ALCOHOL CONSUMPTION IN THE U.K., 1955-1985:
A SYSTEM-WIDE ANALYSIS

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I. INTRODUCTION

In two recent articles, Clements and Johnson (1983) and Clements and Finke (1984) applied Theil's (1980) differential approach to consumption theory to analyse the demand for alcoholic beverages (namely, beer, wine and spirits) in Australia and the U.S. In this paper we apply the same methodology to the consumption of the three alcoholic beverages to the U.K. Our aim is to obtain some reasonably reliable estimates of income and price elasticities of the demand for alcoholic beverages. We shall illustrate the use of these elasticities by analysing the effects of taxes on alcohol consumption.

This paper is organised into the following sections. In Section II we present the U.K. data. In Section III we give the demand model and in Section IV we use the U.K. data to estimate these demand equations. In Section V we analyse the effects of alcohol taxes in determining the pattern of alcohol consumption. In Section VI we give our concluding comments.

II. THE U.K. ALCOHOL DATA

We use U.K. alcohol consumption data pertaining to beer, wine and spirits for the period 1955-1985. (See Selvanathan, 1987, for data sources.) Table 1 presents the quantity and price data in log-change form, $Dq_{it} = \log q_{it} - \log q_{i,t-1}$ and $Dp_{it} = \log p_{it} - \log p_{i,t-1}$, where q_{it} and p_{it} are the per capita quantity consumed and the price of beverage i (i = beer, wine and spirits) in year t . As can be seen, the average annual growth in per capita consumption is approximately 1.0, 5.3 and 3.6 percent for beer, wine and spirits, respectively. The average annual increase in prices of the three beverages are 7.9, 6.7 and 5.7 percent.

TABLE 1
ALCOHOL QUANTITY AND PRICE LOG-CHANGES:
UNITED KINGDOM, 1955-1985

Year	Beer		Wine		Spirits	
	Quantity	Price	Quantity	Price	Quantity	Price
	Dq _{1t}	Dp _{1t}	Dq _{2t}	Dp _{2t}	Dq _{3t}	Dp _{3t}
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1956	.3720	2.1306	.0000	1.8596	6.5597	.1201
1957	.2472	4.2654	6.6403	.6190	1.5748	.0780
1958	-3.2625	1.4307	-1.6902	2.3177	1.5504	1.7460
1959	4.6114	-7.5177	9.4794	-2.9566	5.9719	.5030
1960	3.5889	-2.2435	2.8027	4.8555	6.9959	-.1393
1961	.0000	8.9285	2.7263	7.5217	3.9740	8.9459
1962	3.1235	5.5807	-1.4779	1.3668	1.2903	4.5927
1963	-.3423	3.9935	8.0997	15.9634	5.0010	-4.2055
1964	4.0319	5.2365	6.4252	10.6045	7.0618	5.9276
1965	.1097	9.9906	.0000	2.4303	-7.0618	9.5432
1966	1.0905	5.9040	7.2421	4.1677	1.2121	5.8140
1967	1.7205	4.8053	13.6023	-3.5079	.0000	3.3200
1968	1.0605	2.8835	1.8983	11.5974	3.5507	5.6910
1969	3.7271	7.6569	.1708	7.4954	-7.2321	6.9782
1970	3.2003	8.5566	10.9788	-3.4823	13.9762	2.0063
1971	3.6719	7.7198	7.5091	9.5772	5.2922	3.2692
1972	1.9728	6.2572	10.6211	6.1639	13.4819	1.0272
1973	4.1901	3.9413	19.6255	6.3286	23.2112	2.1862
1974	2.0310	11.5805	-2.9789	19.0670	9.5310	1.8232
1975	2.7588	22.7368	1.2876	13.5656	-4.6520	22.3058
1976	1.0994	18.0986	11.3747	5.3836	12.1555	-1.6109
1977	-1.3548	13.3835	-2.3100	15.7239	-16.0961	33.2409
1978	2.8573	5.6960	10.5263	4.5418	18.7122	-6.4676
1979	.5783	13.3108	6.6946	15.6656	9.6377	10.7628
1980	-4.2918	19.3113	-1.1542	16.5017	-5.9054	16.0420
1981	-5.1158	16.5445	6.8108	10.2121	-5.3891	11.9572
1982	-2.1959	9.9905	7.1005	4.4769	-5.7973	9.0900
1983	2.1053	7.9554	9.7538	4.5053	2.6948	6.3279
1984	-.4539	8.2766	5.8467	2.1724	-.6421	6.6920
1985	-1.1900	9.4109	1.9561	6.9602	6.1499	3.5374
Mean	.9981	7.8605	5.3187	6.7233	3.5603	5.7035

All entries are to be divided by 100. The quantities are expressed in per capita terms. The year 1956, for example, refers to the transition from 1955 to 1956.

