Owen's (1979) up until 1976–77, and ABS estimates were used to update this index in subsequent years. An ABS index was available for the whole period for beer.

Table 1: Elasticity Estimates for Various Alcoholic Beverages: Australia and Overseas

Author	Commodity	Time period	Results		
			Own-price elasticity	Cross-price elasticity	Income elasticity
AUSTRALIA					
Powell (1966)	Tobacco and alcohol.	1949–50 to 1961–62 (National Accounts).	−0.159		0.308
Taplin and Ryan (1969)	Wine		Beer and spirits arg for wine is price	ued to be fairly close substit elastic.	utes for wine. Demand
Podder (1971)	Tobacco and alcohol.	1966–68 (Consumer survey).			1.868
Wills (1972)	Wine	1970–71	Demand for flagon wine inelastic in the short run.		
Miller and Roberts (1976)	Wine	1970–71	−0.96 (fortified wine). −1.80 (table wine)		
Labys (1976)	Wine	1954–71	−1.0		2.0
Owen (1979)	Wine	1955–77		−0.28 (short-run, relative price of wine with respect to beer). −0.62 (long-run, relative price of wine with respect to beer).	0.55 (short-run). 1.229 (long-run).
Clements and Johnson (1982)	Beer, wine, spirits.	System-wide analysis time series 1955–56 to 1976–77.	−0.36 (beer) −0.43 (wine) −0.74 (spirits)	Beer complement for wine and spirits, wine and spirits substitutes.	0.80 (beer). 0.75 (wine). 1.91 (spirits).

Table 1—*continued*

Author	Commodity	Time period	Results		
			Own-price elasticity	Cross-price elasticity	Income elasticity
U.S.A.					
Niskanen (1960)	Beer, wine, spirits.	1934–41, 1947–60	−0.7 (beer)	Spirits and beer weak substitutes; relation between beer and wine markets unstable.	−0.4 (beer).
Horowitz and Horowitz (1965)	Beer	1949–61	Weak negative relation between beer consumption and excise.		0
Hogarty and Elzinga (1972)	Beer	1956–59 (Cross sectional time series).	−0.9	Beer and spirits complements.	0.4
Labys (1976)	Wine	1954–71	−0.440 (domestic price). −1.654 (import price).		2.345 (domestic price). 3.343(imported price).
Mann (1980)	Tobacco and alcohol.	1949–77 (National Accounts).	−0.311		0.373
CANADA					
Johnson and Oksanen (1977)	Beer, spirits, wine.	(Cross sectional, time series).	−0.224 (beer) −0.910 (spirits) −0.502 (wine)		approx. 0 (beer) 0.227 (spirits) approx. 0 (wine).

The other major economic variable considered was income. The measure used was household disposable income on a per person basis and deflated by the CPI.

A number of other less commonly analysed economic variables were considered. These included unemployment rates, the percentage of Australians travelling overseas, the percentage of the workforce composed of women, age structure and ethnic composition of the population. Information on these variables was also obtained from ABS.

4. The Static Approach

The static theory of the individual consumer is often used as the basis for formulating empirical demand functions. Each individual is assumed to behave as though he maximises a utility function with respect to quantities purchased subject to given budget constraint. Under certain assumptions, the maximisation procedure yields single value demand functions of the form:

(1) $X_j = X_j(P_1, P_2, \ldots, P_n, M) \; (j = 1, 2, \ldots, n)$

where X_j is the quantity consumed of the jth commodity, P_j is the price of the j th commodity and M is consumer income.

The fact that the demand function depends upon the prices of all commodities in the individual's consumption-possibility set and income suggests that the demand for all commodities are interrelated and that, in empirical analysis, the demand for all commodities should be considered simultaneously. However, given the estimation difficulties this would entail, it is common practice to include only those commodities of direct interest, in a single equation approach. This is equivalent to making the assumption of separability of the consumer's utility function. It is appreciated that if the assumptions made are incorrect, biased estimates of the parameters may result. The variables of primary interest in this present study were own price, the price of a substitute and income.

Besides deciding on the variables to include in the demand model, another problem in demand analysis (common to most applied econometric work) is the choice of the most appropriate functional form. Economic theory is often unable to suggest what form the function should take. In the work done on estimating demand functions for food, for example, a wide variety of functional forms have been investigated without any one gaining general acceptance among economists (Prais and Houthakker 1955, Brown and Deaton 1970, Leser 1973). In this paper, the choice of functional form was given particular emphasis because, following the results obtained in the U.S. for meat by Chang (1977), it was expected that substantially different results would be obtained through an inappropriately specified functional form. Therefore, to determine what form the demand functions for wine and beer should take, the methodology suggested by Huang (1979) which was based on the work of Box-Cox (1964) and Zarembka (1974)was adopted.[1] This approach, using the Box-Cox transformation, imposes on the data the additional requirement to identify the functional form which is most consistent with it, given a particular specification of variables.

[1] From this analysis only the preferred model specification for the demand of wine and beer is presented here. The model and the procedure used to derive a full set of results based on the Box-Cox transformation are presented in Appendix A.

