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THE DEMAND FOR BEER AND SPIRITS IN IRELAND

By

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ABSTRACT

This paper is primarily an attempt to estimate econometric demand equations for beer and spirits in Ireland, but it is hoped that it also sheds light on some of the general considerations involved in empirical demand analysis. The results, taken in conjunction with earlier studies, suggest that certain variables, in addition to price and income, play a significant role in such demand analysis in Ireland. A useful variable in this context is the dependency ratio, which measures changes in the age structure of the population. The results also support the thesis that dynamic elements are of considerable importance in demand theory. The most serious technical problem encountered in the study was the high degree of multicollinearity in the explanatory variables. It emerged that some of the conventional rules of thumb normally used for identifying the existence of this problem failed to exercise sufficient discrimination, and this provides a salutary lesson.

1 Introduction

In a recent paper Walsh and Walsh (1970) examined alcohol consumption in Ireland from an economic point of view. Although the paper ranged over a number of issues, not the least of which was the question of the extent of Irish consumption in the light of international experience, our present concern is with their attempt to fit demand equations for beer and spirits. The results of this attempt were suggestive rather than conclusive which is hardly surprising in view of the fact that the only independent regressors included were simple price and income variables.

The present paper is a more elaborate attempt to estimate these demand equations. Not only do we consider a longer time period (1949-1970 as opposed to 1953-1967) but we also test a greater variety of independent variables. In particular, several variables used to explain savings behaviour in Ireland in a study by Kennedy and Dowling (1970) are tested. Such a procedure has an added advantage in that it helps to corroborate further the conclusion that, in addition to price and income variables, certain other variables do play a significant role in empirical demand anlaysis in Ireland.

2 Consumption of Beer and Spirits in Ireland in the Post-War Period

In Charts I and II the trend in *per capita* consumption of beer and spirits (the dependent variables) over the post-war period can be observed. In Chart I consumption of these commodities is expressed in physical terms. Here, two alternative ways are suggested for measuring beer consumption.[1] The first of these, the standard barrel, expresses the physical volume of beer consumption in terms of a constant alcohol strength, or, more accurately, a constant specific gravity, whereas the second, the bulk barrel, measures the physical volume regardless of alcohol strength. The unit of measurement for spirits consumption is the proof gallon. In Chart II the volume of beer and spirits consumption is expressed in *expenditure* terms based on constant (1958) prices. The appropriate choice between these dependent variables in the econometric analysis of changes in alcohol consumption is discussed later in the paper.

There are a number of interesting features in these charts, the most remarkable being the dip in alcohol consumption as a whole (Chart III) and particularly in spirits, in the 1950s. Walsh and Walsh (1970), by choosing 1953 as their initial year, received the impression of a relatively uniform rate of increase in alcohol consumption over time. In fact, the 1951 level was not surpassed again until 1961, notwithstanding a twenty-five per cent increase in real *per capita* personal disposable income over the same period. Indeed, the level of consumption in 1960 was only marginally in excess of the 1948 figure whereas real *per capita* personal disposable income was thirty per cent greater.

In regard to the relative trends in beer and spirits consumption, it emerges that, apart from short-run fluctuations, the position did not alter significantly throughout the period between 1946 and 1960. Since then, as Chart I reveals, the growth in the physical volume of spirits consumption has been much more rapid than the corresponding growth in beer consumption.[2] Throughout the post-war period, spirits consumption has tended to fluctuate relatively more than beer consumption, a point which, as we shall see, has implications for our regression analysis. This feature is more evident in Chart I than in Chart II.

As the charts imply, the choice of the beginning and end years of our period is not a matter of indifference. The terminal year, 1970, was chosen because it was the latest year for which all the relevant data were available when the research was in progress. The early post-war years were dominated by the recovery from the effects of war-time scarcities and it was feared that factors peculiar to these years might disturb the relationship. The choice of 1949 as the first year was dictated by the fact that it was felt this marked the end of the period of immediate post-war recovery—a choice which, though somewhat arbitrary, was justified by a number of considerations.[3]

[1] The significance and derivation of these and all other variables are explained more fully in notes on sources and methods at the end of the paper.

[2] That the same trend does not emerge so clearly in Chart II is due to an optical illusion arising from the fact that the consumption scale used in Chart II is more compressed than the corresponding scale in Chart I.