The unconditional budget share is defined as $w_{it} = p_{it}q_{it}/M_t$, where $M_t = \sum_{i=1}^n p_{it}q_{it}$ is the total per capita consumption expenditure, n being the number of goods. Thus w_{it} is the proportion of total consumption expenditure devoted to commodity i . The arithmetic average of w_{it} is defined as $\bar{w}_{it} = \frac{1}{2}(w_{it} + w_{i,t-1})$. These shares are presented in columns 2-4 of Table 2. Column 5 of the table contains the budget share of the three beverages as a group, $\bar{w}_{gt} = \sum_{i=1}^3 \bar{w}_{it}$. As can be seen, the share of total alcohol in the consumer's budget is on average about 6.8 percent. It increased from 6.3 percent in 1956 to 7.4 percent in 1985. The conditional budget share of i is defined as $\bar{w}'_{it} = \bar{w}_{it}/\bar{w}_{gt}$. The conditional budget shares are the proportions of total alcohol expenditure devoted to the three beverages. From the last three columns of the table we see that the conditional share of beer has fallen by about 10 percentage points over the sample period and is 53.5 in 1985. Most of this fall has been offset by the increase in wine share, which increased from 10.1 percent in 1956 to 22.2 in 1985. The spirits share fluctuates a bit over the 30 year period, but it exhibits less change than the other two.

The above information can be summarized in the form of the Divisia volume and price indexes for the alcoholic beverages group:

$$DQ_{gt} = \sum_{i=1}^3 \bar{w}'_{it} Dq_{it}, \quad DP_{gt} = \sum_{i=1}^3 \bar{w}'_{it} Dp_{it}.$$

These indexes are presented in columns 2 and 3 of Table 3. On average, per capita alcohol consumption increased by 2.4 percent per annum while alcohol prices rose by 7.0 percent.

TABLE 2
ARITHMETIC AVERAGES OF UNCONDITIONAL AND CONDITIONAL BUDGET SHARES:
UNITED KINGDOM, 1955-1985

Year	Unconditional				Conditional		
	Beer $\bar{w}_1$	Wine $\bar{w}_2$	Spirits $\bar{w}_3$	Total Alcohol $\bar{w}_g$	Beer $\bar{w}'_1$	Wine $\bar{w}'_2$	Spirits $\bar{w}'_3$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1956	3.986	.636	1.656	6.277	63.495	10.132	26.373
1957	3.932	.634	1.644	6.211	63.314	10.210	26.476
1958	3.795	.628	1.604	6.028	62.969	10.418	26.614
1959	3.533	.620	1.605	5.759	61.353	10.769	27.878
1960	3.353	.637	1.643	5.633	59.528	11.312	29.160
1961	3.386	.669	1.741	5.795	58.429	11.537	30.034
1962	3.531	.672	1.824	6.027	58.589	11.142	30.268
1963	3.563	.721	1.790	6.074	58.661	11.870	29.469
1964	3.589	.834	1.811	6.234	57.571	13.374	29.054
1965	3.733	.866	1.847	6.446	57.915	13.440	28.646
1966	3.852	.880	1.835	6.567	58.661	13.401	27.938
1967	3.930	.934	1.842	6.707	58.600	13.931	27.469
1968	3.914	.994	1.854	6.761	57.886	14.695	27.419
1969	3.972	1.037	1.823	6.832	58.137	15.183	26.679
1970	4.166	1.046	1.843	7.055	59.049	14.822	26.129
1971	4.256	1.077	1.895	7.228	58.882	14.896	26.222
1972	4.190	1.138	1.898	7.226	57.985	15.746	26.268
1973	4.019	1.248	2.052	7.319	54.916	17.046	28.038
1974	3.915	1.342	2.151	7.408	52.844	18.121	29.035
1975	3.996	1.316	2.087	7.399	54.011	17.782	28.207
1976	4.179	1.288	2.010	7.478	55.889	17.230	26.881
1977	4.240	1.300	2.004	7.544	56.201	17.238	26.561
1978	4.094	1.306	2.021	7.422	55.169	17.596	27.234
1979	3.919	1.348	2.037	7.305	53.657	18.458	27.885
1980	3.868	1.390	2.027	7.285	53.095	19.081	27.824
1981	3.895	1.443	1.944	7.282	53.491	19.812	26.697
1982	3.884	1.507	1.850	7.241	53.638	20.809	25.552
1983	3.879	1.566	1.796	7.241	53.561	21.632	24.807
1984	3.927	1.621	1.794	7.342	53.493	22.077	24.430
1985	3.950	1.637	1.801	7.388	53.460	22.162	24.379
Mean	3.882	1.078	1.858	6.817	57.148	15.531	27.321

The year 1956, for example, refers to the transition from 1955 to 1956. All entries are to be divided by 100.

TABLE 3
DIVISIA INDEXES OF ALCOHOL CONSUMPTION, CONSUMER PRICE INDEX AND
REAL INCOME LOG-CHANGES: UNITED KINGDOM, 1955-1985