A. Wine

The log-linear functional form is the preferred specification on statistical grounds (see Appendix A). The value of the likelihood function for this model is closest to that of the maximum likelihood model. The log-linear functional form is also consistent on *a priori* economic grounds (see below).
The log-linear specification is:

(2) $\text{Log}(CW)_t = b_0 + b_1(PW/PB)_t + b_2 IN_t + u_t$

where CW represents the consumption of wine per person; PW is the price of wine; PB is the price of beer; IN is real disposable income per person; b_0, b_1 and b_2 are parameters to be estimated; and u_t is the error term.

The estimated parameters of these equations are presented in Table A1 (Appendix A). All parameter estimates have the expected signs. The price ratio coefficient is significant at the 10 per cent level, while the income coefficient is significant at the 1 per cent level.

Because economic considerations are also important in the choice of a model, these will now be considered. Price and income elasticities of demand for a commodity provide some insight into the characteristics of demand for that commodity. For this reason, elasticity estimates have been calculated for wine for a range of years. Elasticities obtained using each of the functional forms documented in Table A1 (Appendix A) are presented here as a measure of comparison of the sensitivity of elasticity estimates using different functional forms. These estimates appear in Table 2.[2] However before examining these estimates, a word of caution is in order. In models based on annual time series, income elasticity estimates may be distorted either by the omission of important variables from the demand model (e.g., changes in tastes and preferences) or by correlation between price and income.[3]

The elasticities computed at the mean values appear to be insensitive as to which of the two functional forms, for which the likelihood ratio test indicated no significant differences, is actually used i.e., log-linear and double-log functional forms. For price elasticity, the estimates differ by 0.176, while for income elasticity they differ by 0.056. By comparison, the range is 0.683 and 0.642 when the price and income elasticities calculated at the mean for functional forms (2) to (7) (see Table A1 in Appendix A) are compared. This result indicates the extent to which elasticity estimates can vary, depending on the functional form chosen, and is consistent with Prais and Houthakker's (1955) observation that for income elasticities, estimates can vary by 50 per cent or more among different functional forms.[4]

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[2] The elasticities presented in Table 2 and later in Table 3 are conditional on model specification. The price employed is a price ratio. The choice of near substitute as a deflator was suggested by the results obtained in preliminary stages of the analysis. Use of the price ratio implies tnat the own-price and cross-price elasticities are equal, but of opposite sign. As another aspect of model specification, extensive tests for multicollinearity showed tnat it was unlikely to be a problem.

[3] Wold and Jureen (1953) point out that because of data deficiencies in annual models, more reliable estimates of income elasticities may be derived from quarterly time series or cross-sectional data.

[4] Although not calculated, it is possible that the elasticity estimates using the different functional forms and calculated at the mean may fall within the confidence interval of the elasticity for the log-linear model.

Table 2: Price and Income Elasticities of Demand for Wine Based on Alternative Functional Forms: Selected Years

Year	Elasticity estimated by equation [a,b]						
	1	2	3	4	5	6	7
(a) *Price*							
1955–56 ..	−0.0013	−1.494	−0.225	−0.446	−0.953	−0.530	−1.429
1959–60 ..	−0.0015	−1.480	−0.243	−0.446	−1.020	−0.490	−1.309
1963–64 ..	−0.0018	−1.384	−0.260	−0.446	−1.022	−1.458	−1.444
1966–67 ..	−0.0021	−1.127	−0.270	−0.446	−0.863	−0.441	−0.898
1969–70 ..	−0.0031	−0.869	−0.312	−0.446	−0.771	−0.381	−0.570
1972–73 ..	−0.0031	−0.789	−0.304	−0.446	−0.689	−0.391	−0.563
1975–76 ..	−0.0030	−0.607	−0.283	−0.446	−0.488	−0.420	−0.460
1978–79 ..	−0.0026	−0.506	−0.256	−0.446	−0.367	−0.466	−0.425
At the means	−0.0023	−0.953	−0.270	−0.446	−0.732	−0.440	−0.758
(b) *Income*							
1955–56 ..	0.680	3.199	1.250	1.733	2.287	1.796	3.221
1959–60 ..	0.737	3.168	1.300	1.733	2.255	1.728	3.069
1963–64 ..	0.976	2.964	1.476	1.733	2.501	1.522	2.529
1966–67 ..	1.218	2.413	1.582	1.733	2.183	1.420	1.920
1969–70 ..	1.645	1.861	1.745	1.733	1.857	1.287	1.342
1972–73 ..	2.254	1.708	2.008	1.733	1.961	1.118	1.071
1975–76 ..	3.108	1.299	2.232	1.733	1.658	1.006	0.732
1978–79 ..	3.441	1.084	2.265	1.733	1.404	0.991	0.602
At the means	1.464	2.041	1.677	1.733	1.958	1.399	1.532

[a] The price and income elasticities are defined as:
$\eta_p = b_1.\ (PR^{\mu}/CW^{\lambda})$ and $\eta_y = b_2.\ (IN^{\mu}/CW^{\lambda})$, respectively, where $PR = PW/PB$.
[b] Equation numbers correspond to the functional forms given in Table A1.

