Dynamic Almost Ideal Demand Systems: An Empirical Analysis of Alcohol Expenditure in Ireland

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Abstract

This paper presents a dynamic form of the Almost Ideal Demand System (AIDS). We employ three versions of the static AIDS model to determine the preferred long-run equilibrium model and represents the short-run dynamics by an error correction mechanism. This estimation procedure is then applied to alcohol expenditure in Ireland. The estimated point elasticities are consistent with previous studies and *a priori* expectations. Beer and spirits are found to be price inelastic in both the short and long run. While wine is price inelastic in the short run and price elastic in the long run.

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Abstract: This paper presents a dynamic form of the Almost Identical Demand System (AIDS). We employ three versions of the AIDS model to determine the preferred long-run equilibrium model to use in a dynamic specification, that has similar characteristics to an error correction mechanism. This estimation procedure is applied to the demand for alcohol in Ireland. Beer is found to be price inelastic in both the short and long run. Spirits is price elastic in the short run and price inelastic in the long run. Wine is price elastic in the both the short and long run.

I Introduction

The interest in modelling demand systems has increased with the availability of longer horizon databases and advancements in econometric methodology. The Almost Ideal Demand System (AIDS), developed by Deaton and Muellbauer (1980), remains the most popular specification over the last 20 years. However, a feature of previous demand studies is that the point elasticity estimates are not robust to the estimation period. In particular, it appears that the short-run elasticity estimates substantially differ from their long-run values. It is this characteristic that we explore in this paper in the context of the demand for alcohol in Ireland for the period 1960-1998. We estimate price and expenditure (income) elasticities for three different categories of alcohol: beer, spirits and wine. Employing a dynamic demand system modelling approach, these elasticities are estimated for both short run and long run.

The application of this dynamic AIDS model to alcohol demand is of particular importance to the drinks industry and to the Irish economy in general. In 1998, around €4.13 billion was spent on alcohol products alone. This constituted around 10% of total personal expenditure in Ireland for that year. In terms of employment, Conniffe and McCoy (1993) estimated that in 1990 some 33,000 full-time equivalent people were employed in the alcohol industry. Foley (1999) showed that this figure had increased to over 43,000 persons by 1998. Also, in 1998, the government collected in excise duty some €748 million; €465 million from beer sales, €188 million from spirits and €95 million from wine. As a percentage of government's total net receipts, beer was 2.3%, spirits was 0.9% and wine was 0.4%. Furthermore, the total tax content on a pint of beer in 1998 was 35.6% of the price and for a glass of spirits it was 35.5% of the price (Revenue Commissioners, Statistical Report 1998). Analysis of alcohol use in Ireland, particularly in relation to estimation of elasticities is of particular importance to both the alcohol industry (in the form of production and pricing policies) and the government (in the collection of revenue).

This paper contributes to the existing literature in two ways. First, with the exception of Walsh and Walsh (1970), Thom (1984) and Conniffe and McCoy (1993) there has been no substantive economic analysis of the demand for alcoholic beverages in Ireland. Employing more recent econometric techniques and a longer database, the robustness of previous studies is investigated. Second, we advance previous methodology that is employed in estimating demand systems using time series data. We modify the standard Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980) by representing demand as a dynamic data generating process (DGP) that allows the use of time series information to estimate short- and long-run elasticities. We apply this methodology to estimate the demand elasticities for individual alcoholic drinks in Ireland. The dynamic AIDS representation is of an error correction[1] form of the AIDS model, that models the disequilibrium separate from the AIDS long-run equilibrium and thus gives the short-run relationship between the demand variables.

The remainder of the paper is set out as follows. In Section II we discuss the static and dynamic AIDS modelling in estimating elasticities. This section also contains a short review of recent empirical evidence. The data is outlined in Section III. Section IV investigates the time series properties of the relevant data and provides the econometric estimation, including the calculation of long run elasticity measures and tests for the dynamic AIDS. Section V presents the dynamic AIDS results. A final section concludes.

II Methodology

Following Deaton and Muellbauer (1980), we define the alcohol expenditure function as

(1) $$e(p, v) = a(p) + b(p)v$$

where, v is the utility and a(p) and b(p) can be regarded as the expenditures costs on subsistence and bliss respectively defined as:

(2) $$a(p) = \alpha_0 + \sum_{i=1}^{N} a_i \ln(P_i) + (1/2) \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma^*_{ij} \ln P_i \ln P_j$$

(3) $$b(p) = \beta_0 \prod P_i^{\beta i} = \beta_0 P_1^{\beta 1} P_2^{\beta 2} P_3^{\beta 3} \ldots\ldots$$

[1] A comprehensive discussion of the error correction mechanism is given in Hendry, Pagan and Sargan (1984) and Engle and Granger (1987).

where, the i^{th} commodity price is denoted by P_i and γ^*_{ij} is the parameter on the natural log of the i^{th} commodity price and the natural log of the j^{th} commodity price. Applying Shepards Lemma to the expenditure function (i.e. differentiating with respect to P_i), the expenditure shares (S^*_i) on each type of alcoholic beverage are:

$$(4) \quad S^*_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_i + \beta_i \ln(C^*/P) + u_i$$

where, γ_{ij} is the parameter on the log of the j^{th} commodity price, u_i is a disequilibrium (or error) term, and β_i is the parameter on the log of total alcohol expenditure (C^*) divided by P where P is the price index given by:

$$(5) \quad \ln P = \alpha_0 + \sum_{i=1}^{N} \ln(P_i) + (1/2) \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \ln P_i \ln P_j$$

$$\text{and } \gamma_{ij} = 1/2(\gamma^*_{ij} + \gamma^*_{ji})$$

To satisfy the properties of demand functions that are adding up, homogeneity and symmetry, the following restrictions were imposed.
To satisfy the properties of demand functions restrictions such as aggregation, homogeneity and symmetry have to be imposed. Engel aggregation implies $\sum_{i=1}^{N} \beta_i = 0$ while Cournot aggregation implies $\sum_{i=1}^{N} \gamma_{ij} = 0$ while further adding up implies $\sum_{i=1}^{N} a_i = 1$. These conditions can be imposed by not estimating one of the equations in the system. Homogeneity implies $\sum_{j=1}^{N} \gamma_{ij} = 0$ while symmetry implies $\gamma_{ij} = \gamma_{ji}$. However the γ_{ij} estimated are not the parameter estimates from the Slutsky matrix, so that negativity cannot be imposed in an AIDS model.