[3] For further discussion of the subject, see Kieran A. Kennedy and Brendan R. Dowling, *Post-War Economic Growth in Ireland : the Role of Exports and Home Demand* (forthcoming).

3 Functional Form

Generally, it is not possible to decide *a priori* what functional form should be applied in a given regression problem. However, although potentially an unlimited number of forms could be tested, traditionally empirical work on individual commodities involves choosing between a linear, double-logarithmic or a semi-logarithmic function. Each has its particular merits.

On balance, we favoured the double-logarithmic form.[4] This form has, however, the disadvantages of lacking a saturation level and of implying constant elasticities. It can be argued that the absence of a satiety level poses no problems in this study; although it may not be possible to make the claim for any specific individual at an instant of time, it is doubtful if, on the aggregate, the saturation level of alcohol consumption has been approached. Further, the assumption of constant elasticities, although restrictive, is not excessively so. Finally, it should be noted that Walsh and Walsh (1970) found no significant difference between the performance of the double-logarithmic and the linear specifications in their regression work.

4 Relation of the Chosen Functional Form to Classical Demand Theory

A demand equation in this form may be expressed as follows in terms of price and income variables:

$$\text{(I)} \log X_1 = \alpha_0 + \alpha_1 \log P_1 + \alpha_2 \log P_2 + \alpha_3 \log P_3 + \ldots + \eta_1 \log Y + \log \varepsilon$$

where X_1 is the good under consideration; P_1 is the price of the good; P_2, P_3, etc. are the prices of all other goods and Y is the money income or, more accurately, the budget variable. The coefficients of the variables may be interpreted as elasticities.

It has been pointed out by Bridge (1971) and Geary (1973) among others that this form does not satisfy the requirements of classical demand theory in that it cannot be derived from a utility curve. In particular, unless all income-budget elasticities are equal to unity, the Engel aggregation condition (viz. that $\Sigma_i w_i \eta_i = 1$, where w_i are budget shares and η_i are budget elasticities) is violated. Thus, as the consumer's budget is increased, he will tend to spend more on those goods with high income elasticities, which in turn implies that $\Sigma w_i \eta_i$ will exceed unity. However, notwithstanding this, we share the view of other analysts who maintain that the constant elasticity formulation above can provide quite a reasonable description of consumer behaviour. It should also be borne in mind that the classical model is based on assumptions that have not themselves been empirically validated. Further, its essentially static nature begs some of the most important aspects of consumer behaviour, aspects which will be considered later in discussing the Houthakker-Taylor model. Finally, as Bridge (1971) argues, classical theory pays inadequate attention to the many problems surrounding aggregation over individuals.

[4] Prais and Houthakker (1971, pp. 93-100) in their cross-section study found the semi-logarithmic form to be most appropriate for foodstuffs. However, the double-logarithmic function came a close second.

Clearly, Equation I in its present form would be difficult to estimate, due to the number of parameters involved. Some simplifying assumption must be made. As is usual in this type of analysis, we assume that the beer and spirits demand functions are homogeneous of degree zero in income and prices, which implies that the consumer does not suffer from ' money illusion ' but is concerned, rather, with the relative prices of goods and his real income. We assume further that all cross price elasticities, with the exception of the beer-spirits and spirits-beer cross price elasticities, can be set equal to zero.

If an accurate price index is available for use as an overall deflator, these two assumptions can be applied to reduce Equation I to the more conventional form where the only independent regressors are deflated income and deflated beer and spirits prices. The resulting price elasticities should properly be viewed, however, as compensated elasticities representing measures of the substitution rather than the total price effects (Geary 1973). While there is no reason why this price effect should not be estimated, it can be argued that government revenue authorities are more likely to be interested in the uncompensated price elasticities.[5]

5 General Price Deflator

The most obvious deflator is the consumer price index (C.P.I.) based on the annual average of the quarters. However, theoretical considerations suggest that an alternative should be considered, namely, the implied price of personal consumption expenditure (P.C.E.) which can be derived from the National Income and Expenditure tables. The principal reason for using this deflator lies in the fact that the implied price of personal consumption covers a greater range of goods and services than the consumer price index. Accordingly, this deflator is employed throughout the paper.