The differences between the estimates are most obvious when calculated away from the means. Moreover, it is evident that for the various models, the estimated elasticities vary considerably over the sample period. The exception to this is the double-log specification. Although this model was found to be not significantly different from the maximum likelihood formulation, and although the double-log model may have some appeal because of ease of interpretation, in any analysis oriented towards offering policy advice, the greater flexibility offered by the other functional forms in not imposing constant elasticities is to be preferred. Furthermore, as Huang (1979) argues, although the statistical procedure followed is of benefit in that it provides information useful for discriminating among the various functional forms, the procedure should be seen as a complement to, and not a substitute for, sound theoretical and *a priori* considerations.

The elasticities estimated from the proposed maximum likelihood formulation and from the log-linear formulation (the next best) suggest that income elasticities increase monotonically over the sample period, while price elasticities increase up to the early 1970's and then decline slightly. With respect to price elasticity, the results obtained from the log-linear formulation are in agreement with *a priori* judgment.

B. Beer

The model used to estimate the price and income elasticities of demand for beer was of the same form as that used for wine. However, it was not possible to obtain the maximum likelihood functional form for the beer model because the Box-Cox transformation was removing all the variability from the dependent variable before λ could be maximised. For this reason, the results in Tabe A. 3 are confined to those obtained from the more commonly analysed functional forms (see Appendix A). The log-linear model was the functional form for which the largest value of the likelihood function was obtained:

(3) $\text{Log}(CB)_t = b'_0 + b'_1 (PB/PW)_t + b'_2 IN_t + v_t$

where CB represents the per person consumption of beer; b'_0, b'_1 and b'_2 are parameters to be estimated; and v_t is the error-term. The other variables are as defined previously.

When this model was compared with the others using the likelihood ratio test, it was found to be superior to the linear-log and to the linear-inverse models, but no significant difference was found between it and linear, double-log or log-inverse models. The statistical characteristics of these four models were generally similar in that all coefficients on price and income were significant at the 1 per cent level, with the exception of the coefficient for price in the log-inverse model; high $\bar{R}^2$ values were obtained; and all coefficients were of the expected sign.

Price and income elasticities were calculated from each model for selected years. The results obtained are in Table 3. As was observed earlier for wine, fairly substantial differences in the elasticity estimates for beer were also in evidence.

Table 3: Price and Income Elasticities of Demand for Beer Based on Alternative Functional Forms: Selected Years

Year	Elasticity estimated by equation [a,b]					
	1	2	3	4	5	6
(a) *Price*						
1955–56	−0.189	−0.262	−0.190	−0.267	−0.124	−0.121
1959–60	−0.190	−0.242	−0.190	−0.248	−0.134	−0.131
1963–64	−0.180	−0.226	−0.190	−0.219	−0.144	−0.133
1966–67	−0.171	−0.218	−0.190	−0.201	−0.149	−0.131
1969–70	−0.158	−0.188	−0.190	−0.160	−0.173	−0.141
1972–73	−0.152	−0.193	−0.190	−0.158	−0.188	−0.131
1975–76	−0.145	−0.207	−0.190	−0.162	−0.157	−0.117
1978–79	−0.156	−0.230	−0.190	−0.193	−0.141	−0.113
At the means	−0.167	−0.221	−0.190	−0.199	−0.147	−0.127
(b) *Income*						
1955–56	0.422	0.266	0.372	0.502	0.499	0.556
1959–60	0.424	0.277	0.372	0.315	0.480	0.537
1963–64	0.402	0.314	0.372	0.339	0.423	0.448
1966–67	0.381	0.337	0.372	0.345	0.395	0.400
1969–70	0.353	0.371	0.372	0.352	0.358	0.333
1972–73	0.338	0.427	0.372	0.389	0.311	0.278
1975–76	0.323	0.475	0.372	0.413	0.280	0.238
1978–79	0.348	0.482	0.372	0.451	0.276	0.253
At the means	0.374	0.356	0.372	0.358	0.373	0.367

[a] The price and income elasticities are defined as:
$\eta_p = b'_1 (PR^{\mu}/CB^{\lambda})$, and $\eta_y = b'_2 (IN^{\mu}/CB^{\lambda})$, respectively. Where $PR = PB/PW$.

[b] Equation numbers correspond to the functional forms given in Table A3.

The preferred estimate for the price elasticity calculated at the mean was −0.221, while the preferred estimate of the income elasticity, also calculated at the mean, was 0.356. There are basically two reasons for the choice of these values. First, they were obtained from the log-linear model which, besides being the model with the highest likelihood value, is also the model having the most theoretical appeal. Second, as will be seen shortly, these values are the closest to those obtained in the dynamic model for beer.

5. A Dynamic Alternative

The static approach for estimating demand functions has been criticised on the grounds that it does not provide a realistic description of how consumers behave. For example, consumers often react with some delay to price and income changes, causing the adjustment toward the new equilibrium to be spread over several time periods. There is a growing body of literature on the dynamics of household behaviour.[5] In this analysis, it is proposed to test the hypothesis that wine and beer consumption is not determined solely by price and income, but that consumption habits are also influential in determining the overall level of consumption. To test this hypothesis, the Houthakker-Taylor habit formation model was used.

The Houthakker-Taylor (HT) model is of a distributed lag kind and is so constructed that, without observing the actual level of habits or stocks, it is possible to make an estimate of their effect on the relationship between consumption, price and income. Further, if a constant depreciation rate for stocks/habits is assumed, it is possible to determine the effect of stocks/habits on consumption. The distributed lag results from the effect of variations in the current value of a state variable, stocks/habits, the value of which is in turn changed by current decisions.