The Marshallian price and expenditure elasticities are measured respectively as:

$$(6) \quad \varepsilon^M_{ij} = -\delta + \frac{\gamma_{ij}}{S_i} - \frac{\beta_i}{S_i} S_j$$

$$(7) \quad \eta_i = 1 + \frac{\beta_i}{S_i}$$

where, δ is the Kronecker delta defined equal to 1 if $i = j$ and 0 if $i \neq j$.

The AIDS specification is the most popular approach used in modelling demand systems in the last 20 years. For example, during the period 1980-1991, Buse (1994) reports that 89 empirical applications used the AIDS in demand studies and of these six have looked at alcohol demand: Thom (1984), Jones (1989), Gao, Wailes and Cramer (1995), Nelson and Moran (1995), Andrikopoulous, Brox and Carvalho (1997) and Blake and Neid (1997). The success in the application of this static AIDS model relies on the stability of the estimated parameters. However, previous empirical evidence suggests that for most products prices and expenditure shares are unit roots and thus in the absence of cointegration, parameter estimates - and, by definition, elasticity estimates - are spurious.

The static AIDS specification ignores potential significant short-run elasticity measures that differ from the long-run estimates. Moreover, in the context of tax policy and business strategy, decision-makers are more likely to be more concerned with short-run elasticity estimates and the speed to which these estimates reach their long-run level.

A dynamic version of the AIDS model that incorporates such short-run estimates is an error correction representation of the AIDS model.[2] This form allows for disequilibrium in the short-run by treating the error term u_i in (4) as the equilibrium error. This error term then ties the short-run behaviour of the dependent variable to its long-run value. We therefore define the long-run equilibrium as the AIDS solution as given by equation (4), with the disequilibrium (or error term) u given by:

$$(8) \quad S^*_i - \alpha_i - \sum_{j=1}^{N} \gamma_{ij} \ln P_i - \beta_i \ln(C^*/P) = u$$

where, u is assumed to be a white noise stationary series process. Therefore, a general version of the dynamic AIDS (assuming one lag in the DGP) is given by:

$$(9) \quad \Delta S^*_{it} = \delta_0 + \delta_i \Delta S^*_{it-1} + \sum_{j=1}^{N} \gamma_{1ij} \Delta \ln P_{jt} + \sum_{j=1}^{N} \gamma_{2ij} \Delta \ln P_{jt-1} + \beta_1 \Delta \ln(C^*/P)_t + \beta_2 \Delta \ln(C^*/P)_{t-1} + \lambda_i u_{it-1} + \gamma_t$$

or equivalently as:

$$(9a) \quad \Delta S^*_{it} = \delta_0 + \delta_i \Delta S^*_{it-1} + \sum_{j=1}^{N} \gamma_{1ij} \Delta \ln P_{jt} + \sum_{j=1}^{N} \gamma_{2ij} \Delta \ln P_{jt-1} + \beta_1 \Delta \ln(C^*/P)_t$$

[2] Karagiannis, Katranidis and Velentzas (2000) propose a similar dynamic form of the AIDS in their estimation of the demand for meat in Greece.

$$+ \beta_2 \Delta \ln(C^*/P)_{t-1} + \lambda_i \left[S^*_i - \alpha_i - \sum_{j=1}^{N} \gamma_{ij} \ln P_j - \beta_i \ln(C^*/P)\right]_{t-1} + \gamma_t$$

where Δ represents the first difference operator, ΔS_{it-1} captures consumer habits, u_{it-1} is the estimated residuals lagged from the AIDS cointegrating equation, $\lambda_i < 1$ (for stability) and S^*_i and C^* are defined as before. The parameter λ_i measures the speed of adjustment to the long-run equilibrium, for example, if $\lambda_i = 1$ adjustment is instantaneous. Estimates of short-run elasticities are obtained by using (6) and (7) and the estimated parameters of (9).

Estimation of the long-run equilibrium requires defining the expenditure shares S^*_i and nominal expenditure C^* in (4). We propose three versions of the demand system depending on the definitions of S^*_i and C^* as they relate to individuals' budgeting for alcoholic drinks.[3]

Definition 1 models the share of expenditure on alcoholic drinks in terms of total alcohol expenditure:

$$\text{(10a)} \quad S_{1it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \beta_i \ln(C_a/P_a)_t + u_{it}$$

$i = 1,\ldots,N$ (beer, spirits, wine)

$j = 1,\ldots.,N$ (beer, spirits, wine)

where

$C_a = \sum_{i=1}^{N} C_{it}$, where C_{it} is the expenditure on the i[th] alcoholic drink out of N at time t,

$S_{1it} = C_{it}/C_{at}$ = share of expenditure on i[th] alcoholic drink in total alcohol expenditure at time t.

P_a = price index of alcohol.

P_{it} = retail price of i[th] alcoholic drink at time t.

Definition 2 is given by the demand equations for the individual alcoholic drinks depending directly on aggregate consumption:

$$\text{(10b)} \quad S_{2it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \gamma_{i,N+1} \ln P_{ot} + \beta_i \ln(C/P)_t + u_{it}$$

where

[3] Blake and Neid (1997) provides a detailed discussion of system-wide versions of the AIDS.

S_{2it} = C_{it}/C_t = share of expenditure on i^{th} alcoholic drink in total personal consumption at time t.

P_o = price index of other goods.

C/P = total personal consumption in real terms.

Definition 3 models the demand for alcoholic drinks as depending directly on personal disposable income:

$$(10c) \quad S_{3it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \gamma_{i,N+1} \ln P_{ot} + \beta_i \ln(Y/P)_t + u_{it}$$

where

S_{3it} = C_{it}/Y_t = share of expenditure on i^{th} alcoholic drink in personal disposable income at time t.

Y/P = personal disposable income in real terms.

As with (4), demand theory implies a number of restrictions on equations (10a-c). Adding up implies:

$$(11) \quad \sum_{i=1}^{N} a_i = 1 \, , \quad \sum_{i=1}^{N} \gamma_{ij} = \sum_{i=1}^{N} \beta_i = 0$$

This can be imposed by not estimating one of the equations. In the case of (10a) we choose the Nth drink equation while in (10b) and (10c) we choose the equation relating to all other goods.

Further, homogeneity and symmetry requires, respectively:

$$(12) \quad \sum_{j=1}^{N} \gamma_{ij} + \gamma_{i,N+1} = 0$$

$$(13) \quad \gamma_{ij} = \gamma_{ji}$$

where $\gamma_{i,N+1}$ = 0 in (10a).