6 Price Variables

Annual indices of beer and spirits prices were calculated, based on quarterly retail price indices supplied by the Central Statistics Office (C.S.O.) for various categories of beer and spirits. These annual indices were then divided by the implied price of personal consumption expenditure, in order to gauge movements in these indices relative to the overall price level. As was mentioned above, it was thought appropriate to allow for the possibility that beer consumption might be influenced by changes in the price of spirits and vice versa. Both price variables were, therefore, introduced into the respective regressions on beer and spirits consumption.

In the regression equations presented below, the *per capita* consumption of beer is measured in terms of standard barrels (X_1), while the *per capita* consumption of spirits is expressed in terms of proof gallons (X_3). The other forms of the dependent variable are considered later. Further, since the equations presented

[5] Indeed, the revenue effect rather than the total price effect is likely to be considered most relevant by the authorities and the magnitude of this depends on additional factors such as the share of taxation in total price.

in the main body of the text have been chosen from the wide selection of equations in the tables of parameter estimates, the reference numbers used in the text are the same as those in the tables. Finally, it should be noted that, in the light of earlier discussion, the variables are in logarithmic form.

Effect of price on beer consumption

In the following equation the dependent variable X_1 is regressed on the level of real personal disposable income *per capita* (Y_1) and the beer price variable (P_1):

$$(2)\ X_1 = -1.748 + 0.486Y_1 + 0.076P_1$$
$$\quad (-10.523)\quad (3.084)\qquad (0.320)$$
$$\bar{R}^2 = 0.880;\ SE = 0.0153;\ F = 78;\ \tau = 4;\ DW = 0.75;\ \chi^2\,(1) = 1.50$$

Here, the *t*-ratios for the significance of the individual coefficients are in parentheses below the relevant coefficients; $\bar{R}^2$ is the adjusted coefficient of multiple correlation; SE is the standard error of estimate; F is the F-value for testing the significance of the whole equation; τ is the Geary-tau statistic; DW is the Durbin-Watson statistic; and χ^2 (degrees of freedom in brackets) is a chi-square statistic based on the value of the determinant of the Z′Z matrix where the Z′Z matrix is the correlation matrix of the regressors. The test is described below.

The primary point of interest in this first regression equation is the lack of significance which can be attached to the price variable. This is similar to the Walsh and Walsh (1970) conclusions, notwithstanding the use of a longer time period and a modified price variable in Equation (2) above. Another aspect of this equation, and one which could be important, is that the Durbin-Watson statistic provides evidence of the existence of significant residual autocorrelation.[6] Thus the equation suggests that not only is the price variable not significant but that, further, a model with simple income and price variables leaves out some important explanatory factors.

A short comment is necessary concerning the use of the determinant of the Z′Z matrix for a chi-square test. Since this matrix is the correlation matrix of the regressors, it follows that the value of its determinant must lie between zero and unity. Farrar and Glauber (1967, p. 99) argue that the value of this statistic will, therefore, yield ' at least heuristic insight into the degree of interdependence within an independent variable set.' Thus, as the Z matrix tends to singularity (a condition which holds when there is an exact relation between the set, or some sub-set, of the independent variables), the value of the determinant tends to zero. Conversely, it tends to unity as the Z matrix approaches orthogonality. If the determinant is transformed into an approximate chi-square statistic as above—an operation which requires the assumption of multivariate normality in the parent population—it then proves possible to test for the *degree*

[6] The no-autocorrelation value tends towards 2. 0.

TABLE 1: PARAMETER ESTIMATES FOR BEER REGRESSION EQUATIONS 1949-70 (t-RATIOS IN PARENTHESES)