In the remainder of this section, the HT model will be developed for wine. Exactly the same arguments apply in the development of the HT model for beer.

The specification for the HT model for wine begins with the assumption that the consumption of wine is a linear function of the level of stocks/habits, the price of wine relative to that of beer and income.[6] That is,

(4) $CW_t = \alpha + \beta ST_t + \gamma(PW/PB)_t + \varepsilon IN_t$

where

- CW is the per person consumption of wine.
- ST is the state variable which defines the level of stocks or habit (psychological stocks).
- PW is the price of wine.
- PB is the price of beer.
- IN is per person real disposable income, and
- α, β, γ and ε are parameters.

[5] For a summary see Philps (1974).

[6] The testing of alternative functional forms was not undertaken.

Although the stocks variable may be interpreted as though it were observable, in fact the variable is not easily measurable. However, this does not prevent the HT model being estimated as stocks may be removed from the model by assuming that they change according to the scheme:

$$(5)\ \frac{d\,ST}{dt} = \dot{ST}_t = CW_t - \delta ST_t$$

where δ is a constant depreciation rate and $\dot{ST}$ indicates the rate of change in stocks over time.

In developing a finite approximation to their dynamic model, Houthakker and Taylor (1966, pp. 11–27) make explicit the assumption of linearity in the behaviour of the stock variable. This provides a simplified means for obtaining estimates of the structural parameters from the estimating equation:

$$(6)\ CW_t = A_O + A_1\, CW_{t-1} + A_2\,((PW/PB)_t - (PW/PB)_{t-1}) + A_3\,(PW/PB)_{t-1} + A_4\,(IN_t - IN_{t-1}) + A_5\, IN_{t-1}$$

The estimates of the structural parameters α, β, γ, and ε are functions of the parameters of equation (6).[7]

For commodities where habit plays an important role in determining the level of consumption, β is expected to be positive, while for commodities that are durable, and are characterized by the durable inventory effect, β is expected to be negative. The parameter represents the rate of adjustment and the larger δ is, the more rapid the rate of stock depreciation. From (6), the short-run effect[8] of price is given by A_2, while the long-run effect is given by:

$$(7)\ \frac{\gamma\delta}{\delta - \beta} = \frac{A_3}{1 - A_1}$$

Similarly, A_4 measures the short-run effect of income, while the long-run effect is calculated from

$$(8)\ \frac{\varepsilon\delta}{\delta - \beta} = \frac{A_5}{1 - A_1}$$

The parameter δ may be derived from $\frac{A_3}{A_2 - \frac{1}{2}A_3}$ or $\frac{A_5}{A_4 - \frac{1}{2}A_5}$ which are not necessarily the same. Thus the model is over-identified. To derive a single estimate for δ, the restriction given by

$$(9)\ A_2 \,.\, A_5 = A_3 \,.\, A_4$$

was imposed on the model (6).

[7] For a full interpretation of the model and the derivation of the structural parameters see Houthakker and Taylor (1966, pp. 8–15).

[8] The expression for the short-run effects of price and income given here are different to those found in Houthakker and Taylor (1966, p. 17) which we believe to be incorrect. We are grateful to our colleague Dr B. Lee for pointing out this error in the published expressions.

A simple yet effective procedure used by Houthakker and Taylor (1966, pp. 21–25) to impose this restriction is to obtain estimates by the use of constrained least squares. Essentially the function:

$$(10)\quad \theta(k) = A_2 \,.\, A_5 - A_3 \,.\, A_4$$

is defined and solved for $\theta(k) = 0$ where k is the Lagrangian multiplier associated with the restriction. Unfortunately the functional form of θ is both unknown and non-linear so that an immediate solution of $\theta(k)$ is not evident. As a result, $\theta(k)$ is approximated by a linear function $\theta^*(k)$. The value of k which solves $\theta^*(k) = 0$ is arrived at through an iterative procedure. As Houthakker and Taylor (1966, p. 51) point out, the value of k can be interpreted as a measure of the compatability of the model with the data. Samller values of k are to be preferred since this means that the data are more consistent (in the sense of identifiability) with the model.

A. Wine

The results obtained are summarised in Table 4. In general, the model possesses fairly satisfactory statistical characteristics. These include the value obtained for $\bar{R}^2$ (0.98) which indicates that the model provides a high level of explanation of wine consumption, the value obtained for the Durbin's (h) statistic which suggests the absence of first order autocorrelation, and the signs on the estimated coefficients which conform to prior expectations.[9] On the other hand, the estimated coefficient for price in the present period was only significant at the 10 per cent level, while the coefficient for lagged price failed to be significant. However, Houthakker and Taylor (1966, p. 165) point out that such a result is consistent with the predominance of habit formation.[10] Finally, the value of k which provides the solution of $\theta^*(k) = 0$ was very small (0.1178), and this tends to support the proposition that the data and model are compatible.