Consumer demand estimates for alcohol in Ireland are quite numerous (see for example, Madden, 1993) but there is limited number of studies which dissaggregate total alcohol demand in Ireland and analysed the consumption pattern of the different beverages (see for example, Thom, 1984). Also, a number of international studies have used the static

AIDS specification (Jones, 1989; Nelson and Moran, 1995; Gao *et al*., 1995; Andrikopoulous, Box and Carvalho, 1997). In contrast, Johnson, Oksanen, Veall and Fretz (1992) use an unrestricted error correction mechanism (ECM) to estimate short-run and long-run elasticities for Canadian alcohol data. However, unlike the other studies, Johnson *et al*. (1992) methodology does not incorporate a theoretical underlying demand system model.

More recently, Blake and Neid (1997) employed three system-wide versions of the static AIDS to derive time series estimates of the equations determining the demand for alcohol in the UK. Their estimation incorporates non-economic variables such as advertising, licensing, demographics and weather into demand equations provided they were the significant at the 5% level.[4]

Table 1 presents the point demand elasticity estimates for alcohol reported in a wide range of studies and thus provide a comparison of demand elasticities for beer, wine and spirits. A broad range of elasticity estimates are reported, possibly explained by consumption patterns across countries, the use of different estimation techniques and the period under study.

The own price elasticities of Walsh and Walsh (1970) are rejected in favour of the more robust functional form of Thom (1984). We use Thom's estimates as *a priori* expectation of the elasticities for beer, spirits and wine. Similar to the British results, Thom (1984) reports the demand for beer to be inelastic. In contrast, for the majority of British studies, spirits are also found to be inelastic, whereas Thom (1984) and Blake and Neid (1997) find spirits to be elastic. Thom (1984) report that wine is very responsive to price changes, which contrast with the findings of the British studies which report wine to be inelastic (though close to absolute unity).

Elasticity estimates from other countries report similar qualitative findings. The US, Canada and Australia report low price elasticities (i.e., very inelastic) ranging from -0.08 to -0.48 for beer, -0.01 to -0.61 for spirits and -0.05 to -0.6 for wine (excluding Johnson *et al*., 1992). These are somewhat similar to low estimates from Britain (excluding Blake and Neid, 1997).

Expenditure (income) elasticity estimates suggest that beer is a necessity while both spirits and wine are luxuries. However, the variation in these points estimates suggest that these elasticity estimates appear to be very poorly determined, which greatly increases the uncertainty facing both alcohol suppliers and government in strategic decision making.

[4] Blake and Neid (1997) concluded that these non-economic variables greatly improved the explanatory power of the demand equations.

III Data

The data is annual covering the period 1960 through to 1998. Personal expenditure levels and prices for total alcohol and its components, beer, spirits and wine were obtained from the National Income and Expenditure Accounts of the Irish Central Statistics Office (CSO). Constant prices have been calculated using 1995 as the base year. Total personal expenditure and gross national disposable income at both current and constant (at 1995 prices) market prices were obtained from the National Income and Expenditure Accounts. Personal expenditure per capita was calculated using population figures from those of over 15 years of age, obtained from the CSO population database.

Non-economic variables include climate variables such as annual mean daily sunshine, annual mean daily rainfall, mean daily air temperature and mean daily summer (June, July and August) air temperature, and also a demographic variable, that is 15-24 year olds as a percentage of population over 15. The climate variables were obtained from the CSO Statistical Abstract (various issues) while the population variable was obtained from the CSO population database in Dublin. Definitions of the variables being used are provided in the Appendix.[5]

IV Empirical Results

In estimating the three versions of the AIDS model, given by equations (10a)-(10c), we first carry out a statistical evaluation of the variables used in the models. Using standard augmented Dickey-Fuller (ADF) tests (Dickey and Fuller, 1981), all variables in levels are found (at acceptable levels of significance) to be first-difference stationary, with the exception of the weather variables that are stationary in levels.[6]

An iterative seemingly unrelated regression (ISUR) procedure is employed to estimate regressions (10a)-(10c). This procedure adjusts for cross-equation contemporaneous correlation and consequently takes into account the optimisation process behind the demand system.[7] The results of the parsimonious estimation of these equations are presented in Table

[5] The expenditure (at constant prices) in alcohol, as a percentage of personal expenditure has fallen from 10.5% in 1960 to 8.1% in 1998. In 1960, of the expenditure in alcohol, 75% was on beer, 23% on spirits and 2% on wine. This breakdown has changed considerably over the last three decades; in 1998, Irish expenditure on alcohol was divided among beer (65%), spirits (19%) and wine (16%). To conserve space the data is not presented in this paper but is available from the authors on request.

[6] Some of the price and population variables are found to be near I(2) in our sample. However, given the low power of the ADF test in small samples these variables will be treated as I(1), as they are also *a priori* expected to be first difference stationary. To conserve space these are not reported in the paper but are available by request from the authors.

[7] Since SUR is sensitive to the excluded equation (in our case the wine equation), ISUR is used instead of SUR, as the process of iteration ensures that the obtained estimates asymptotically approach those of the maximum likelihood method (see Judge, Griffiths, Hill, Lutkepohl and Lee, 1980).

2. For each definition, the three alcoholic drinks have estimations from two regressions, associated with and without non-economic variables in the regressions.

In general, the equations including non-economics variables perform better in terms of goodness of fit, stationarity of the residuals and diagnostic tests. In each equation, the R^2 (bar) is higher when non-economic variables are included. Similarly the presence of serial correlation while still remaining a problem in some equations is reduced. Finally stationarity of the residuals can be established at higher levels of significance when non-economic variables are included.

The results are similar across the three versions of the AIDS model. The own-price estimates for beer and spirits indicate a positive relationship with their shares, and, conversely, the own-price estimate for wine gives a negative relationship.

Independent of the form of AIDS model chosen, the results from the beer regressions are robust to the inclusion of non-economic data. For each of the alternative AIDS models, the own-price estimates for beer and spirits indicate a positive relationship with their shares. Conversely, the own-price estimate for wine gives a negative sign. Also evident are the cross-price and expenditure effects associated with the three alcoholic products. The results are similar to Blake and Neid (1997).

Of the non-economic variables the young population variable (i.e., ln(15-24)) is significant at the 10% level in most of the regressions and to a lesser degree the weather variables enter the parsimonious regressions. For example, one interesting result comes from Table 2 (definition 1) which shows the almost one for one trade off between beer and spirits with changes in summer temperature (ln(sumtemp)). A 1^{o}C increase in the year's mean summer temperature would result in a 13% increase in the beer share in total alcohol and a 13.5% decrease in the spirits share in total alcohol.

