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Authors(s)	Thom, Rodney
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THE DEMAND FOR ALCOHOL IN IRELAND

Rodney Thom

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The Demand for Alcohol in Ireland

This paper uses a dynamic version of Deaton and Muellbauer's (1980a) Almost Ideal Demand System (AIDS) to estimate price and expenditure elasticities for alcohol consumption in Ireland. The study differs from previous work on this topic in at least three important respects. First, the data set is based on quarterly observations over 1969(1) to 1980(4) disaggregated into expenditures on beer, spirits and wine. Walsh and Walsh (1970) report price on income elasticities for beer and spirits but not for wine, while O'Riordan (1975) and McCarthy (1977) each report budget and price elasticities for the composite commodity alcohol using annual data.

Second, using a flexible functional form permits systematic testing of homogeneity and symmetry restrictions implied by utility maximization. Previous studies use either ad hoc functional forms (Walsh and Walsh) or restrictive models such as the Linear Expenditure System (McCarthy) which typically impose restrictions on the preference ordering. Third, rather than assume that consumers adjust to equilibrium in each period the AIDS model is modified using the proposals of Anderson and Blundell (1982, 1983) who develop a dynamic system in which observed expenditure changes are treated as part of a dynamic adjustment process arising from "habit persistence, adjustment costs, incorrect expectations and misinterpreted real price changes." (Anderson and Blundell, 1982, p. 397). A considerable advantage of this approach is that it not only allows for a dynamic specification but also permits identification of the equilibrium structure and direct estimation of expenditure, own-price and cross-price elasticities.

Section II outlines the approach used and the elasticity estimates are presented in Section III. These estimates are used in Section IV to derive tax elasticities which relate changes in total revenue from alcohol taxation to changes in the rates of excise duty on beer, spirits and wine. A significant feature of the results is that these elasticities are unambiguously positive suggesting that tax revenue increases with the rates of excise duty applied to each good.

II. A Dynamic Model

Due to the limitations imposed by data availability it is assumed that consumers can allocate total expenditure by a two-stage budgeting process which determines expenditure on broad subgroups, including alcohol, at the first stage and expenditure within each group at the second stage.[1] Employing the Almost Ideal Demand System of Deaton and Muellbauer enables us to express a set of equilibrium equations of the form,

$$w = \pi x \tag{1}$$

where w is a 3 by 1 vector of budget shares in alcohol expenditure, π is a 3 by 5 matrix of coefficients and x is a 5 by 1 vector in the prices of beer, wine and spirits, total alcohol expenditure and a constant. It should be noted that the existence of these subgroup demand functions implies that the underlying, or first-stage, utility function is weakly separable in the broad subgroups. That is, weak separability is both necessary and sufficient for the second stage of two-stage budgeting and, given this assumption, the demand functions in

(1) "possesses all the usual properties of demand functions since they derive from a standard utility maximizing problem". (Deaton and Muellbauer 1980b, p. 124).[2] Although weak separability is necessary and sufficient for the second stage of the process, the allocation of total expenditure into broad subgroups at the first stage "is more problematical ... [and] ... an exact solution that does not require the composite commodity theorem demands conditions considerably stronger (and less plausible) than weak separability alone". (Deaton and Muellbauer, 1980b, p. 125). The AIDS model used below should therefore be considered as a reasonable approximation to Marshallian demands. While this approach is not perfect it is commonly used in empirical studies of demand systems. Anderson and Blundell (1983), for example, exclude durable goods from their expenditure system and, implicitly, take the same approach as used in the present paper.

The AIDS model is used because it is linear in the variables and, as will be explained below, permits simple testing of homogeneity and symmetry restrictions on (1). The ith budget share in (1) is given by,

$$w_i = \alpha_i + \sum_{j=1}^{n} \pi_{ij} LnP_j + \beta_i Ln(m/P) \qquad (2)$$

where P_j is the price of good j, m is total expenditure on alcohol and P is a subgroup price index given by,

$$LnP = \alpha_0 + \sum_{1}^{n} \alpha_k LnP_k + .5 \sum_{1}^{n}\sum_{1}^{n} \pi_{kj} LnP_k LnP_j \qquad (3)$$