Table 4: Regression Estimates and Estimates of the Structural Parameters of the (HT) Model for Wine[a]

$$CW(t) = \underset{(1.43)}{-0.685} + \underset{(0.159)}{0.810^{***}}\, CW(t-1) - \underset{(3.194)}{5.566^{**}}\, \frac{\Delta PW}{PB}(t)$$

$$- \underset{(2.223)}{3.325^{*}}\, \frac{PW}{PB}(t-1) + \underset{(0.342)}{0.802^{**}}\, \Delta IN(t) + \underset{(0.276)}{0.485^{**}}\, IN(t-1)$$

$\bar{R}^2 = 0.98$ $\quad h = 1.18$ $\quad F_{5,17} = 281.6$

$\alpha = -0.888$ $\quad \beta = 0.642$ $\quad \gamma = -4.312$ $\quad \varepsilon = 0.618$

$\delta = 0.852$ $\quad k = 0.1178$

[a] The figures in parentheses are standard errors. Asterisks indicate levels of significance; one asterisk indicates significance at the 10 per cent level; two asterisks indicate significance at the 5 per cent level and three asterisks indicate significance at the 1 per cent level.

In all cases, one-tailed t tests have been used. $\bar{R}^2$ is the adjusted coefficient of determination; h is the Durbin statistic; F is the F statistic; and k is the parameter which solves $\theta^*(k) = 0$.

[9] Wohlgenant and Hahn (1982) suggest that the main problem in estimating the HT model is serial correlation. However, there was no indication of first and second order autocorrelation in either models.

[10] An alternative explanation is that this may be due to multicollinearity as reported in Owen (1979). The condition number for the variables in the regression indicated that multicollinearity could be present.

One of the features of the HT model is that it enables the effect of habit formation to be clearly separated from the effect of inventory adjustment. The stock coefficient $\beta = 0.642$ indicates that aggregate wine consumption is habit forming. However, the large value for the depreciation rate $\delta = 0.852$ indicates that habits decline rapidly, as far as wine consumption is concerned. As a result of a psychological stock of wine buying habits, the long-run price elasticity is expected to be higher than the short-run elasticity, and a relatively rapid adjustment to the long-run equilibrium could be expected.

Table 5: Price and Income Elasticity Estimates: Short-Run and Long-Run[a]

Elasticity	Price	Income
Short-run	−0.428	0.880
Long-run	−1.349	2.808

[a] The short-run price elasticity is given by $A_2.(\overline{PR}/\overline{CW})$, while the long-run price elasticity is given by $(A_3/1 - A_1) . (\overline{PR}/\overline{CW})$, where $PR = PW/PB$. The short-run income elasticity is given by $A_4.(\overline{IN}/\overline{CW})$ and $(A_5/1 - A_1) . (\overline{IN}/\overline{CW})$ provides the long-run estimate.

Estimates of the short-run and long-run price elasticities are shown in Table 5. The immediate effect of a 10 per cent increase in the price of wine would be a decline of more than 3 per cent in wine consumption, with a further decline of about 10 per cent occurring in subsequent periods. Furthermore, as mentioned earlier, the rate of adjustment towards the equilibrium takes place relatively very rapidly. With respect to income, the immediate effect of a 10 per cent increase in real income would be a 7 per cent increase in wine consumption in the first year, with further increases amounting to about 21 per cent spread out over subsequent periods. In making each of the above statements on the effect price and income changes would have on consumption, the *ceteris paribus* condition is assumed to hold.[11]

B. Beer

The results obtained for beer are given in Table 6. These results were not as satisfactory as those for wine. For instance, the level of significance of the coefficients were less, with none significant at the 1 per cent level, and only two significant at the 5 per cent level. The value of k to satisfy $\theta^*(k) = 0$ was 0.5. Ideally, the null hypothesis $k = 0$ should be tested. This was not done, so it is difficult to be definitive about whether the restriction imposed in estimating the HT model is supported by the data.

[11] The HT model was respecified with the real prices of wine and beer included separately in order to examine the effects of the ratio form for the price variable on the elasticity estimates (see footnote 2 and Wohlgenant and Hahn (1982)). The own-price and income elssticities were of the same order of magnitude as reported above, whereas the cross-price elasticities were 0.81 (short-run) and 2.37 (long-run).

Table 6: Regression Estimates and Estimates of the Structural Parameters of the (HT) Model for Beer[a]

$$CB(t)\ 39.666 + 0.732^{**}\ CB\ (t-1) - 41.566^{*}\ \Delta\frac{PB}{PW}(t)$$
(52.457) (0.324) (26.482)

$$-\ 9.908\ \frac{PB}{PW}(t-1) + 5.991^{**}\ \Delta IN(t) + 1.340^{**}\ IN(t-1)$$
(20.610) (3.377) (1.987)

$\bar{R}^2 = 0.965$ $F_{5,17} = 128.404$ $h =$ not defined[b]
$\alpha = 271.319$ $\beta = -0.038$ $\gamma = -42.001$ $\varepsilon = 6.146$
$\delta = 0.273$ $k = 0.5$

[a] Refer to Table 4 for interpetation of table. [b] The Durbin h statistic could not be calculated because it entailed taking the square root of a negative number.

The value suggested for the stock coefficient (−0.038) is close to 0 and therefore indicates that habit plays little or no part in determining beer consumption. This result tends to contradict the popular notion of a beer consumer and is more than likely a reflection of inadequacies of the data rather than a result which could be accepted with confidence.