(1)	Divisia Indexes				
	Volume	Price	Price-Quantity Correlation	CPI Log-change	Real Income Log-change
	DQ_g	DP_g	ρ_g	DP^*	$DQ = DM - DP^*$
(1)	(2)	(3)	(4)	(5)	(6)
1956	1.97	1.57	-.99	4.20	.58
1957	1.25	2.78	-.64	3.16	1.76
1958	-1.82	1.61	.51	2.81	2.15
1959	5.51	-4.79	.55	.55	4.10
1960	4.49	-.83	.05	1.10	3.00
1961	1.51	8.77	-.22	2.67	1.59
1962	2.06	4.81	.97	3.90	1.06
1963	2.23	3.00	.09	2.02	3.57
1964	5.23	6.16	.49	3.18	2.69
1965	-1.96	8.85	-.16	4.49	1.16
1966	1.95	5.65	-1.00	3.86	1.28
1967	2.90	3.24	-.92	2.63	1.75
1968	1.87	4.93	.41	4.65	2.29
1969	.26	7.45	1.00	5.24	.26
1970	7.17	5.06	-.84	6.08	1.96
1971	4.67	6.83	.02	8.99	1.82
1972	6.36	4.87	-.82	7.00	4.97
1973	12.15	3.86	-.20	8.73	3.99
1974	3.30	10.10	-1.00	14.84	-.59
1975	.41	20.98	-.07	21.69	-.88
1976	5.84	10.61	-1.00	15.37	-.48
1977	-5.43	19.06	-1.00	14.65	-1.21
1978	8.52	2.18	-.94	7.94	6.25
1979	4.23	13.03	-.41	12.68	4.25
1980	-4.14	17.87	.00	16.49	-1.90
1981	-2.83	14.07	-.69	11.24	-.78
1982	-1.18	8.61	-.87	8.23	1.12
1983	3.91	6.81	-.91	4.51	4.29
1984	.89	6.54	-.95	4.84	1.75
1985	1.30	7.44	-1.00	5.89	2.44
Mean	2.42	7.04	-.35	7.12	1.81

The year 1956, for example, refers to the transition from 1955 to 1956. All entries in columns 2,3,5 and 6 are to be divided by 100.

Table 3 also presents the Divisia price quantity correlation coefficient:

$$\rho_{gt} = \frac{\Gamma_{gt}}{\sqrt{K_{gt}\Pi_{gt}}},$$

where $\Gamma_{gt} = \sum_{i=1}^3 \bar{w}_{it}' (Dp_{it} - DP_{gt})(Dq_{it} - DQ_{gt})$ is the Divisia price-quantity covariance; and $K_{gt} = \sum_{i=1}^3 \bar{w}_{it}' (Dq_{it} - DQ_{gt})^2$ and $\Pi_{gt} = \sum_{i=1}^3 \bar{w}_{it}' (Dp_{it} - DP_{gt})^2$ are the Divisia quantity and price variances. The correlation is negative in 20 cases out of 30 with an average of $-.4$. This reflects the tendency of the drinker to move away from those beverages having above-average price increases. The last two columns of Table 3 will be discussed subsequently.

The within-alcohol relative price changes $(Dp_i - DP_g)$, and quantity changes $(Dq_i - DQ_g)$ at sample means are:

	Relative Price Log-changes ($Dp_i - DP_g$)	Relative Quantity Log-changes ($Dq_i - DQ_g$)
Beer	.82	-1.42
Wine	-.31	2.90
Spirits	-1.33	1.14

As can be seen, wine and spirits have a negative relative price change while that of beer is positive. In addition, the relative consumption growth of wine and spirits is positive while that of beer is negative. This implies that a higher relative price of a beverage inhibits its consumption.

III. ALCOHOL DEMAND EQUATIONS

In this section we present the alcohol demand equations. In the following section we use the U.K. alcohol data to estimate these equations.

Conditional Demand Equations

The conditional demand equations explain the allocation of total alcohol expenditure to the three beverages in terms of the variables pertaining to the alcoholic beverages group. Under block-independence the conditional demand equation for beverage i can be written as (see Clements and Johnson, 1983)

$$(2.1) \quad \bar{w}_{it} Dq_{it} = \theta'_i \bar{w}_{gt} DQ_{gt} + \sum_{j=1}^3 \pi_{ij}^g Dp_{jt} + \epsilon_{it},$$

where $\theta'_i = \theta_i / \theta_g$ is the conditional marginal share of i ; $\theta_i = \partial(p_i q_i) / \partial M$ is the unconditional marginal share of i ; $\theta_g = \sum_{i=1}^3 \theta_i$ is the marginal share of the alcoholic beverages group; π_{ij}^g is the conditional Slutsky coefficient and ϵ_{it} is a serially independent normally distributed disturbance.

The marginal share θ'_i answers the question, if income increases resulting in a certain additional amount of expenditure on alcohol, what is the proportion of this additional expenditure devoted to beverage i ? The Slutsky coefficient π_{ij} measures the effect of a change in the price of good j on the demand for i , where i and j belong to the alcoholic beverages group and under the condition that the total alcohol consumption remains constant.

The Slutsky coefficients satisfy

$$(2.2) \quad \sum_{j=1}^3 \pi_{ij}^g = 0, \quad i=1,2,3.$$

This means that a proportionate change in all prices in the alcoholic beverages group does not affect the demand for any beverage in the group, total consumption of alcohol remaining unchanged. Constraint (2.2) is known as demand homogeneity. The Slutsky coefficients also satisfy

$$(2.3) \quad \pi_{ij}^g = \pi_{ji}^g, \quad i,j=1,2,3.$$

Equation (2.3) is known as Slutsky symmetry. This means that when total expenditure on alcohol is held constant, the effect of an increase in the price of beverage j on the demand for i is equal to the effect of a price increase of i on the demand for j . The matrix $[\pi_{ij}^g]$ is negative semidefinite with rank $3 - 1 = 2$.