Given that $\Sigma w_i = 1$ (2) and (3) must satisfy the following adding-up restrictions,

$$\sum_i \alpha_i = 1; \sum_i \pi_{ij} = \sum_i \beta_i = 0$$

while utility theory gives the homogeneity and symmetry restrictions,

$$\sum_j \pi_{ij} = 0, \text{ for all } i$$

$$\pi_{ij} = \pi_{ji}, \text{ for all } i, j; i \neq j$$

Anderson and Blundell (1982, p. 1561) propose a dynamic version of (1) which assumes that "changes in w(t) are responses to anticipated and unanticipated changes in x(t) in an attempt to maintain a long-run relationship of the form (1) in the sense that should x(t) stabilize to some constant value over time then so would the expected value of w(t)", (1982, p. 1561), where t is time. Such a model may be written as,

$$B(L)w(t) = \Gamma(L)x(t) + u(t) \tag{4}$$

where B and Γ are matrix polynominals in the lag operator L and u is a vector of random errors. Anderson and Blundell also demonstrate that (4) may be reparameterized to give the observationally equivalent system,

$$\begin{aligned} \Delta w_n(t) = & - \sum_2^p B_i \Delta w_n(t-i+1) + \sum_1^q \Gamma_i \Delta x^*(t-i+1) \\ & - A(w_n(t-p) - \pi_n x(t-q)) + u(t) \end{aligned} \tag{5}$$

where Δ is the first difference operator, * indicates that the constant is deleted in differencing and the subscript n denotes that the last row is lost due to adding-up restrictions. B, Γ and A are matrices of dynamic parameters and p, q are the lags on w and x respectively. The advantage of (5) is that it allows identification of the equilibrium structure and also permits likelihood ratio tests on the symmetry and homogeneity restrictions imposed by utility maximization.

Under the assumption of weak separability the uncompensated price (E_{ij}) and expenditure (E_{im}) elasticities may be expressed as,

$$E_{ij} = E^*_{ij} + E_{im}E_{mj} \tag{6}$$

$$E_{im} = 1 + \beta_i/w_i \tag{7}$$

where,

$$E^*_{ij} = w_i^{-1}(\pi_{ij}-\beta_i(\alpha_j+\sum_k \pi_{kj}\mathrm{Ln}P_k))-c_{ij} \tag{6a}$$

and, c_{ij}=1 for i=j and zero otherwise. E_{mj} is the elasticity of total expenditure on alcohol with respect to P_j. To approximate E_{mj} we define m as PQ, where Q is an index of the quantities in (1) and denote the elasticity of Q with respect to P by θ so that

$$\frac{dQ}{dP} = \theta \frac{Q}{P}$$

and $$\frac{dm}{dP} = Q + P\frac{dQ}{dP} = Q(1+\theta)$$

Further, let

$$\frac{dm}{dP_j} = \frac{\partial P}{\partial P_j}\frac{\partial m}{\partial P} = \frac{\partial P}{\partial P_j} Q(1+\theta)$$

and $$E_{mj} = \frac{P_j}{m}\frac{\partial m}{\partial P_j} = \frac{P_j}{m}\frac{\partial P}{\partial P_j} Q(1+\theta)$$

from (3)

$$\frac{\partial P}{\partial P_j} = P(\alpha_j + \sum_k \pi_{kj} LnP_k)/P_j$$

so that,

$$E_{mj} = (\alpha_j + \sum_k \pi_{kj} LnP_k)(1+\theta) \qquad (8)$$

Although θ is not estimated by the present study it is generally accepted that alcohol consumption is relatively inelastic with respect to P. McCarthy (1977), for example, estimates θ over the range -.62 to -.80 on Irish data. The elasticity estimates presented in Section III therefore give estimates of E_{ij} for plausible values of θ between -.6 and -1.

III Data and Estimation[3]

This paper uses quarterly data for Irish consumption of beer (B), spirits (S) and wine (W) over 1969(1) to 1980(4). Quarterly series for beer and spirits consumption were obtained by aggregating the monthly series given in the Irish Statistical Bulletin. Only annual data is, however, available for wine consumption. The quarterly series for wine was approximated by using the 'quarterly wreights' implied by the other two series. That is, let AB_t, AS_t and AW_t represent the annual consumption of each good in year t. Define $v1i_t = QBi_t/AB_t$ and $v2i_t = QSi_t/AS_t$, i =1...4, where QBi_t=consumption of beer in the quarter i of year t. Quarterly wine consumption is then approximated by $QWi_t = AW_t(v1i_t + v2i_t)/2$. Each quarterly series is

deflated by the average quarterly consumption in 1969 to produce consumption price indicies based on 1969=1. The price series for each good, based on expenditure data, were deflated to 1969=1 and the total expenditure index was approximated by,

$$m = \sum_{1}^{n} s_i q_i P_i ; \sum_{1}^{n} s_i = 1 \qquad (9)$$

where i=B, S or W and s_i are the relative weights given to beer, spirits and wine in the CPI.