Equation	Dependent	Intercept	Y_1	Y_2	Y_3	Y_4	P_1	P_2	$y_{1,\,t-1}$
1	X_1	–1.705	0.534						
		(–17.825)	(12.760)						
2	X_1	–1.748	0.486				0.076		
		(–10.523)	(3.084)				(0.320)		
3	X_1	–1.088	0.558				0.263	–0.596	
		(–3.688)	(3.953)				(1.198)	(–2.576)	
4	X_1	–1.662		0.507					
		(–18.27)		(12.94)					
5	X_1	–1.644		0.517	–0.019				
		(–10.291)		(6.353)	(–0.142)				
6	X_1	–1.711		0.436	–0.067		0.177		
		(–9.313)		(3.235)	(–0.445)		(0.762)		
7	X_1	–1.791				0.582			
		(–17.128)				(12.493)			
8	X_1	–2.221		0.491					
		(–3.758)		(11.436)					
9	X_1	–1.957		0.690					
		(–22.412)		(14.866)					
10	X_1	–2.198		0.779					
		(–17.609)		(14.252)					
11	X_2	–2.025	0.439				0.309		
		(–6.88)	(1.573)				(0.739)		
12	X_2	–0.580	0.597				0.720	–1.304	
		(–1.237)	(2.660)				(2.059)	(–3.544)	
13	X_2	–1.799		0.605					
		(–10.973)		(8.574)					
14	X_2	1.538		0.429					
		(4.580)		(12.816)					
15	X_2	–2.381		0.966					
		(–17.509)		(13.373)					
16	X_2	0.574		0.593					
		(1.067)		(7.330)					
17	X_2	–2.968		1.175					
		(–20.659)		(18.689)					
18	X_4	–0.580		0.597			0.073		
		(–2.642)		(3.344)			(0.260)		
19	X_4	0.049		0.839			0.356	–0.815	
		(0.160)		(7.370)			(1.970)	(–3.708)	
20	X_4	–0.889		0.861					
		(–6.693)		(12.198)					

NOTATION

X_1 = Beer consumption *per capita* (standard barrels).
X_2 = Beer consumption *per capita* (bulk barrels).
X_3 = Spirits consumption *per capita* (proof gallons).
X_4 = Deflated expenditure on beer *per capita*.
X_5 = Deflated expenditure on spirits *per capita*.

Y_1 = Total real personal disposable income *per capita*.
Y_2 = Non-agricultural real personal disposable income *per capita*.
Y_3 = Farmers' real personal income *per capita*.
Y_4 = The volume of total personal consumption *per capita*.
$y_{1,\,t-1}$ = Rate of change in total real personal disposable income *per capita*; lagged one year.
y_2 = Rate of change in non-agricultural real personal disposable income *per capita*.
$y_{2,\,t-1}$ = y_2 lagged one year.
P_1 = Index of beer price deflated by the price of personal consumption expenditure.
P_2 = Index of spirits price deflated by the price of personal consumption expenditure.

The variables are in logarithmic form. The coefficients may be interpreted, therefore, as elasticities.

y_2	$y_{2, t-1}$	D_1	D_2	U	S	$\bar{R}^2$	S.E.	F	τ	D.W.	IZ′ZI	$\chi^2(\nu)$	Eqt
						0.885	0.0150	163	4	0.71			1
						0.880	0.0153	78	4	0.75	0.0740	1.50(1)	2
						0.907	0.0135	69	10	1.06	0.0145	0.28(3)	3
						0.888	0.0148	168	4	0.66			4
						0.882	0.0152	80	4	0.66	0.244	5.45(1)	5
						0.880	0.0153	52	4	0.82	0.0188	0.36(3)	6
						0.881	0.0153	156	4	0.71			7
	0.297 (0.956)					0.888	0.0148	84	6	0.66	0.838	35.5(1)	8
		–0.619 (–4.832)				0.947	0.0101	189	7	1.35	0.337	8.01(1)	9
			–0.800 (–5.276)	0.050 (1.310)		0.955	0.0093	150	11	2.21	0.121	2.47(3)	10
						0.769	0.027	36	2	0.35	0.074	1.50(1)	11
						0.855	0.0214	42	8	0.65	0.0145	0.28(3)	12
						0.775	0.0267	74	4	0.26			13
					–1.756 (–10.137)	0.963	0.0108	275	9	1.20	0.730	25.56(1)	14
		–1.225 (–6.137)				0.920	0.0158	123	6	0.94	0.337	8.0(1)	15
		–0.419 (–2.190)			–1.368 (–5.562)	0.969	0.0099	221	7	1.40	0.104		16
			–1.603 (–9.186)	0.141 (3.240)		0.963	0.0108	184	12	2.62	0.1207	2.47(3)	17
						0.887	0.0206	69	6	0.54	0.093	1.91(1)	18
		–0.556 (–3.449)				0.954	0.0121	109	10	2.00	0.0055	0.10(6)	19
		–0.745 (–3.829)				0.925	0.0155	130	6	1.07	0.337	8.01(1)	20