Long-run and short-run elasticity estimates for each of price and income were obtained from the model and these appear in Table 7.[12]

Table 7: Price and Income Elasticity Estimates: Short–Run and Long–Run [a]

Elasticity	Price	Income
Short run	−0.228	0.462
Long run	−0.202	0.385

[a] The short–run price elasticity is given by $A_2.(\overline{PR}/\overline{CB})$, while the long–run price elasticity is given by $(A_3/1 - A_1).(\overline{PR}/\overline{CB})$, where $PR = PB/PW$. The short–run income elasticity is given by $A_4.(\overline{IN}/\overline{CB})$ and $(A_5/1 - A_1).(\overline{IN}/\overline{CB})$ provides the long–run estimate.

6. The Role of Social and Demographic Variables

The focus in this paper so far has been on the influence of income, price and habits on the demand for wine and beer. Results obtained in a number of consumer surveys (ABS 1977), as well as some of the time series studies referred to in Table 1, indicate that certain social and demographic factors are important in the demand for alcohol. In these studies, evidence of this influence is provided by the inclusion of such variables as advertising, ethnic composition and religious affiliation in the various models.

To explore the extent to which social and demographic factors are associated with beer and wine consumption, information on a range of factors selected on the basis of *a priori* reasoning and results obtained in other studies, was gathered for the period 1955–56 to 1978–79 and examined with per person

[12] When the HT beer model was respecified (see footnote 11), the own–price elasticities were −0.15 and −0.52, the cross–price elasticities were −0.09 and −0.31 and the income elasticities were 0.31 and 1.08 for the short–and long–run, respectively. The negative cross-price elasticities are, in our opinion, unrealistic and reinforces our concern for the adequacies of the beer data.

consumption data. However, the inclusion of these variables in the analysis created major problems which made it very difficult to evaluate the least squares estimators in the model because of the occurrence of severe multicollinearity among the regressors. As a result, partial correlation analysis was employed, with the effects of price and income variables removed. Although more precise analysis might be necessary for conclusive results of the effects social and demographic changes have on wine and beer consumption, the partial correlation analysis results appear to be of some interest, and thus a summary of these results is presented in this section. Fuller results are presented in our paper presented to the 1981 AAES Conference.

The hypothesis that changes in the population's ethnic composition (migration from continental Europe) would be associated with an increase in per person wine consumption and a decrease in per person beer consumption was not supported by the data. However, marketing studies suggest a demonstration effect plays an important part in the development of markets of new products, of which wine is an example (see Marris 1968). It follows that the increased exposure of Australians to Europeans and European lifestyles was probably more influential in Australians adopting wine consumption than an increase in the number of European immigrants.

As with population composition, the analysis showed that increased participation by women in the work force was associated with increased consumption of wine and beer per person. This increased female participation is linked with a number of other developments, including changed social attitudes and an increase in the number of families with more than one income. To the extent that an increased proportion of women in the workforce also reflects changed social attitudes, this result may suggest that increased alcohol consumption is associated with changes in societal attitudes.

Data on a commonly used economic indicator—the unemployment rate—supported the hypothesis of a negative association between beer consumption and unemployment rate. However, the result obtained for wine (positive association between wine consumption and unemployment) illustrates the difficulty of drawing strong conclusions from this type of analysis. One explanation of the positive association between the two variables could be the climbing of the unemployment rate since the mid-1970's which coincided with a period of increasing wine consumption per person.

Some recent U.S. research (Folwell *et al.* 1974) suggests foreign travel by Americans influences wine consumption in the U.S.A. Examination of data on overseas travel by Australians in conjunction with the data on wine consumption revealed a positive association, while a negative association was found for beer. Interpretation of this variable is twofold. First, travel could be acting as a proxy for society's affluence, in which case the result for beer is consistent with the partial correlation between beer consumption and unemployment rate. Second, the variable could be reflecting the effects foreign travel and exposure to other countries' lifestyles have on an individual's consumption behaviour.

A commonly held belief is that people who possess high levels of formal education are likely to consume more wine than people with low levels of formal education. Conversely, beer consumption is popularly believed to be more prevalent among people with less formal education than among people with high levels of formal education. The measure of formal education used in the study was based on the number of graduates from universities. Analysis showed a significant positive association between education and wine consumption and a significant negative association between education and beer consumption. The hypotheses, therefore, were not rejected.

7. Summary and Conclusions

One of the problems facing policy makers for the Australian alcoholic beverages industry concerns designing taxation measures which, while having the ability to raise public revenue, do not have undesirable equity or efficiency effects. Although decisions on the appropriate level of taxes for wine and the products that compete with it in the market place are ultimately matters of social judgment (Miller and Roberts 1976), the formulation of policy is assisted by analysis which is able to provide information on the factors influencing consumption. With this in mind, this study set out to arrive at price and income elasticities for wine and beer.

A feature of the paper is the consideration given to the important question of the choice of functional form, an issue which appears to have been ignored in other studies of this type. Both static and dynamic models are investigated and the elasticities obtained from each compared. For the static model, a range of functional forms are shown to give good fits to the data. However, the elasticity estimates obtained varied considerably. Thus, the choice of functional form is critical to the estimates of the elasticity obtained. In the dynamic model, the long-run elasticities are shown to be considerably different to short-run elasticities. The next step would be to combine the flexible functional form approach into the dynamic specification. However, the underlying assumptions of the HT model would make this difficult. There is a clear warning on the use of elasticity estimates for policy analysis when the models upon which these are based have not been tested for functional form and the role of dynamics has not been investigated.