One method of selecting the appropriate lag lengths in (5) is to perform a series of likelihood ratio tests for different values of p and q and select the most unrestricted model admitted by the data. However, given that likelihood ratio tests are sensitive to degrees of freedom the relatively short time series available implies that such tests would be asympotically invalid for any reasonably high order of lags. For example, starting at p=q=4 implies estimation of 61 parameters (including seasonal dummies) from the 44 observations left after differencing and lagging. Given this limitation a first order process was assumed for (5) which gives 25 parameters in 47 observations.[4] Both static and first order dynamic (p=q=1) models were estimated using the appropriate maximum likelihood procedures in the SHAZAM package and homogeneity and symmetry restrictions tested for each model.[5] The results of these likelihood ratio tests are given in Table 1. The most striking feature of Table 1 is that the static model clearly rejects the restrictions implied by utility maximization while the dynamic model rejects homogeneity at the 0.05 level but accepts it at the 0.01 level and also accepts symmetry given homogeneity.

Table 1. Tests on Restrictions[a].

Restrictions	Static Model	Dynamic Model
Unrestricted	L=340.8	L=365.28
Homogeneity	L=325.01 $X^2(2)=31.58$** CV=9.21	L=361.01 $X^2(2)=8.54$* CV=9.21
Homogeneity and Symmetry	L=313.4** $X^2(1)=23.22$ CV=6.63	L=359.28 $X^2(1)=3.46$ CV=6.63

Note a. L = log of likelihood function, CV is the critical value of χ^2 at the .01 significance level.

* significant at the 0.05 level

** significant at the 0.01 level

Furthermore, restricting the dynamic model to zero lags to give the static model would also be rejected at each stage in the testing sequence. The relevant chi-squares are 48.96 (12), 92 (12) and 91.68 (12) for unrestricted, homogeneity and symmetry/homogeneity respectively, and the CV for χ^2 (12) is 26.2 at the 0.01 significance level.

On the basis of this evidence it seems reasonable to accept the dynamic model as an approximation of consumer behaviour. Table 2 gives estimates of the equilibrium parameters and Table 3 present elasticity estimates based on values of w_i and P_i for 1980 (4). Beer consumption is price and expenditure inelastic while the reverse is true for spirits and wine. The results on own-price and expenditure elasticities are in broad agreement with those reported for other countries.[6] Turning to the cross-price elasticities, wine and spirits are unambiguous substitutes as are beer and spirits for values of θ greater than -.9. Beer and wine, on the other hand, are unambiguous complements. An interesting, and perhaps doubtful, feature of the cross-price terms is the relatively high values for EWB and EWS. While strong substitution of wine for spirits is intutively appealing the magnitude of these elasticities is surprising as is the sign on EWB. Apart from these two estimates the remainder of Table 3 appears to be a plausable representation of alcohol consumption.

V. Revenue Elasticities

Given the relatively high rates of taxation on alcohol, the above elasticity estimates are of considerable importance for revenue projections. Letting k_i, v_i and Ps_i be the rate of excise

Table 2. Parameter Estimates - Dynamic Model

Commodity	Estimate				
	α_i	β_i	π_{i1}	π_{i2}	π_{i3}
Beer	.271	-.112	.077		
	(.057)	(.026)	(.027)		
Spirits	.728	.087	.021	-.158	
	(.109)	(.028)	(.014)	(.058)	
Wine	.001	.025	-.098	.137	-.039
	(-)	(-)	(-)	(-)	(-)

Note: Figures in parenthesis are asymptotic standard errors.

(-) indicates that the estimate is derived from the restrictions.