We use Working's (1943) parameterization for the conditional marginal shares, θ'_i equals $\bar{w}'_{it}$ plus a constant β'_i , where $\sum_{i=1}^3 \beta'_i = 0$. Then equation (2.1) becomes

$$(2.4) \quad \bar{w}_{it}(Dq_{it} - DQ_{gt}) = \beta'_i \bar{w}_{gt} DQ_{gt} + \sum_{j=1}^3 \pi_{ij}^g Dp_{jt} + \epsilon_{it}.$$

Under (2.4) the conditional income elasticity is

$$(2.5) \quad \eta'_i = \frac{\theta'_i}{\bar{w}'_{it}} = 1 + \frac{\beta'_i}{\bar{w}'_{it}}.$$

Thus $\eta'_i \gtrless 1$ according to whether β'_i is less or greater than zero. Therefore a commodity will be a necessity or a luxury according to $\beta'_i \gtrless 0$.

Unconditional Demand Equations

The conditional demand equations consider the demand for a beverage in terms of total expenditure on alcohol and the prices of the three beverages. Now we give the unconditional demand equations which explain the demand for a beverage in terms of the total consumption expenditure (or 'income' for short), prices of the three beverages and the price index of all other goods. The unconditional demand equation of commodity i is (see Clements and Johnson, 1983)

$$(2.6) \quad \bar{w}_{it} Dq_{it} = \theta_i DQ_t + \sum_{j=1}^3 \pi_{ij} Dp_{jt} + \pi_{io} DP_{ot} + \zeta_{it},$$

where $\theta_i = \theta_g \theta'_i$ is the unconditional marginal share of beverage i , which answers the question if income increases by one pound, what proportion of this increase will be spent on beverage i ; $\pi_{ij} = \pi_{ij}^g + \phi \theta_g (1 - \theta_g) \theta'_i \theta'_j$, $\pi_{io} = -\phi \theta_g (1 - \theta_g) \theta'_i$ are unconditional Slutsky coefficients with ϕ the inverse of the income elasticity of the marginal utility of income (the income flexibility); $DP_{ot} = (DP_t^* - \bar{w}_{gt} DP_{gt}) / (1 - \bar{w}_{gt})$ is the Divisia price index of all other goods with DP_t^* the CPI log-changes; and ζ_{it} is an error term.

The unconditional Slutsky coefficients satisfy the homogeneity and symmetry constraints,

$$(2.7) \quad \sum_{j=1}^3 \pi_{ij} + \pi_{io} = 0, \quad i=1,2,3,$$

and

$$(2.8) \quad \pi_{ij} = \pi_{ji}, \quad i, j=1,2,3.$$

As before, we use Working's parameterization for the unconditional marginal shares, so that θ_i equals $\bar{w}_{it}$ plus a constant β_i , where $\sum_{i=1}^n \beta_i = 0$. Then equation (2.6) becomes

$$(2.9) \quad \bar{w}_{it}(Dq_{it} - DQ_t) = \beta_i DQ_t + \sum_{j=1}^3 \pi_{ij} Dp_{jt} + \pi_{i0} DP_{ot} + \zeta_{it}.$$

Under Working's model the unconditional income elasticity of good i will become

$$(2.10) \quad \eta_i = 1 + \frac{\beta_i}{\bar{w}_{it}}.$$

The price elasticities are

$$(2.11) \quad \eta_{ij} = \frac{\pi_{ij}}{\bar{w}_{it}}, \quad \eta_{i0} = \frac{\pi_{i0}}{\bar{w}_{it}}.$$

IV. EMPIRICAL RESULTS

We use the U.K. alcohol data to estimate (2.4) and (2.9) for $i=1,2,3$. We include constant terms in each equation to take account of trend-like changes in tastes etc. We use Wymer's (1977) RESIMUL program for estimation.

Estimates of the Conditional Demand Equations

We assume that the total alcohol consumption $\bar{w}_{gt} DQ_{gt}$ and the prices Dp_{jt} , $j=1,2,3$ are predetermined variables and use maximum

likelihood to estimate (2.4) subject to homogeneity and symmetry restrictions (2.2) and (2.3). These estimates are presented in Table 4.

As can be seen, the constant terms in the wine and spirits equations are significant. The constant for the wine equation is positive and for the spirits equation it is negative, indicating an autonomous trend out of the latter into the former. The constant for wine implies that on average per capita consumption is growing autonomously at an exponential rate of $.293/(\bar{w}_{2t} \times 100) = .293/1.637 \approx 18$ percent per annum in 1985. The conditional income coefficients for beer and spirits are highly significant; $\beta'_1 < 0$, $\beta'_2 > 0$ and $\beta'_3 > 0$ imply that beer is a conditional necessity and wine and spirits are conditional luxuries. All the diagonal elements of the conditional Slutsky matrix $[\pi_{ij}^g]$ are significantly negative as they should be. Among the off-diagonal elements π_{13}^g and π_{23}^g are significantly positive, indicating that beer and wine are pairwise substitutes for spirits. The characteristic roots of $[\pi_{ij}^g]$ are $-.6$, $-.9$ and 0 (all $\times 100$), which verifies that the matrix is negative semidefinite. The value of the likelihood ratio test statistic for homogeneity and symmetry is 2.5 , which is far below the critical value of $\chi^2(3) = 7.82$. Thus the hypothesis of demand homogeneity and symmetry are safely acceptable.