Since all the economic variables enter the regressions in level form (although they are all first difference stationary), interpreting the results from these regressions relies on the stationarity of the residuals. The standard augmented Dickey Fuller (ADF) test with various lags on the residuals of the equations (10a)-(10c) are employed to test for the stationarity of the residuals. Under definition 1, both the beer and spirits equations (including non-economic variables) are stationary at 5% and 10% levels of significance, respectively, while the wine equation was stationary at higher levels of significance. For definition 2, the three alcohol equations are stationary, the beer and wine equations at 10% and the spirits at 1% level of significance. Finally, in the case of definition 3, stationarity existed in the spirits equation at 1% level of significance and in the wine equation at 5% level of significance while in the beer equation stationarity could only be established at higher levels of significance.

Table 3 reports the computed long-run point elasticity estimates from the static AIDS, expressed in equations (6) and (7). Taking the estimates from the equations that include non-economic variables, the own-price elasticities range from -0.42 to -0.76 for beer, from -0.68 to -0.92 for spirits and from -1.38 to -1.95 for wine. This means beer and spirits are price inelastic while wine is price elastic. The expenditure elasticities range from 0.77 to 1.02 for beer, 0.81 to 1.04 for spirits and 1.78 to 2.33 for wine and they indicate that beer and spirits are necessities while wine is a luxury. The expenditure point estimates, 1.02 for beer and 1.04 for spirits have wide confidence intervals given that the expenditure variable, ln(C/P) is insignificant at the 10% level. Our estimates are similar to Thom (1984) estimates and Blake and Neid (1997) UK estimates, in particular with regard to beer and wine price elasticity and the three expenditure elasticities. In comparison to other studies (as shown in Table 1), our price elasticity results are less price inelastic, but are however, more in line with a priori expectations. The expenditure elasticities fall within the broad spectrum of these studies.

A final set of tests surround the homogeneity and symmetry restrictions imposed in the AIDS, as given in equations (12) and (13), respectively. Table 2 shows our Wald chi-squared statistic for homogeneity alone, symmetry alone and homogeneity and symmetry together. The results of the tests show that homogeneity and symmetry are rejected for all our systems of equations except for definition 1 version of the AIDS with non-economic variables excluded. These results are similar to most international studies that have used aggregate data, including Blake and Nied (1997) and, in the case of Ireland, Madden (1993) who tested these restrictions on a wide range of Irish commodities. It is interesting to note that in most cases the equations excluding non-economic variables perform better under homogeneity and symmetry. This is *a priori* expected given that non-economic variables should not be robust to the imposition of demand theory restrictions.

V Dynamic AIDS

The preferred long-run equilibrium model to use for the dynamic AIDS is based on a selected range of criterion, which can be obtained from the above estimation and testing, that is Tables 2 and 3. Our criterion is as follows; first, we look at how well do the three specifications perform when demand theory is applied, in particular do the estimated elasticities imply a downward sloping demand curve for alcohol. Looking at our calculated long run elasticities we see that all imply a downward sloping demand curve. Table 2 indicates that the symmetry and homogeneity restrictions are accepted in the case of definition 1 of the AIDS model, and are only accepted at higher levels of significance for the two other versions of the AIDS model.

Second, we look at various diagnostic tests obtained from the regressions such as goodness of fit, serial correlation, etc. From this it appears that definitions 2 and 3 are the preferred options here especially looking at serial correlation and the residual sum of squares.

Third, we consider which model indicates a stationary (long-run) relationship between the dependent and explanatory variables, i.e. whether the residuals are stationary. The only version of the AIDS model that satisfies the stationarity condition for the three alcohol equations is definition 2. Stationarity is only significant at a significance level greater than 10% for the wine equation under definition 1 and for the beer equation under definition 3.

Overall, all three versions of the static AIDS model perform well and give acceptable results such that any one of the three could be used for estimating a dynamic form. We choose definition 2 as the preferred model[8] mainly because the three alcohol equations are more strongly stationary which is necessary condition in estimating the dynamic error correction process. Another important reason for choosing definition 2 over 1 or 3 is that it uses consumption expenditure data, which is a preferable to disposable income to use in a demand system like the AIDS.

The disequilibrium of the static AIDS model - definition 2 version - will enable us to reconcile the short run behaviour of the demand for the individual beverages with their long-run behaviour. Using (9), the equations that will be estimated are as follows:

$$(14)\quad \Delta S_{2b,t} = \alpha_{1b} + \alpha_{2b}\Delta S_{2b,t-1} + \gamma_{b0}\Delta \ln P_{b,t} + \gamma_{b1}\Delta \ln P_{b,t-1} + \gamma_{s0}\Delta \ln P_{s,t} + \gamma_{s1}\Delta \ln P_{s,t-1} + \gamma_{w0}\Delta \ln P_{w,t} + \gamma_{w1}\Delta \ln P_{w,t-1} + \beta_{b0}\ln P_{o,t} + \beta_{b1}\ln P_{o,t-1} + \delta_{b0}\Delta \ln(C/P)_t + \delta_{b1}\Delta \ln(C/P)_{t-1} + 2_{b1}\ln sun_t + 2_{b2}\ln rain_t + \lambda_b u_{b,t-1} + \gamma_t$$

where $u_{b,t-1}$ is the estimated residuals lagged one period from the definition 2 version of the AIDS beer equation

$$(15)\quad \Delta S_{2s,t} = \alpha_{1s} + \alpha_{2s}\Delta S_{2s,t-1} + \gamma_{b0}\Delta \ln P_{b,t} + \gamma_{b1}\Delta \ln P_{b,t-1} + \gamma_{s0}\Delta \ln P_{s,t} + \gamma_{s1}\Delta \ln P_{s,t-1} + \gamma_{w0}\Delta \ln P_{w,t} + \gamma_{w1}\Delta \ln P_{w,t-1} + \beta_{s0}\Delta \ln P_{o,t} + \beta_{s1}\Delta \ln P_{o,t-1} + \delta_{s0}\Delta \ln(C/P)_t + \delta_{s1}\Delta \ln(C/P)_{t-1} + 2_{s1}\delta_1 \ln rain_t + 2_{s2}\Delta \ln(15\text{-}24)_t + 2_{s3}\Delta \ln(15\text{-}24)_{t-1} + \lambda_s u_{s,t-1} + \gamma_t$$

where $u_{s,t-1}$ is the estimated residuals lagged one period from the definition 2 version of the AIDS spirits equation.