Bearing in mind that the analysis was based on time series data and that there are difficulties associated with using data of these kind in estimating demand models for alcohol (Simon 1966), the main finding from the static approach was that the log-linear model is the preferred specification on statistical as well as economic grounds for both wine and beer. Results from this model showed demand for wine to be price inelastic in the short-run. Furthermore, there was evidence to suggest that in recent years demand was becoming more price inelastic. With respect to income, wine is shown to be highly elastic in the short-run. This might mean that there are opportunities for further growth of the wine market as real incomes rise. The increases in income elasticity observed over time, although not easy to explain, could suggest that as incomes increase, people switch to higher priced premium wines and/or the consumption of goods and services (for example eating out) which are related to wine consumption. Demand for beer in the short-run is indicated by results from the static model to be inelastic with respect to price and income, and this is in agreement with expectations.

The results obtained from the dynamic model for wine were generally satisfactory and showed consumption to be inelastic in the short-run and elastic in the long-run, with respect to both price and income. Similarly, beer was shown to be price inelastic in the short-run as well as the long-run. However, some caution needs to be exercised in the use of this last result since the results obtained from the dynamic model for beer appeared somewhat suspect compared to the results obtained for wine.

Because of certain data deficiencies and the speed and nature of change which has beset the wine industry over the last decade, it is difficult to form strong conclusions on the basis of one piece of analysis. Nevertheless, the price elasticities obtained for wine suggest that a price increase would lead to a greater than proportional decrease in consumption in the long-run. Thus, policy evaluations based merely on the short-run elasticity of consumption could be misleading. The longer term consumption effects are very important in determining the full impact of a policy change such as the imposition of a tax on wine. For a detailed analysis of the short-run versus the long-run effects of a tax on wine, see Tsolakis (1983). Also, given the size of the elasticities estimated, increased sales generated by price cutting—a feature of the industry in recent years—should, in the long-run, result in greater revenue than if price cutting did not occur.

Finally, because demand for beer was found to be price inelastic, the taxes on this commodity do not affect sales to anything like the same degree as similar taxes on wine. However, as noted above, caution is required in the use of the estimates for beer.

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Appendix A: The Model and Procedure

The choice of functional form was given particular emphasis in the analysis of this paper. The model used in the static approach to estimate the price and income elasticities for wine and beer was based on the work of Box and Cox (1964) and Zarembka (1974) and had the following general form:

Wine

(A.1) $CW_t^{(\lambda)} = b_0 + b_1 (PW/PB)_t^{(\mu)} + b'_2 IN_t^{(\mu)} + u_t.$

Beer

(A.2) $CB_t^{(\lambda)} = b'_0 + b'_1 (PB/PW)_t^{(\mu)} + b'_2 IN_t^{(\mu)} + v_t.$

where in the above, the superscripts (λ) and (μ) imply the Box-Cox transformation defined as:

$$Z^{(\lambda)} = \frac{Z^{(\lambda)} - 1}{(\lambda)} \quad \text{for } \lambda \neq 0$$

$$Ln(z) \quad \text{for } \lambda = 0$$

CW represents the consumption of wine per person; *CB* represents the consumption of beer per person; *PW* is the price of wine; *PB* is the price of beer; and *IN* is real disposable income per person.

The maximisation of the likelihood function for equation (A.1) to provide parameter estimates can be accompanied by iterative least squares as discussed by Zarembka (1974). Huang *et al.* (1978) have developed a computer program which searches over a two-dimensional grid of λ and μ values for that combination of λ and μ which coincides with the peak in the maximum likelihood surface. However, in this present study, because of the presence of autocorrelation, the estimation procedure was extended, and involved a three-dimensional search for the maximum likelihood solution over a grid of various values of λ, μ and ρ (the autocorrelation parameter). The form of the likelihood function is a simple extension of that given in Savin and White (1978).

Parameter estimates for wine based on selected values of λ, μ and ρ are presented in Table A1.

The maximum value for the likelihood function is obtained at $\lambda = -0.4$, $\mu = 2.0$ and $\rho = 0.8$. All parameter estimates in all models have the expected signs, and most are highly significant. Since the functional form of the maximum likelihood model is difficult to interpret, it is usual to examine other more commonly analysed functional forms to see whether the value of their likelihood function is not significantly different from that of the maximum likelihood function. This can be achieved by restricting λ and μ to take on specific values.

To test the null hypothesis that a specific functional form is not significantly different from that of the maximum likelihood functional form, use was made of the likelihood ratio test utilised by Huang (1979) in his paper on the demand for meat. If L is the ratio of the likelihood values for the two functions being compared, the test statistic $-2 \ln L$ is distributed approximately as $\chi^2_{(f)}$: where (f) is the degrees of freedom and is equal to the number of transformation parameters, in this case 2. The results of the likelihood ratio tests are shown in Table A2.

The log-linear and the double-log models are shown to be not significantly different from the estimated maximum likelihood model, while the linear, the linear-log, the inverse, and the log-inverse were significantly different at the 5 per cent level. The log-linear specification is preferred because the value of the likelihood function for this model is closest to that of the maximum likelihood model.