Table 5 gives the conditional demand elasticities, based on the Table 4 estimates. At sample means, the conditional income elasticities are $.6$, 1.2 and 1.8 for beer, wine and spirits, respectively. Note that, within alcohol, spirits is a fairly strong luxury. All the conditional price elasticities are less than one in absolute value, the own-price elasticities being $-.1$, $-.4$, and $-.3$ (at sample means).

TABLE 4
 CONDITIONAL DEMAND EQUATIONS FOR ALCOHOLIC BEVERAGES:
 UNITED KINGDOM, 1955-1985

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

(Asymptotic standard errors are in parentheses)

Beverage	Constant $\alpha_i \times 100$	Conditional Income Coefficient β'_i	Conditional Slutsky Coefficients $\times 100$		
			π_{i1}^G	π_{i2}^G	π_{i3}^G
Beer	-.039 (.126)	-.260 (.043)	-.511 (.220)	.164 (.140)	.346 (.158)
Wine	.293 (.091)	.035 (.031)		-.403 (.136)	.239 (.108)
Spirits	-.254 (.102)	.225 (.037)			-.585 (.159)

χ^2 -value = 2.496 with 3 degrees of freedom; characteristic roots ($\times 100$) of the conditional Slutsky matrix: -.59, -.91 and 0.

Estimates of the Unconditional Demand Equations

We estimate the unconditional demand equations (2.9) subject to (2.7) and (2.8) with a constant term δ_i in each equation. The estimates are presented in Table 6. As can be seen, the constant terms in the wine and spirits equations are significant. All three income coefficients are also significant. All the own-Slutsky coefficients are negative and π_{22} and π_{33} are highly significant. All the π_{io} 's are positive indicating that each beverage is a substitute for all other goods. The marginal share of the group, θ_g , is highly significant and indicates that a one-pound increase in income leads to an 8 pence rise in alcohol expenditure. The estimate of the income

TABLE 5
 CONDITIONAL DEMAND ELASTICITIES FOR ALCOHOLIC BEVERAGES:
 UNITED KINGDOM, 1955-1985
 (Asmyptotic standard errors are in parentheses)

Beverage	Conditional Income Elasticity	Conditional Price Elasticities		
	$1 + (\beta'_i/\bar{w}_{it})$	$\pi^g_{i1}/\bar{w}_{it}$	$\pi^g_{i2}/\bar{w}_{it}$	$\pi^g_{i3}/\bar{w}_{it}$
1956				
Beer	.59 (.07)	-.13 (.06)	.04 (.04)	.09 (.04)
Wine	1.35 (.31)	.26 (.22)	-.64 (.21)	.38 (.17)
Spirits	1.85 (.14)	.21 (.10)	.14 (.07)	-.35 (.10)
1985				
Beer	.51 (.08)	-.13 (.06)	.04 (.04)	.09 (.04)
Wine	1.16 (.14)	.10 (.09)	-.25 (.08)	.15 (.07)
Spirits	1.92 (.15)	.19 (.09)	.13 (.06)	-.32 (.09)
Sample Means				
Beer	.55 (.08)	-.13 (.06)	.04 (.04)	.09 (.04)
Wine	1.23 (.20)	.15 (.13)	-.37 (.13)	.22 (.10)
Spirits	1.82 (.14)	.19 (.09)	.13 (.06)	-.32 (.09)

Based on Table 4 estimates.

TABLE 6

UNCONDITIONAL DEMAND EQUATIONS FOR ALCOHOLIC BEVERAGES:

UNITED KINGDOM, 1955-1985

$$\bar{w}_{it}(Dq_{it} - DQ_t) = \delta_i + \beta_i DQ_t + \sum_{j=1}^3 \pi_{ij} Dp_{jt} + \pi_{io} DP_{ot} + \zeta_{it}$$

(Asymptotic standard errors are in parentheses)

Beverage	Constant	Income Coefficient	Slutsky Coefficients $\times 100$			
	$\delta_i \times 100$	β_i	π_{i1}	π_{i2}	π_{i3}	π_{io}
Beer	.090 (.151)	-.023 (.007)	-.763 (.454)	.128 (.190)	-.211 (.204)	.845 (.492)
Wine	.201 (.105)	.008 (.004)		-.530 (.156)	-.126 (.114)	.528 (.243)
Spirits	-.291 (.123)	.022 (.006)			-1.477 (.202)	1.814 (.334)
$\theta_g = .075$ (.010)			$\phi = -.458$ (.134)			

flexibility ϕ is also highly significant and agrees well with the previous findings (Clements 1981, Clements and Nguyen (1980), Clements and Theil (1979), Selvanathan (1987), Theil (1975/76, 1980) and Theil and Suhm (1980).