D_1 = Employment dependency ratio.
D_2 = Labour force dependency ratio.
U = Non-agricultural unemployment rate.
S = Specific gravity of beer.
$\bar{R}^2$ = The adjusted coefficient of multiple correlation.
S. E. = Standard error of estimate.
F = F-ratio.
τ = Geary-tau statistic.
D.W. = Durbin-Watson statistic.
IZ′ZI = The determinant of the Z′Z matrix where Z is the (standardised) matrix of observations of the independent variables.
χ^2 (ν) = Chi-square statistic with ν degrees of freedom for multicollinearity.

TABLE 2: PARAMETER ESTIMATES FOR SPIRITS REGRESSION EQUATIONS 1949-70 (t-RATIOS IN PARENTHESES)

Equation	Dependent	Intercept	Y_1	Y_2	Y_3	Y_4	P_1	P_2	$y_{1, t-1}$
21	X_2	−1.160	1.586					−1.445	
		(−1.777)	(8.923)					(−2.981)	
22	X_3	−1.113	1.793				−0.392	−1.308	
		(−1.683)	(5.664)				(−0.795)	(−2.521)	
23	X_3	−1.066		1.507				−1.430	
		(−1.830)		(10.236)				(−3.376)	
24	X_3	−1.057		1.592			−0.184	−1.348	
		(−1.775)		(6.589)			(−0.453)	(−2·875)	
25	X_3	−0.996		1.575	−0.175			−1.356	
		(−1.665)		(8.826)	(−0·700)			(−3.067)	
26	X_3	−1.831				1.610		−1.111	
		(−2 933)				(8.559)		(−2.361)	
27	X_3	−3.256		1.405				1.238	1.013
		(−2.849)		(9.853)				(−3.115)	(2.167)
28	X_3	−0.567		1.536				−1.491	
		(−0.384)		(9.044)				(−3.210)	
29	X_3	−3.523		1.368				−1.180	
		(−2.741)		(9.072)				(−2.896)	
30	X_3	−2.404		1.750				−0.907	
		(−7.452)		(22.955)				(−4.282)	
31	X_3	−3.477		1.667				−0.823	
		(−5.640)		(20.380)				(−4.103)	
32	X_3	−2.224		1.766				−0.945	
		(−5.384)		(21.201)				(−4.130)	
33	X_5	−0.283		1.602				−1.357	
		(−0.448)		(10.016)				(−2.949)	
34	X_5	−1.602		1.841				−0.842	
		(−3.555)		(17.305)				(−2.848)	
35	X_5	1.608		1.912			−1.145	−0.772	
		(−3.498)		(11.230)			(−0.537)	(−2.348)	

NOTATION

X_1 = Beer consumption *per capita* (standard barrels).
X_2 = Beer consumption *per capita* (bulk barrels).
X_3 = Spirits consumption *per capita* (proof gallons).
X_4 = Deflated expenditure on beer *per capita*.
X_5 = Deflated expenditure on spirits *per capita*.

Y_1 = Total real personal disposable income *per capita*.
Y_2 = Non-agricultural real personal disposable income *per capita*.
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$y_{1, t-1}$ = Rate of change in total real personal disposable income *per capita*; lagged one year.
y_2 = Rate of change in non-agricultural real personal disposable income *per capita*.
$y_{2, t-1}$ = y_2 lagged one year.
P_1 = Index of beer price deflated by the price of personal consumption expenditure.
P_2 = Index of spirits price deflated by the price of personal consumption expenditure.