Table 3. Estimated Elasticities

Elasticity	Value of θ				
	-.6	-.7	-.8	-.9	-1
EBB	-.592	-.633	-.675	-.717	-.758
ESS	-1.292	-1.354	-1.415	-1.476	-1.538
EWW	-1.606	-1.603	-1.601	-1.598	-1.595
EBS	.296	.256	.217	.177	.137
EBW	-.185	-.183	-.181	-.180	-.178
ESB	.192	.128	.063	-.001	-.065
ESW	.360	.363	.366	.368	.370
EWB	-1.427	-1.499	-1.571	-1.643	-1.716
EWS	2.201	2.131	2.063	1.994	1.925
EBM	.800	.800	.800	.800	.800
ESM	1.232	1.232	1.232	1.232	1.232
EWM	1.386	1.386	1.386	1.386	1.386

Note: Eij are own-price elasticities for i=j and cross-price elasticities for i≠j. EiM are expenditure elasticities, i=Beer, Spirits, Wine.

duty, the VAT rate and seller's price for good i then

$$P_i = (1+v_i)(Ps_i+k_i) \tag{10}$$

and tax revenue from good i is

$$R_i = q_i(P_i-Ps_i) \tag{11}$$

Total tax revenue from alcohol is given by,

$$R = \sum_i q_i[k_i+v_i(Ps_i+k_i)] \tag{12}$$

Setting v_i equal for all i gives the elasticity of total revenue with respect to each k as,

$$E_{Rkj} = (1+v)(q_j+\sum_i(P_i-Ps_i)E_{ij}q_i/P_j)(k_j/R) \tag{13}$$

Where

$$E_{ij}\frac{q_i}{P_j} = \frac{\partial q_i}{\partial P_j} \quad : \quad \frac{\partial Ps_i}{\partial k_j} = 0$$

Note that if the cross-price elasticities are ignored then (13) reduces to

$$E_{Rkj} = (1+v)q_j(1+x_jE_{jj})(k_j/R) \tag{14}$$

where x_j is the proportion of tax in the final price of good j and E_{jj} is the own-price elasticity.[7] Given that x_j is less then one and that the E_{jj} are negative for all j it follows that price inelasticity is a sufficient, but not necessary, condition for E_{Rkj} to be positive.

Table 4. Minimum Estimates of E_{Rkj}

Tax Change on	Value of θ				
	-.6	-.7	-.8	-.9	-1
Beer, x=.4	.265	.251	.237	.223	.208
x=.6	.256	.249	.224	.198	.172
x=.8	.245	.207	.170	.132	.095
Spirits, x=.4	.141	.128	.114	.100	.086
x=.6	.174	.149	.123	.097	.071
x=.8	.191	.153	.115	.077	.039
Wine, x=.4	.018	.018	.018	.017	.017
x=.6	.012	.012	.012	.011	.011
x=.8	.002	.003	.006	.008	.009

The necessary condition is that the product of own-price elasticity and the proportion of tax in final price be less than unity. The elasticity estimates in Table 3 imply that raising excise duty on beer will unambiguously increase tax revenue as EBB is always less than one in absolute value. For spirits, revenue will be an increasing function of k providing x is less than 0.65 for $\theta = -1$ or less than 0.77 for $\theta = -.6$ Likewise revenue will increase with excise duty on wine for values of x less than 0.62.

Table 4 gives estimates of E_{Rkj} using (12) which allows for cross-price effects. In deriving these estimates it is assumed that both v_i and x_i are equal for all goods. The VAT rate is set at 0.2 and x is varied between 0.4 and 0.8. As we are primarily interested in the possibility of revenue declining in response to increased taxation the figures given in Table 4 are the minimum sample estimates.[8] Setting x_i=0.4 for each good the minimum estimates of E_{Rkj} with $\theta = -.6$, are .265, .141 and .018 for increases in the excise duty on beer, spirits and wine respectively.

The significant feature of Table 4 is the complete absence of negative estimates. Even with taxation accounting for 80 percent of final price an increase in excise duty on any good will still generate some increase in total revenue. For example, given the estimates of ESS an increase in excise duty on spirits would reduce tax revenue from spirits with x equal to 0.8. However, as both beer and wine consumption are increasing functions of the price of spirits the estimates in Table 4 imply that this revenue loss is more

then compensated for by increased revenue from the other goods.

VI. Conclusions

The principal objective of this paper was to estimate price and expenditure elasticities for beer, spirits and wine using quarterly Irish data over 1969 to 1980. In contrast to other work on alcohol consumption in Ireland the demands for these goods were modelled in the context of a flexible dynamic system which permits identification of the equilibrium structure. An important reason for estimating the price elasticities is that they play a crucial role in determining the responsiveness of tax revenues to changes in the rates of excise duty on beer, spirits and wine. Section IV uses the elasticity values to estimate the impact of tax changes on total tax revenue and concludes that the elasticities are unambiguously positive. That is, any observed decline in revenue from alcohol taxation is most likely due to factors other than increased tax rates.