$$(16)\quad \Delta S_{2w,t} = \alpha_{1w} + \alpha_{2w}\Delta S_{2w,t-1} + \gamma_{b0}\Delta \ln P_{b,t} + \gamma_{b1}\Delta \ln P_{b,t-1} + \gamma_{s0}\Delta \ln P_{s,t} + \gamma_{s1}\Delta \ln P_{s,t-1} + \gamma_{w0}\Delta \ln P_{w,t} + \gamma_{w1}\Delta \ln P_{w,t-1} + \beta_{w0}\Delta \ln P_{o,t} + \beta_{w1}\Delta \ln P_{o,t-1} + \delta_{w0}\Delta \ln(C/P)_t + \delta_{w1}\Delta \ln(C/P)_{t-1} + 2_{w1}\Delta \ln(15\text{-}24)_t + 2_{w2}\Delta \ln(15\text{-}24)_{t-1} + \lambda_w u_{w,t-1} + \gamma_t$$

[8] We also estimate the dynamic form of the AIDS model under definitions 1 and 3. To conserve space these are not reported in the paper but are available by request from the authors.

where $u_{w,t-1}$ is the estimated residuals lagged one period from the definition 2 version of the AIDS wine equation

In the equations above the first-difference terms on the right hand side capture the short-run disturbances in the respective shares of the individual drinks in total personal expenditure. We include current values and a lagged value for the changes in prices, changes in expenditure and changes in population variables to determine whether past or present values are significant in determining the short run disturbances of the individual drinks. In estimation, a parsimonious form of equations (14)-(16) is reported.

The error correction term u_i where i = beer, spirits and wine, captures the long-run equilibrium relationship, given by the standard AIDS equation, and λ_i captures the speed of adjustment toward the long-run equilibrium. If λ_i is large or closer to one in absolute value then there is a rapid adjustment, i.e. the disturbance quickly disappears and we are back along the long run path. The smaller that λ_i is the slower the adjustment back to long run equilibrium. In estimating the dynamic AIDS all variables in equations (14)-(16) must be stationary. Our climate variables in the beer and spirits equation are entered in level form since they are I(0), i.e. they are stationary in levels.

The dynamic AIDS is estimated using an ISUR procedure, and the results for the system are given in Table 4. Both beer and spirits equations give satisfactory results with most of the variables significant at 10% levels, the R^2 are high and the equations pass all of the diagnostic tests. Our beer gives a value for λ as -0.4022. This means that 40% of the disturbance to the long-run equilibrium in the previous period is corrected or adjusted back to long-run equilibrium in this period. The spirits error correction term (-0.9195) indicates that consumers are able to adjust spirits consumption to long run equilibrium considerably faster. 90% of the disturbance is corrected or adjusted back to that long-run equilibrium path within one period. Looking to our wine equation we see that most of the estimates are insignificant at the 10% level. The R^2 is also very low but it still passes all diagnostic tests. The error correction term (significant at the 12% level) indicates that approximately one-third of the disturbance to the long-run equilibrium path is corrected within the next period.

The short run point elasticities were calculated using (6) and (7) and are presented in Table 7 along with the estimated range for our long run point elasticities. They indicate that beer is price inelastic while spirits and wine are price elastic. Beer and spirits are found to be necessities in the short run while wine is a luxury. Using the calculated long-run and short-run point elasticities and also the calculated error correction term we are now able to interpret the pattern of demand for the individual drinks.

Looking at the short-run pattern of the demand for beer we estimate a price elasticity of -0.581. This lies within the range given for the long-run elasticities therefore there exists small changes in the price response between the short and long run. The short-run expenditure elasticity of 0.144 is minimal and less than that of the long run expenditure elasticity, hence there is less of a response to expenditure changes in the short run than over the long run. The short-run own price elasticity for spirits is given as -1.2155, which indicates that spirits is price elastic in the short run. In the long run, spirits are price inelastic, this implies a change in demand behaviour for spirits when moving from the short to the long run. Also given the fact that the speed of adjustment back to the long run equilibrium is very rapid (as given by $\lambda_{spirits} = -0.9195$) then the behaviour of spirits demand changes quickly from being price elastic to being price inelastic, that is, the long-run elasticity[9]. The expenditure elasticity lies within the range given by the long run elasticities so again there are small changes in the expenditure response between the short and long run. Finally wine has short-run elasticities indicating it to be price elastic and expenditure elastic in the short run, a result which is of similar magnitude to its long run behaviour. The long-run wine elasticities are slightly larger in absolute value indicating that responses to changes in price and expenditure are slightly more sensitive over the long run.

VII Conclusions

This paper uses three versions of Deaton and Muellbauer 's AIDS model to calculate long-run elasticities of beer, spirits and wine. The demand theory restrictions and other diagnostic tests all three versions of the static AIDS perform well and the elasticities calculated (excluding some irrational estimates) are acceptable. From calculating our long-run elasticities we find that beer and spirits are price inelastic while wine is price elastic. The own price elasticities range from -0.42 to -0.76 for beer, -0.68 to -0.92 for spirits and -1.38 to -1.95 for wine. The expenditure elasticities indicate that wine is a luxury (elasticity measure range from 1.78 to 2.33) while both beer (0.77 to 1.02) and spirits (0.81 to1.04) are necessities. These point estimates are similar to previous studies (see for example, Thom, 1984, and Blake and Neid, 1997).

In calculating the short-run elasticities we estimated a dynamic error correction form of the AIDS by employing a one-lagged dynamic data generating process. This was achieved by selecting one of the three versions of the AIDS model based on selected criteria, which ranged from demand theory restrictions to the possibility of cointegration between the dependent and independent variables. Definition 2 of the AIDS, which defines the expenditure share as that share of expenditure on each alcoholic drink from the total alcohol expenditure, was taken as the long-run equilibrium model.

[9] The coefficient on the spirits price effect is also insignificant, unlike the case for beer. Therefore the short-run spirits price effect is likely to have wide confidence intervals.

We found that in the short run beer was price inelastic while spirits and wine were price elastic. The expenditure elasticities indicated that beer is a necessity in the short run while spirits and wine were luxuries. This meant that both beer and wine exhibit the same behaviour in the short and long run. However the demand for spirits changes from being price elastic in the short run to be price inelastic in the long run. Moreover using a dynamic generating process we were able to calculate consumers' speed of adjustment and we found that consumers are able to adjust spirits consumption to the long-run equilibrium considerably faster.