The variables are in logarithmic form. The coefficients may be interpreted, therefore, as elasticities.

y_2	$y_{2,\,t-1}$	D_1	D_2	U	S	$\bar{R}^2$	S.E.	F	τ	D.W.	IZ′ZI	$\chi^2(\nu)$	Eqt.
						0.899	0.0299	94	6	0.84	0.221	4.87(1)	21
						0.897	0.030	62	8	0.81	0.0146	0.28(3)	22
						0.919	0.0267	120	4	0.56	0.2307	5.12(1)	23
						0.916	0.0273	77	6	0.51	0.0183	0.35(3)	24
						0.917	0.0271	78	6	0.53	0.053	1.04(3)	25
						0.892	0.0309	87	6	0.62	0.251	5.64(1)	26
						0.932	0.024	97	6	0.87	0.201	4.31(3)	27
−0.219 (−0.369)						0.915	0.027	77	4	0.54	0.179	3.77(3)	28
	1.130 (2.104)					0.932	0.025	96	6	0.58	0.177	3.77(3)	29
		−1.365 (−8.112)				0.982	0.0127	376	13	2.12	0.0705	1.4(3)	30
	0.534 (1.990)	−1.273 (−7.830)				0.984	0.0118	329	13	2.42	0.0497	0.96(6)	31
			−1.689 (−7·525)	−0.161 (−3·005)		0.981	0.0129	275	14	2.35	0.022	0.42(6)	32
						0.921	0.029	124	6	0.89	0.231	5.12(1)	33
		−1.344 (−5.724)				0.971	0.0178	232	11	2.32	0.0705	1.4(3)	34
		−1.359 (−5.635)				0.969	0.018	167	13	2.40	0.0055	0.1(6)	35

D_1 = Employment dependency ratio.
D_2 = Labour force dependency ratio.
U = Non-agricultural unemployment rate.
S = Specific gravity of beer.
$\bar{R}^2$ = The adjusted coefficient of multiple correlation.
S. E. = Standard error of estimate.
F = F-ratio.
τ = Geary-tau statistic.
D.W. = Durbin-Watson statistic.
IZ′ZI = The determinant of the Z′Z matrix where Z is the (standardised) matrix of observations of the independent variables.
$\chi^2(\nu)$ = Chi-square statistic with ν degrees of freedom for multicollinearity.

of interdependence or multicollinearity. The actual test applied is, in fact, an adaptation of the Farrar and Glauber test, as recommended by Haitovsky (1969). This test asks whether the hypothesis of singularity may be rejected. Thus, following Haitovsky, the chi-square statistic associated with Equation 2 is 1.5 with 1 degree of freedom. Hence, even in the case of this basic regression equation, the value of the determinant may not be taken to differ significantly from zero even at the ten per cent confidence level, which implies that we cannot reject the hypothesis of singularity.

If the spirits price variable is now included, the equation becomes:

$$(3)\ X_1 = -1.088 + \underset{(3{\cdot}953)}{0.558Y_1} + \underset{(1{\cdot}198)}{0.263P_1} - \underset{(-2{\cdot}576)}{0.596P_2}$$
$$(-3{\cdot}688)$$
$$\bar{R}^2 = 0.907;\ SE = 0.0135;\ F = 69;\ \tau = 10;\ DW = 1.06;\ \chi^2\,(3) = 0.28$$

The spirits price variable is here represented by P_2. The most striking aspect of this equation is the negative coefficient of this variable which is significant at the two per cent level. This suggests that beer and spirits are complementary goods! Moreover, the coefficient of P_1, though not significant, has the wrong sign. However, on testing, it emerges that the value of the determinant points to multicollinearity of increasing severity which implies that the regression equation should not be taken at face value. Indeed, researchers, when faced with results such as those above, tend to discount them as invalid, appealing to multicollinearity as the cause. A common device then introduced is to drop one or both of the price variables from the demand equation. Such a course of action was adopted by Hogarty and Elzinga (1972) when they uncovered a significant negative cross elasticity between beer consumption and the price of spirits in the United States of America.

Clearly, such a procedure is open to abuse. It is possible to argue, however, that what is at issue is not the rejection of one's initial hypothesis (that both price variables should be included) in the light of the evidence but, rather, the recognition that it is not always possible to include all of one's *a priori* information in the initial hypothesis, because of the limited nature of the estimating techniques employed. For example, the demand function as described above does not require the own price coefficient to be negative even though such is believed to be the case. Thus, the approach adopted here, whereby results such as those above are rejected, is at fault not because it is inconsistent but because it does not allow for all available information from the outset.[7] The effect of dropping both price variables from the beer demand equation may be observed by examining Equation 1, Table 1. A comparison of Equations 1, 2 and 3 suggests that, due to the degree of multicollinearity present in the latter two equations, the role of the price variables is hard to determine.