With reference to the beer model, it was not possible to obtain the maximum likelihood functional form. As was pointed out earlier, the estimation procedure involved a search over a three-dimensional grid of λ, μ and ρ values. The problem encountered for beer was that a global maximum could not be obtained on the likelihood surface, even after extensive searching. The analysis eventually broke down when the value of λ in the direction suggested by the search (-2.6) removed all the variability from the dependent variable. For this reason, the results reproduced in Table A3 are confined to those obtained from the more commonly analysed functional forms.

The log-linear model has the highest value for the likelihood function and is therefore preferred.

Table A1: Wine Demand Model: Parameter Estimates and Values of Maximum Likelihood Function for Selected λ, μ, *and* ρ, *and Related Statistical Results*[a]

Functional Form	b_0	b_1	b_2	ρ	λ	μ	$\bar{R}^2$	DW	$L(\lambda,\mu,\rho)$
(1) Maximum likelihood estimates with both λ and μ free.	1.295*** (0.031)	−0.000805 (0.072)	0.00258*** (0.00025)	0.800*** (0.122)	−0.4	2.0	0.975	1.55	−20.241
(2) Linear-log	−57.450*** (5.249)	−12.320*** (3.234)	26.378*** (1.974)	0.600*** (0.163)	1.0	0.0	0.864	1.58	−29.662
(3) Log-linear	0.940*** (0.124)	−0.270* (0.198)	0.117*** (0.009)	0.700*** (0.146)	0.0	1.0	0.932	1.62	−21.318
(4) Double-log	−2.065*** (0.380)	−0.446** (0.216)	1.733*** (0.143)	0.700*** (0.146)	0.0	0.0	0.922	1.71	−22.992
(5) Linear	−11.419*** (1.643)	−9.430*** (2.876)	1.772*** (0.119)	0.600*** (0.163)	1.0	1.0	0.886	1.47	−27.494
(6) Log-inverse	−15.186*** (2.988)	−0.441** (0.247)	19.118*** (3.217)	0.900*** (0.889)	0.0	−1.0	0.833	1.54	−25.395
(7) Inverse	−249.22*** (48.060)	−9.818*** (3.971)	282.71*** (51.755)	0.900*** (0.889)	1.0	−1.0	0.350	1.49	−32.348

[a] The figures in parentheses are standard errors. These were obtained from OLS regressions and are conditional upon the values of λ and μ. Asterisks represent levels of significance of the coefficients. One asterisk indicates significance at the 10 per cent level; two asterisks indicate significance at the 5 per cent level; and three asterisks indicate significance at the 1 per cent level. For price and income, one-tailed tests were used, while in all other cases a two-tailed test was used. $\bar{R}^2$ is the adjusted coefficient of determination; λ and μ are the transformation parameters; ρ is the autocorrelation coefficient; and $L(\lambda, \mu, \rho)$ is the value of the log-likelihood function.

Table A2: Wine Demand Model: Results of the Likelihood Ratio Test

Equation[a]	λ	μ	$-2 \ln L$	Decision
(1) ..	−0.4	2.0	..	.. ..
(2) ..	1.0	0.0	18.842	Reject at the 0.01 significance level.
(3) ..	0.0	1.0	2.154	Cannot reject at the 0.05 significance level.
(4) ..	0.0	0.0	5.503	Cannot reject at the 0.05 significance level.
(5) ..	1.0	1.0	14.506	Reject at the 0.01 significance level.
(6) ..	0.0	−1.0	10.308	Reject at the 0.01 significance level.
(7) ..	1.0	−1.0	24.214	Reject at the 0.01 significance level.

[a] Equation numbers correspond to the functional forms given in Table A1.

Table A3: Beer Demand Model: Parameter Estimates and Values of the Likelihood Function for Selected λ, μ and ρ, and Related Statistics[a]

Functional form	b'_0	b'_1	b'_2	ρ	λ	μ	$\bar{R}^2$	DW	$L(\lambda, \mu, \rho)$
(1) Linear-log	1.746 (27.299)	−30.987** (15.100)	69.133*** (10.244)	0.7255*** (0.140)	1.0	0.0	0.926	1.60	−64.8602
(2) Log-linear	4.888*** (0.050)	−0.218*** (0.069)	0.025*** (0.003)	0.7594*** (0.133)	0.0	1.0	0.998	1.67	−62.0710
(3) Double-log	4.236*** (0.130)	−0.190*** (0.074)	0.372*** (0.049)	0.6982*** (0.146)	0.0	0.0	0.998	1.73	−62.8137
(4) Linear	122.28*** (10.122)	−36.386*** (13.888)	4.647*** (0.715)	0.7603*** (0.1326)	1.0	1.0	0.929	1.54	−64.0910
(5) Log-inverse	0.288 (0.672)	−0.149** (0.083)	5.316*** (0.725)	0.6910*** (0.148)	0.0	1.0	0.966	1.79	−64.1056
(6) Inverse	714.050*** (144.680)	−23.780* (16.682)	969.000*** (155.970)	0.7394*** (0.137)	1.0	−1.0	0.917	1.64	−66.1411

[a] Refer to Table A1 for interpretation of table.