Given the significantly high rate of excise duties on alcohol in Ireland, policy implications of the elasticity measures are relevant. Concentrating on the long run elasticities we have already seen that both beer and spirits are price inelastic. This suggest that an increase in price on beer or spirits (due to an increase in excise) will increase tax revenue since the price change will decrease the quantity demanded *ceteris paribus*, but not by as much as the increase in price (tax) and thus increases government revenue. This is all the more important since excises on beer and spirits provide bigger revenue than excises on wine. Note however, the *ceteris paribus* assumption is unlikely to hold in practice. An increase in tax would increase the incentive for suppliers of alcohol to increase the price they charge to consumers in order to cover lower profit margins[10]. The fact that beer and spirits are price inelastic provides the incentive or opportunity for the government and then also the alcohol producers to increase price. Therefore the actual excise increase may in fact result in a reduction in revenue. Hence analysis of consumer demand for alcoholic beverages both in the long run and in the short run and also analysis that incorporates dynamic industry effects is necessary in deriving tax/revenue effects on alcohol. This study goes in some way to supplying such analysis.

The dynamic approach taken in this paper to estimate demand systems has future applications, among others, in agricultural, health and energy economics. The fact that the AIDS model is a very popular makes it easier to apply a dynamic AIDS similar to the one used here.

[10] With additional duty on alcohol, profit margins (as a percentage of price) for alcohol would fall.

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Table 1: Comparison of Demand Elasticities for Beer, Wine and Spirits

		Own price elasticity			Expenditure elasticity		
Study	**Model and period**	**Beer**	**Spirits**	**Wine**	**Beer**	**Spirits**	**Wine**
Ireland							
Thom (1984)	AIDS model 1969(1) to 1980(4)	-0.59 to -0.76	-1.29 to -1.54	-1.61 to -1.60	0.8	1.386	1.23
Walsh and Walsh(1970)	Linear Model 1953-68	0.09	-0.57	-	0.63 to 0.79	1.94 to 2.06	-
Britain							
Blake and Neid (1997)	AIDS model 1952-91	-0.95	-1.32	-0.95	0.89	0.98	1.61
Clements & Selvanathan(1987)	Working's Model 1955-1975	-0.19	-0.24	-0.23	0.41	1.81	1.91
Duffy (1983)	Log-Lin, Lin, Simultaneous Mdls 1963-83	-	0.8 to 1	0.65 to 0.87	0.8 to 1.1	1.6	2.5
Duffy (1987)	Rotterdam Model 1963-83	-0.29	-0.51	-0.77	0.6	1.42	1.7
Jones (1989)	AIDS Model 1964-1983 (Quat)	-0.27	-0.95	-0.77	0.31	1.14	1.15
McGuinness (1983)	Linear Model 1956-1979	-0.18	-0.3	0.38	0.13	1.54	1.11
Selvanathan (1989)	Theil's Differential Approach 1955-1985	-0.2	-0.79	-0.49	0.41	2.18	1.74
Selvanathan (1991)	Rotterdam Model 1955-85	-0.13	-0.31	-0.4	0.52	1.83	1.31
United States							
Gao et al (1995)	AIDS equivalent Model 1987-1989 (cross sectional)	-0.23	-0.40	-0.25	-0.09	5.03	1.21
Nelson & Moran (1995)	Rotterdam, AIDS(1), CBS, NBR 1964-1990	-0.08	-0.08	-0.26	0.79	1.26	1.06
Clements & Selvanathan (1987)	Working's Model 1949-1982	-0.09	-0.1	-0.22	0.75	1.34	0.46
Selvanathan (1991)	Rotterdam Model 1949-1982	-0.11	-0.11	-0.05	0.71	1.36	0.63
Canada							
Andrikopoulous et al (1997)	AIDS Model 1958-1987	-0.48	-0.54	-0.51	0.96	0.083	2.22
Selvanathan (1991)	Rotterdam Model 1953-82	-0.26	-0.01	-0.16	0.71	1.29	0.97
Johnson et al (1992)	Unrestricted ECM						
	long run elasticity	-0.14 to -0.28	0.37 to 0.84	-1.17 to -1.26	0.27 to 0.46	1.02 to 1.27	2.19 to 2.62
	short run elasticity	-0.3	-0.85 to -0.45	-0.88 to -0.70	0.16 to 0.48	1	1
Australia							
Clements & Johnson (1983)	Rotterdam Model 1956-1977	-0.11	-0.53	-0.4	0.75	2.32	0.75
Clements & Selvanathan (1987)	Working's Model 1956-1977	-0.12	-0.52	-0.34	0.73	2.5	0.62
Selvanathan (1991)	Rotterdam Model 1955-85	-0.15	-0.61	-0.6	0.84	1.94	0.73

Notes: (1) Only the estimates from the AIDS model are reported.

Table 2: Iterative Seemingly Unrelated Regression of the Static AIDS Model of Demand for Alcohol in Ireland

Definition 1

$$S_{1it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \beta_i \ln(C_a/P_a)_t + u_{it}$$

Definition 2

$$S_{2it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \gamma_{i,N+1} \ln P_{ot} + \beta_i \ln(C/P)_t + u_{it}$$

Definition 3

$$S_{3it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \gamma_{i,N+1} \ln P_{ot} + \beta_i \ln(Y/P)_t + u_{it}$$