Finally, it should be noted that a common rule of thumb for detecting multicollinearity, namely, that it is associated with insignificant *t*-ratios, is here belied. A more rigorous test, such as suggested by Haitovsky, is necessary.

[7] This is discussed more adequately by Theil and Goldberger (1961).

Effect of price on spirits consumption

The dependent variable is now X_3 - *per capita* consumption of spirits (proof gallons).

$$(21)\quad X_3 = -1.160 + 1.586Y - 1.445P_2$$
$$\qquad\quad (-1.777)\quad (8.923)\quad (-2.981)$$
$$\bar{R}^2 = 0.899;\ SE = 0.0299;\ F = 94;\ \tau = 6;\ DW = 0.84;\ \chi^2\,(1) = 4.87$$

The most striking difference between this and the preceding two regressions is that the own price variable, P_2, emerges as significant with the ' correct ' sign. It may be noted that the degree of significance is higher than that recorded by Walsh and Walsh (1970). Further, the absolute value of the coefficient implied here is substantially in excess of any value they recorded. However, this high value, as will be shown later, is contingent upon the fact that the demand equation has not as yet been fully specified—the Durbin-Watson and Geary-tau statistics provide strong evidence of autocorrelation. When other significant independent variables are included below, the coefficient of P_2 takes a value that is normally less than unity.

When the beer price variable (P_1) is included, as in Equation 22, Table 2, its coefficient is negative and non-significant. The inclusion of P_1 results in serious multicollinearity—the value of the χ^2 statistic at 0.28 (3) is very low.

Source of multicollinearity

Since the existence of multicollinearity is cited as the basis for ignoring some of the results above, the phenomenon should be considered in greater detail. As yet, reference has been made only to the presence of the problem and not to its localisation or its specific pattern. For this it is not sufficient to examine the simple correlation coefficients between the variables—a set of dummy variables could constitute a perfectly collinear set without any simple correlation coefficient being particularly great. A more reliable indicator for the localisation of multicollinearity is provided by examining the coefficient of multiple determination (R^2) between each of the independent regressors taken in turn and the rest of the set of independent regressors (Johnston 1972, p. 163). From this test it emerged that the two price variables were particularly subject to the problem. The value of R^2 between P_1 and the other elements of the set, some of which have yet to be introduced, emerged as 0.96 while the corresponding statistic for P_2 is 0.91. Further, as supplementary evidence, it might be noted that the simple correlation coefficients between the two price variables themselves and between each of the price variables and the income variable are all in excess of 0.8.

It is well known that multicollinearity causes specific estimates not only to be subject to large errors but also to be extremely sensitive to the sets of sample data used. Ample evidence of this latter aspect is provided if Equation 3 is re-run, replacing the dependent variable X_1 with the alternative mentioned above, viz., the *per capita* consumption of beer (bulk barrels) which we designate as X_2. The result is Equation 12, Table 1, where it can be seen that the values of the coefficients of P_1 and P_2 have altered radically. In particular, the coefficient of P_2 now implies that a one per cent increase in the spirits price index will induce a greater than one per cent reduction in beer consumption ! Clearly, such results must be treated with scepticism.

In conclusion, it is argued that the most reasonable course of action is to assume both cross-price elasticities to be zero. Then Equations 2 and 21 in Tables 1 and 2, respectively, become the relevant equations and it can be argued that beer is not price responsive whereas spirits consumption is—conclusions which agree with Walsh and Walsh's earlier findings.

Other price variables

Other price variables, the principal ones being the rate of change in P_1 and P_2 (lagged and unlagged), were introduced. Generally, these variables emerged as insignificant in both the beer and spirits regressions and were, therefore, abandoned.