Table 7 gives the income and own-price elasticities for the alcohol group and the unconditional elasticities for beer, wine and spirits. The income elasticity of demand for alcohol as a whole is 1.1 and the own-price elasticity is -.5 (at sample means). The unconditional income elasticities defined in (2.10) of beer, wine and spirits (at sample means) are .4, 1.7 and 2.2, respectively. This shows that beer is a necessity and wine and spirits are luxuries. All price elasticities are less than one in absolute value.

TABLE 7
UNCONDITIONAL DEMAND ELASTICITIES FOR ALCOHOLIC BEVERAGES:
UNITED KINGDOM, 1955-1985

(Asymptotic standard errors are in parentheses)

Beverage	Group Income Elasticity	Group Price Elasticity	Income Elasticity	Price Elasticities			
	$\theta_g/\bar{W}_{gt}$	$\phi\theta_g/\bar{W}_{gt}$	$\theta_i/\bar{W}_{it}$	$\pi_{i1}/\bar{W}_{it}$	$\pi_{i2}/\bar{W}_{it}$	$\pi_{i3}/\bar{W}_{it}$	$\pi_{i0}/\bar{W}_i$
1956							
Beer			.42 (.18)	-.19 (.11)	.03 (.05)	-.05 (.05)	.21 (.12)
Wine			2.26 (.63)	.20 (.30)	-.83 (.25)	-.20 (.18)	.83 (.38)
Spirits			2.33 (.36)	-.13 (.12)	-.08 (.07)	-.89 (.12)	1.10 (.20)
Total alcohol	1.19 (.16)	-.55 (.13)					
1985							
Beer			.42 (.18)	-.19 (.11)	.03 (.05)	-.05 (.05)	.21 (.12)
Wine			1.49 (.24)	.08 (.12)	-.32 (.10)	-.08 (.07)	.32 (.15)
Spirits			2.22 (.33)	-.12 (.11)	-.07 (.06)	-.82 (.11)	1.01 (.19)
Total alcohol	1.02 (.14)	-.46 (.11)					
Sample Means							
Beer			.41 (.18)	-.20 (.12)	.03 (.05)	-.05 (.05)	.22 (.13)
Wine			1.74 (.37)	.12 (.18)	-.49 (.14)	-.12 (.11)	.49 (.23)
Spirits			2.18 (.32)	-.11 (.11)	-.07 (.06)	-.79 (.11)	.98 (.18)
Total alcohol	1.10 (.15)	-.50 (.12)					

Based on Table 6 estimates.

V. THE EFFECTS OF ALCOHOL TAXES

In this section we use the demand model to analyse the effects of alcohol taxes on alcohol consumption and the welfare cost of the taxes.

The Tax Data

Columns 2-5 of Table 8 give the U.K. alcohol tax revenue data for the period 1962-1985 in pounds per capita, from the U.K. National Accounts, 1986 (disaggregated tax data are not available before this period). If we denote by p_i and p_i^0 the post-tax price, pre-tax price, respectively, of beverage i and by t_i the tax rate on i , then in year t

$$(5.1) \quad p_{it} = p_{it}^0 + t_{it}p_{it}^0 = (1 + t_{it})p_{it}^0.$$

The tax revenue from beverage i is

$$\begin{aligned} R_{it} &= p_{it}q_{it} - p_{it}^0q_{it} \\ &= t_{it}p_{it}^0q_{it} \\ &= t_{it}(p_{it}q_{it} - R_{it}). \end{aligned}$$

Therefore,

$$(5.2) \quad t_{it} = \frac{R_{it}}{p_{it}q_{it} - R_{it}},$$

which is the ratio of tax revenue to the pre-tax value of sales. Columns 6-8 of Table 8 present these tax rates based on equation (5.2). As can be seen, the average tax rate for the three beverages are 51, 37 and 113 percent over the 24-year period.

TABLE 8
ALCOHOL TAXES: UNITED KINGDOM, 1962-1985

Year (1)	Tax Revenues (Pounds per Capita)				Tax Rates × 100 (Percentage of Pre-Tax Price)		
	Beer (2)	Wine (3)	Spirits (4)	Total (5)	Beer (6)	Wine (7)	Spirits (8)
1962	4.75	.47	3.13	8.35	58.30	25.00	91.26
1963	4.70	.52	3.32	8.54	54.19	21.21	100.57
1964	5.30	.63	3.89	9.82	56.52	21.66	106.60
1965	6.00	.72	4.10	10.82	58.63	24.68	113.20
1966	6.50	.84	4.54	11.88	59.56	26.14	120.98
1967	6.99	.98	4.75	12.72	60.28	27.98	124.29
1968	7.06	1.20	5.29	13.55	57.61	30.28	128.63
1969	7.99	1.46	5.43	14.88	58.44	35.68	137.44
1970	8.14	1.58	6.18	15.91	50.22	35.92	128.36
1971	8.42	2.00	6.55	16.97	44.65	39.30	120.40
1972	8.61	2.05	7.42	18.08	40.97	32.30	115.24
1973	9.18	2.49	9.34	21.01	39.97	29.66	109.60
1974	10.51	3.09	10.72	24.33	39.93	31.93	115.52
1975	14.27	4.32	12.56	31.15	42.89	41.12	111.01
1976	17.72	5.37	16.05	39.14	44.44	44.15	153.14
1977	20.01	6.03	15.84	41.88	44.52	43.02	101.25
1978	21.04	7.07	18.96	47.07	42.34	43.48	114.03
1979	24.44	8.96	22.89	56.29	42.98	44.37	110.28
1980	29.83	10.67	24.67	65.17	46.15	45.74	104.36
1981	36.29	13.23	26.30	75.83	52.13	48.85	104.07
1982	40.86	15.18	27.78	83.82	55.50	50.44	108.83
1983	45.16	18.48	28.98	92.63	55.44	54.81	98.73
1984	48.98	18.09	30.80	97.88	55.71	47.03	98.81
1985	52.88	19.57	33.03	105.48	55.22	46.30	93.69
Mean	18.57	6.04	13.86	38.47	50.69	37.13	112.93