	Definition 1						Definition 2						Definition 3					
	Beer		Spirits		Wine		Beer		Spirits		Wine		Beer		Spirits		Wine	
Intercept	1.036	0.699	0.025	-0.564	-0.046	0.865	0.028	0.033	-0.073	-0.174	-0.033	0.017	0.101	0.042	0.004	-0.130	-0.021	0.170
	(8.395)	(4.237)	(0.144)	(-2.985)			(0.945)	(1.286)	(-2.070)	(-7.215)	(-2.094)	(1.420)	(4.787)	(1.580)	(0.170)	(-7.417)	(-2.576)	(2.509)
LnP_b	0.153	0.159	-0.227	-0.120	0.074	-0.040	0.017	0.013	0.030	-0.018	0.002	-0.007	0.018	0.025	-0.020	-0.004	0.002	-0.003
	(4.094)	(4.598)	(-4.383)	(-3.578)			(2.796)	(2.409)	(-4.093)	(-2.538)	(0.478)	(-3.066)	(3.551)	(4.966)	(-3.161)	(-1.212)	(0.824)	(-2.244)
LnP_s	-0.196	-0.211	0.314	0.088	-0.118	0.123	0.010	0.014	0.043	0.007	-0.007	0.010	0.013	-0.003	0.038	0.001	-0.005	0.005
	(-4.446)	(-5.110)	(5.149)	(1.956)			(1.666)	(2.655)	(6.016)	(1.158)	(-2.123)	(3.342)	(2.655)	(-0.467)	(6.289)	(0.330)	(-2.594)	(3.192)
LnP_w	0.061	0.069	-0.112	-0.003	0.051	-0.066	0.009	0.005	-0.015	-0.001	0.003	-0.004	0.005	0.011	-0.013	0.002	0.002	-0.002
	(2.033)	(2.464)	(-2.685)	(-0.114)			(1.855)	(1.227)	(-2.594)	(-0.148)	(1.119)	(-2.149)	(1.237)	(2.783)	(-2.643)	(0.641)	(1.407)	(-1.936)
LnP_o	-	-	-	-	-	-	-0.035	-0.031	-0.002	0.001	0.002	0.002	-0.032	-0.031	-0.006	-0.002	0.002	0.001
							(-7.002)	(-6.904)	(-0.272)	(0.177)	(0.904)	(1.206)	(-7.880)	(-8.378)	(-1.113)	(-0.925)	(1.039)	(0.704)
Ln (C/P)*	-0.066	-0.067	0.046	-0.023	0.020	0.090	0.003	0.001	0.012	0.001	0.005	0.009	-0.008	-0.010	0.001	-0.004	0.003	0.004
	(-3.330)	(-3.620)	(1.672)	(-1.274)			(0.803)	(0.470)	(2.817)	(0.417)	(2.411)	(6.839)	(-3.243)	(-4.469)	(0.442)	(-2.649)	(3.004)	(7.348)
Ln sumtemp	-	0.130	-	-0.135	-	0.005	-	-	-	-	-	-	-	-	-	-	-	-
		(-2.849)		(-2.954)														
Ln sun	-	-	-	-	-	-	-	0.007	-	-	-	-	-	-	-	-	-	-
								(1.697)										
Ln rain	-	-	-	-	-	-	-	-0.009	-	-0.005	-	-	-	-	-	-	-	-
								(-2.637)		(-1.820)								
Ln 15-24	-	-	-	0.464	-	-0.464	-	-	-	0.067	-	-0.030	-	0.027	-	0.062	-	-0.017
				(9.677)						(9.020)		(-7.366)		(3.124)		(10.815)		(-7.849)
R^2(bar)	0.82	0.85	0.86	0.87	-	-	0.70	0.76	0.85	0.91	0.63	0.78	0.76	0.79	0.76	0.88	0.79	0.89
ADF	-3.72	-3.84	-2.68	-3.42	-1.58	-2.83	-3.33	-3.37	-2.28	-4.65	-1.70	-3.30	-1.87	-3.03	-2.17	-5.46	-2.28	-3.56
		[3]	[3]	[3]	[3]	[3]	[1]	[1]	[1]	[1]	[5]	[5]	[3]	[1]	[5]	[1]	[5]	[1]
AUTO[1]	13.42	10.46	21.94	18.32	-	-	9.96	4.44	14.31	3.62	29.13	16.50	13.01	8.81	18.48	9.32	22.59	9.19
HETERO[1]	0.28	0.39	11.35	9.22	-	-	2.15	0.98	1.72	0.11	11.72	14.37	0.51	0.23	6.07	0.00	10.21	5.34

	Non-economic variables excluded	Non-economic variables included	Non-economic variables excluded	Non-economic variables included	Non-economic variables excluded	Non-economic variables included
Homogeneity	5.569	28.629	9.567	59.247	32.755	123.809
Symmetry	7.196	11.711	30.183	23.219	36.088	17.008
Homogeneity and Symmetry	10.408	226.291	75.887	121.515	48.040	136.623

Notes: For Definition 1, the wine equation is not estimated, rather the parameters are calculated to ensure the adding up restriction hold. The estimates in this table are based on an Iterative Seemingly Unrelated Regression (ISUR). t-statistics are in parentheses. Lag lengths and degrees of freedom for the diagnostic tests are reported in brackets. The period of under study is 1960-98. i ,j = beer, spirits, wine. Tests for the homogeneity and Symmetry restrictions are a Wald test distributed Π^2 (3) and jointly tested with a Π^2 (6) distribution. See Appendix for definition of variables and terms.

Table 3: Estimates of Demand Elasticities

		Definition 1		Definition 2		Definition 3	
		Excl	Incl	Excl	Incl	Excl	Incl
Own-Price	Beer	-0.69	-0.68	-0.70	-0.77	-0.58	-0.42
	Spirits	0.01	-0.68	0.57	-0.75	0.84	-0.93
	Wine	-0.36	-1.95	-0.58	-1.59	-0.60	-1.39
Income	Beer	0.89	0.89	1.05	1.03	0.83	0.77
	Spirits	1.15	0.92	1.43	1.04	1.06	0.82
	Wine	1.26	2.18	1.67	2.33	1.51	1.78

Notes: Figures derived from the regressions results reported in Table 2. Excl refers to the estimated regressions that exclude non-economic variables and Incl refers to the estimated regressions that include non-economic variables.

Table 4: Dynamic AIDS Modelling

Definition 2

$$\Delta S_{2i,t} = \alpha_{1i} + \alpha_{2i}\,\Delta S_{2i,t-1} + \sum_{j=0}^{1}\sum_{i}\gamma_j \Delta \ln P_{i,t-j} + \sum_{j=0}^{1}\beta_j \ln P_{o,t-j} + \sum_{j=0}^{1}\delta_j \Delta \ln (C/P)_{t-j} + 8_i u_{i,t-1} + \gamma_t$$