Although the results appear plausible on *a priori* grounds there are several reasons for treating them with some caution. First, the initial stage of two-stage budgeting requires assumptions which are stronger then weak separability so that the AIDS model, equation (2), is only on an approximation to the true Marshallian demand functions. Some doubt must therefore be cast on whether or not it is valid to use such an approximation to test demand theory restrictions as in Section III. This problem is further compounded by the use of these tests in choosing between the static and dynamic versions of the AIDS model. However, it should be noted that the tests reported in Table 1 reject the

unrestricted static model in favour of the dynamic model so that the use of the latter does not totally depend on its acceptance of homogeneity and symmetry restrictions.

Second, due to the limited time series available a first order dynamic process is imposed on the model. While it is totally plausible that the data might accept longer lags, extending p and q beyond a first order process greatly increases the number of parameters to be estimated from a fixed number of observations. Furthermore, given that consumers are unlikely to adjust expenditures to equilibrium in each quarter, some form of dynamic process may be preferable to a static model even if the choice of lag length is somewhat arbitrary.

Third, the model may be criticised on the grounds that it ignores several potentially important determinants of alcohol expenditures. For example, advertising, home brewing, duty-free purchases and, in the case of Ireland, smuggling may play significant roles in the demand for beer, spirits and wine. While the omission of these variables cannot be totally justified it is important to remember that the objective was to derive estimates of price and expenditure elasticities, which can be used to measure the responsiveness of tax revenues, rather than to present a comprehensive study of all factors determining alcohol consumption. Finally it is not clear that these factors could be conveniently incorporated into a flexible functional form model, such as AIDS, which yields demand functions consistent with utility maximization.

Footnotes

[1]Quarterly expenditure and price data are not available for other goods.

[2]Although weak separability places important restrictions on the degree of substitution between goods in different groups it does affect the substitution pattern within groups. See Deaton and Muellbauer (1980b, p. 128-129).

[3]Data on three prices and on consumption of wine were supplied by Brendan Walsh to whom the author expresses his thanks.

[4]Unrestricted versions of (5) were estimated for both third and second order lags. The restriction to $p=q=2$ was accepted as was the restriction to first order from second order lags. This procedure is justified on the grounds that it is consistent irrespective of the restrictions on π and (5) will be exactly identified if π is unrestricted so that equation by equation OLS estimation is maximum likelihood.

[5]Seasonal dummies were added to the model. The price equation (2) was approximated by $LnP = \sum_{1}^{n} w_j LnP_j + \alpha_0$ as suggested by Deaton and Muellbauer (1980a). The equation for wine consumption was deleted in the estimation.

[6]See, for example, Duffy (1982) for estimates based on UK quarterly data.

[7]Assuming $E_{ij}=0$ for $i \neq j$ implies that $\partial R/\partial k_j = \partial R_j/\partial k_j$.

[8]Assumed values of x are used because we are interested in whether or not there are values which would make E_{Rkj} negative. It may be the case that these elasticities are positive for values of x actually in operation but may become negative for other, equally plausible, levels of taxation.

References

Anderson, G.J. and R.W. Blundell, 1982, "Estimation and Hypothesis Testing in Dynamic Singular Equation Systems", Econometrica, Vol. 50, pp. 1559-1571.

_____, 1983, "Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumer's Expenditure in Canada", Review of Economic Studies, Vol. 50, pp. 397-410.

Deaton, A.S. and J. Muellbauer, 1980a, "An Almost Ideal Demand System", American Economic Review, Vol. 70, pp. 312-326.

_____, 1980b, Economics and Consumer Behaviour, Cambridge University Press, 1980.

Duffy, M., 1983, "The Demand for Alcoholic Drink in the UK, 1963-1978", Applied Economics, Vol. 15, pp. 125-140.

McCarthy, C., 1977, "Estimates of a System of Demand Equations Using Alternate Commodity Classification of Irish Data, 1953-1974", Economic and Social Review, Vol. 8, pp. 201-211.

O'Riordan, W., 1975, "An Application of the Rotterdam System to Irish Data", Economic and Social Review, Vol. 6, pp. 511-529.

Walsh, B.M., and D. Walsh, 1970, "Economic Aspects of Alcohol Consumption in the Republic of Ireland", Economic and Social Review, Vol. 2, pp. 115-138.