The Welfare Cost of Alcohol Taxes

The welfare cost of the alcohol taxes can be expressed as Harberger (1964)

$$W_t = -\frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 T_{it} S_{ij} T_{jt} ,$$

where $T_{it} = t_{it} p_{it}^0$ is tax per unit of i measured in terms of pounds and $S_{ij} = \partial q_i / \partial p_j$ with constant real income. Clements and Johnson (1983) show that this cost can be expressed as a proportion of income as

$$(5.3) \quad \frac{W_t}{M_t} = -\frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \frac{t_{it}}{1+t_{it}} \pi_{ij} \frac{t_{jt}}{1+t_{jt}} ,$$

where π_{ij} is the $(i,j)^{th}$ unconditional Slutsky coefficient.

We compute W/M using the estimates of the π_{ij} 's given in Table 6 and the results are presented in Table 9. Column 2 of this table gives the welfare cost as a fraction of total consumption expenditure based on equation (5.3) and column 3 expresses this cost in terms of pounds per capita. Columns 4 and 5 give the cost as a percentage of alcohol expenditure and as a percentage the revenue from alcohol taxes. As can be seen, the welfare cost in 1985 is .29 percent of total consumption expenditure or 10.88 pounds per capita per annum. This cost is 3.9 percent of expenditure on the beverages and 10.3 percent of the government revenue generated.

TABLE 9
WELFARE COST OF ALCOHOL TAXES:
UNITED KINGDOM, 1962-1985

Year	As a percentage of total consumption	Pounds per capita $\frac{(2)}{100} \times M$	As a percentage of alcohol expenditure $\frac{(3)}{M_g} \times 100$	As a percentage of revenue from alcohol taxes $\frac{(3)}{R} \times 100$
(1)	(2)	(3)	(4)	(5)
1962	.270	.968	4.440	11.593
1963	.281	1.066	4.640	12.481
1964	.297	1.195	4.642	12.175
1965	.316	1.344	4.872	12.420
1966	.333	1.492	5.015	12.566
1967	.342	1.600	5.057	12.580
1968	.348	1.745	5.152	12.879
1969	.369	1.957	5.349	13.156
1970	.342	1.960	4.742	12.323
1971	.322	2.057	4.435	12.118
1972	.300	2.162	4.166	11.956
1973	.285	2.334	3.833	11.108
1974	.299	2.818	4.047	11.581
1975	.303	3.518	4.079	11.295
1976	.382	5.150	5.066	13.158
1977	.287	4.428	3.801	10.573
1978	.310	5.511	4.250	11.708
1979	.304	6.411	4.160	11.389
1980	.298	7.268	4.112	11.153
1981	.309	8.360	4.226	11.025
1982	.325	9.652	4.530	11.516
1983	.307	9.972	4.205	10.766
1984	.301	10.438	4.086	10.664
1985	.289	10.875	3.901	10.310
Mean	.313	4.345	4.450	11.771

Based on data given in Table 8 and Table 6 estimates. $M_g = \sum_{i=1}^3 p_i q_i$ is expenditure on all three alcoholic beverages and $R = \sum_{i=1}^3 R_i$ is total revenue from alcohol taxes.

A Simulation of Alcohol Consumption

Going back to Table 8 it can be seen that the taxes have changed quite a bit over the last 20 years. To analyse the extent to which these changes have affected consumption, we simulate alcohol consumption with the tax rates held constant at their 1962 values.

If we apply the log-change operator to (5.1), we get

$$Dp_{it} = D(1 + t_{it}) + Dp_{it}^0.$$

We give the log-changes $D(1 + t_{it})$ in Table 10. We can simulate the constant tax rates by replacing Dp_{it} in the demand equation (2.9) with $Dp_{it}^0 = Dp_{it} - D(1+t_{it})$, which is the price log-change purged of its tax component. We obtain simulated consumption Dq_{it}^s as

$$(5.4) \quad Dq_{it}^s = \frac{\delta_i}{\bar{w}_{it}} + \frac{\theta_i}{\bar{w}_{it}} DQ_t + \sum_{j=1}^3 \frac{\pi_{ij}}{\bar{w}_{it}} [Dp_{jt} - D(1+t_{jt})] + \frac{\pi_{io}}{\bar{w}_{it}} DP_{ot} + \frac{\zeta_{it}}{\bar{w}_{it}}.$$