	Beer		Spirits		Wine	
	Parsimonious	Non-Parsimonious	Parsimonious	Non-Parsimonious	Parsimonious	Non-Parsimonious
Intercept	-0.008	-0.011	0.029	0.019	-0.015	-0.018
	(-1.430)	(-0.492)	(2.441)	(1.191)	(-3.158)	(-2.250)
$\Delta S_{2i,t-1}$	-0.155	-0.201	-0.045	0.010	-0.010	-0.061
	(-1.632)	(-1.229)	(-0.459)	(0.088)	(-0.856)	(-0.394)
$\Delta \ln P_{b,t}$	0.024	0.021	-	-0.004	-0.001	-0.002
	(4.039)	(2.649)		(-0.807)	(-0.849)	(-0.695)
$\Delta \ln P_{b,t-1}$	-	0.009	0.006	0.009	-	-0.001
		(1.098)	(2.185)	(1.766)		(-0.428)
$\Delta \ln P_{s,t}$	0.020	0.021	0.004	0.009	-	0.001
	(3.042)	(1.974)	(1.125)	(1.224)		(0.225)
$\Delta \ln P_{s,t-1}$	-	-0.004	-	-0.005	-0.001	-0.001
		(-0.397)		(-0.724)	(-0.737)	(-0.324)
$\Delta \ln P_{w,t}$	-	0.002	-	-0.002	0.001	0.001
		(0.448)		(-0.764)	(1.991)	(0.634)
$\Delta \ln P_{w,t-1}$	-0.004	-0.003	-0.004	-0.004	-	-0.0003
	(-1.600)	(-0.706)	(-2.226)	(-1.508)		(-0.186)
$\Delta \ln P_{o,t}$	-0.048	-0.041	-0.010	-0.006	-0.002	-0.003
	(-7.057)	(-3.368)	(-2.294)	(-0.737)	(-0.844)	(-0.591)
$\Delta \ln P_{o,t-1}$	-	-0.010	-	0.001	-	0.003
		(-0.702)		(0.055)		(0.590)
$\Delta \ln(C/P)_t$	-0.047	-0.037	-0.029	-0.024	-	0.0002
	(-4.596)	(-2.258)	(-3.827)	(-2.063)		(0.035)
$\Delta \ln(C/P)_{t-1}$	-	-0.007	0.025	0.018	0.006	0.006
		(-0.480)	(3.558)	(1.793)	(2.068)	(1.114)
$Lnsun_t$	0.012	0.010	-	0.003	-0.004	-0.002
	(3.454)	(2.138)		(0.988)	(-4.111)	(-1.459)
$Lnrain_t$	-0.004	-0.005	-0.009	-0.007	-	0.001
	(-1.576)	(-1.270)	(-4.800)	(-2.466)		(0.674)
$Lnsumtemp_t$	-	0.003	-0.008	-0.010	0.007	0.008
		(0.274)	(-1.829)	(-1.453)	(4.058)	(2.380)
$Lntemp_t$	-	-0.001	-	0.004	-	-0.001
		(-0.055)		(0.669)		(-0.189)
$\Delta \ln(15\text{-}24)_t$	-	0.027	0.043	0.044	-	-0.007
		(0.833)	(3.324)	(1.933)		(-0.616)
$\Delta \ln(15\text{-}24)_{t-1}$	-	-0.030	-	-0.015	-	0.005
		(-0.963)		(-0.659)		(0.447)
$u_{i,t-1}$	-0.346	-0.406	-0.691	-0.813	-0.183	-0.197
	(-2.421)	(-2.217)	(-5.436)	(-5.708)	(-1.664)	(-1.333)
R^2(bar)	0.897	0.734	0.601	0.542	0.430	0.260
AUTO[1]	0.419	0.419	0.014	0.293	0.316	0.353
HETRO[1]	0.010	2.153	0.206	0.383	0.699	0.074

Notes: Results are based on Defintion 2 of the dynamic AIDS model, equations (14)-(16). The estimates in this table are based on an Iterative Seemingly Unrelated Regression (ISUR). t-statistics are in parentheses. Degrees of freedom for the diagnostic tests are reported in brackets. i = beer, spirits, wine. The period of under study is 1960-98. See Appendix for definition of variables and terms.

Table 5: Estimates of Long- and Short-Run Demand Elasticities

		Long Run	Short Run
Own-Price	Beer	-0.765	-0.527
	Spirits	-0.751	-0.851
	Wine	-1.593	-0.796
Income	Beer	1.026	0.157
	Spirits	1.039	0.856
	Wine	2.326	1.862

Notes: Figures derived from the parsimonious regressions results reported in Table 4.

Appendix

List of the data symbols considered in the empirical analysis.

$\mathbf{S_{1b}}$	Share of personal expenditure (nominal) per capita on beer in total personal expenditure (nominal) per capita on alcohol.
$\mathbf{S_{1s}}$	Share of personal expenditure (nominal) per capita on spirits in total personal expenditure (nominal) per capita on alcohol.
$\mathbf{S_{1w}}$	Share of personal expenditure (nominal) per capita on wine in total personal expenditure (nominal) per capita on alcohol.
$\mathbf{S_{2b}}$	Share of personal expenditure (nominal) per capita on beer in total personal expenditure (nominal) per capita.
$\mathbf{S_{2s}}$	Share of personal expenditure (nominal) per capita on spirits in total personal expenditure (nominal) per capita.
$\mathbf{S_{2w}}$	Share of personal expenditure (nominal) per capita on wine in total personal expenditure (nominal) per capita.
$\mathbf{S_{3b}}$	Share of personal expenditure (nominal) per capita on beer in national disposable income (nominal) per capita.
$\mathbf{S_{3s}}$	Share of personal expenditure (nominal) per capita on spirits in national disposable income (nominal) per capita.
$\mathbf{S_{3w}}$	Share of personal expenditure (nominal) per capita on wine in national disposable income (nominal) per capita.
$\mathbf{LnP_b}$	Natural log of the retail price of beer (1995 = 100).
$\mathbf{lnP_s}$	Natural log of the retail price of sprits (1995 = 100).
$\mathbf{lnP_w}$	Natural log of the retail price of wine (1995 = 100).
$\mathbf{ln(C_a/P_a)}$	Natural log of per capita real personal consumption expenditure on total alcohol (1995 prices).
ln(C/P)	Natural log of per capita real personal consumption expenditure (1995 prices).
ln(Y/P)	Natural log of per capita real national disposable income (1995 prices).
$\mathbf{lnP_o}$	Natural log of the retail price of other goods (1995 = 100).
lnsun	Natural log of mean daily sunshine.
lnrain	Natural log of mean daily rainfall.

lntemp Natural log of mean daily temperature.

lnsumtemp Natural log of mean daily summer (June, July and August) temperature.

Ln(15-24) Natural log of the percentage of 15-24 year olds in the population over the age of 15.

Definition of the individual alcoholic drinks

Beer Includes stout, ale and lager.

Spirits Includes whiskey, gin rum, brandy and other spirits.

Wine Includes cider and perry.

Definition of the diagnostic tests

RSS Residual sum of squares.

MEAN Mean of the dependent variable.

AUTO[1] Lagrange multiplier statistic for residual autocorrelation ($\chi 2$ distributed with 1 degree of freedom; 5% critical value = 3.84).

HETERO[1] Langrange multiplier test for heteroscedasticity of the residuals based on a regression of squared residuals on squared fitted values ($\chi 2$ distributed with 1 degree of freedom).

ADF[n] Augmented Dickey-Fuller unit root test statistic on the residuals of the estimated regression. The ADF is based on

$$\Delta x_t = \alpha + \beta x_{t-1} + \gamma Time + \sum_{j=1}^{n} \delta_j \Delta x_{t-j} + v_t$$

where x_t denotes the residuals of the regression and [n] denotes lag length to ensure v_t is white noise. The critical values for stationarity of the residuals are (-3.53 at the 5% level and -3.21 at the 10% level).