Dividing (2.9) by $\bar{w}_{it}$ and then substituting from (5.4), we obtain the difference between the simulated and observed consumption as

$$(5.5) \quad Dq_{it}^s - Dq_{it} = - \sum_{j=1}^3 \frac{\pi_{ij}}{\bar{w}_{it}} D(1+t_{jt}).$$

Converting from changes to levels we obtain

$$(5.6) \quad q_{it}^s = q_{i,t-1}^s \exp\{Dq_{it}^s\}.$$

We evaluate Dq_{it}^s from (5.5) using the estimates of the π_{ij} 's presented in Table 6 together with the values of $D(1+t_{jt})$ presented in Table 10. We then use equation (5.6) to obtain the values of q_{it}^s with

TABLE 10
ALCOHOL TAX RATE LOG-CHANGES:
UNITED KINGDOM, 1962-1985

Year	Beer $D(1 + t_{1t})$	Wine $D(1 + t_{2t})$	Spirits $D(1 + t_{3t})$
1963	-2.625	-3.077	4.752
1964	1.499	.366	2.964
1965	1.340	2.458	3.144
1966	.585	1.158	3.583
1967	.449	1.450	1.487
1968	-1.683	1.778	1.920
1969	.529	4.067	3.780
1970	-5.328	.173	-3.901
1971	-3.783	2.456	-3.550
1972	-2.575	-5.152	-2.369
1973	-.710	-2.017	-2.652
1974	-.026	1.732	2.782
1975	2.090	6.734	-2.115
1976	1.084	2.128	18.206
1977	.049	-.788	-22.939
1978	-1.520	.323	6.154
1979	.450	.614	-1.764
1980	2.197	.946	-2.858
1981	4.006	2.115	-.141
1982	2.191	1.062	2.306
1983	-.034	2.864	-4.958
1984	.169	-5.157	.038
1985	-.314	-.498	-2.609
Mean	-.085	.684	.055

All entries are to be divided by 100. The year 1963, for example, refers to the transition from 1962 to 1963.

1962 as the base year. Table 11 present the actual and simulated consumption of the three beverages. In 1985 simulated per capita consumption for beer is 108 litres while observed consumption is 108.6. Accordingly, this constant tax package causes beer consumption to be about $(108.0-108.6)/108.6 = .6$ percent lower than the observed value in 1985. On the other hand, wine and spirits consumption in 1985 are 9 and 2 percent higher than otherwise. Thus, applying the argument in reverse, the observed changes in tax since 1962 have caused beer consumption to be .6 percent higher, wine 9 percent lower and spirits 2 percent lower.

VI. CONCLUDING COMMENTS

In this paper we used the differential approach to analyse the demand for beer, wine and spirits in the U.K., 1955-1985. We found that the estimated mean income elasticity of demand for the three alcoholic beverages as a group to be 1.10 and the mean own-price elasticity to be -.5. The mean (unconditional) income and own-price elasticities for the individual beverages are

	Income Elasticity	Own-price Elasticity
Beer	.41	-.20
Wine	1.74	-.49
Spirits	2.18	-.79

We also used the demand model to simulate the effects of the changes in alcohol taxes that have taken place over the period 1962-1985. We found that the constant tax package has more effect on wine and spirits than on beer.

TABLE 11

ACTUAL AND SIMULATED CONSUMPTION OF ALCOHOLIC BEVERAGES:

UNITED KINGDOM, 1962-1985

(Litres per Capita)

Year	Actual Consumption			Simulated Consumption with Alcohol Tax Rates held constant		
	Beer	Wine	Spirits	Beer	Wine	Spirits
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1962	87.8	4.03	1.95	87.8	4.03	1.95
1963	87.5	4.37	2.05	87.4	4.33	2.12
1964	91.1	4.66	2.20	91.4	4.64	2.84
1965	91.2	4.66	2.05	91.8	4.72	2.24
1966	92.2	5.01	2.08	93.1	5.13	2.34
1967	93.8	5.74	2.08	94.8	5.93	2.37
1968	94.8	5.85	2.15	95.6	6.13	2.49
1969	98.4	5.86	2.00	99.4	6.30	2.40
1970	101.6	6.54	2.30	101.4	7.05	2.66
1971	105.4	7.05	2.43	104.2	7.69	2.72
1972	107.5	7.84	2.78	105.8	8.35	3.03
1973	112.1	9.54	3.50	110.1	10.06	3.74
1974	114.4	9.26	3.85	112.5	9.86	4.20
1975	117.6	9.38	3.68	115.7	10.22	3.98
1976	118.9	10.51	4.15	118.2	11.74	5.15
1977	117.3	10.27	3.53	115.3	11.19	3.70
1978	120.7	11.41	4.26	118.7	12.54	4.66
1979	121.4	12.20	4.69	119.4	13.41	5.07
1980	116.3	12.06	4.42	114.6	13.24	4.69
1981	110.5	12.91	4.19	109.7	14.24	4.47
1982	108.1	13.86	3.95	107.9	15.34	4.31
1983	110.4	15.28	4.06	109.8	17.01	4.26
1984	109.9	16.20	4.04	109.5	17.73	4.22
1985	108.6	16.52	4.29	108.0	18.02	4.39

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