7 Income Variables

The regression equations presented above imply that the income variable is indeed important. This must now be analysed in greater detail, drawing, in particular, on the experience gained by Kennedy and Dowling in their work. There are several possible ' income ' variables. Thus, in classical demand theory, the effective constraint is that total expenditure cannot exceed the consumer's budget and hence some researchers prefer to use total personal expenditure as the determining variable. Clearly, this differs from personal disposable income because savings are not included.[8] Accordingly, in deference to classical demand theory, total consumption expenditure might be favoured as the dependent variable. In fact, if allowance is made for some of the dynamic elements of consumer behaviour, further arguments can be adduced for employing this variable. Thus, to the extent that the consumer exercises greater control over his expenditure than over his income, the former can be taken as a more accurate measure of the consumer's ' true ' or ' permanent ' income (Houthakker and Taylor 1970, p. 59). These considerations led to the use of Y_4, the volume of consumption *per capita*. It should be observed, however, that the national accounts statistics used in the derivation of this variable are not optimal to the extent that they include, for example, total expenditure on durable goods rather than the services yielded in any one year by these goods.

Changes in the distribution of income as between occupations can have quite significant effects on aggregate consumer behaviour. It is commonly held, for example, that the farming community and the non-agricultural community tend,

[8] It has also been pointed out, particularly with reference to cross-section work, that the choice between income and total expenditure has statistical ramifications. See, for example, Liviatan (1961).

on the aggregate, to respond to the same stimuli in different ways. The basis for maintaining such a behavioural assumption usually reduces to a Friedmanite theory whereby groups whose incomes are particularly subject to substantial and frequent fluctuations (e.g. farmers in Ireland) are held to respond to this instability through a lower than average aggregate marginal propensity to consume out of current income. Though the farming community is by no means unique in suffering from income fluctuations, its relatively large size in Ireland suggests that special treatment is in order. Kennedy and Dowling (1970, p. 28) found in their paper that the division was important and, specifically, that farmers' income was a very useful factor in explaining variations in personal saving whereas the non-agricultural component was not so uniformly significant. Also, the implied elasticities were such as to suggest that farmers save much more of a given increase in their current income than the non-agricultural community.

Thus, the following income variables were also tested: firstly, non-agricultural real personal disposable income in *per capita* terms, Y_2; and, secondly, farmers' real personal disposable income *per capita*, Y_3.[9] For comparative purposes, total real personal disposable income *per capita*, Y_1, was also fitted as in the equations presented above.

Beer consumption and the income-expenditure variables

The role of the split income variable can be interpreted from the following regression equation:

$$(5)\ X_1 = -1.644 + 0.517Y_2 - 0.019Y_3$$
$$\qquad (-10.291) \quad (6.353) \quad (-0.142)$$
$$\bar{R}^2 = 0.882;\ SE = 0.0152;\ F = 80;\ \tau = 4;\ DW = 0.66;\ \chi^2\ (1) = 5.45$$

The most obvious point to be noted is the very significant coefficient associated with Y_2 which contrasts sharply with a non-significant Y_3 coefficient. The inference to be drawn from this equation is, therefore, that the non-agricultural component of personal disposable income is the most relevant income variable for our work. This may be compared with Kennedy and Dowling's conclusion (1970, pp. 27-28) that farmers' income is more useful than non-agricultural income in explaining savings behaviour in Ireland—a conclusion that complements the finding above.

When Y_3 is dropped, as in Equation 4, Table 1, the overall fit of the equation improves. Further, a comparison of Equation 4 with Equation 1, Table 1, reveals that, by the light of such conventional criteria as $\bar{R}^2$, Y_2 performs slightly better than Y_1, the total income variable. This finding held in all the regressions run. If Equation 4 is then compared with Equation 7 it emerges that the split income variable Y_2 is also marginally more useful than the total expenditure variable Y_4. Examination of other trials revealed that this is generally the case.

[9] A modified version of this variable, excluding agricultural stocks, was also used. However, the resulting variable was always insignificant and was, therefore, dropped.

Spirits consumption and the income-expenditure variables

For spirits, splitting the income variable in Equation 21, we have the following spirits regression:

$$(25)\ X_3 = -0.996 - 1.356P_2 + 1.575Y_2 - 0.175Y_3$$
$$(-1.665)\ (-3.067)\quad (8.826)\quad (-0.700)$$
$$\bar{R}^2 = 0.917;\ SE = 0.0271;\ F = 78;\ \tau = 6;\ DW = 0.53;\ \chi^2\,(3) = 1.04$$

The points made above in relation to beer are here even more obvious—non-agricultural income is again the important component. Further, if Equations 21, 23 and 26 of Table 2 are ranked by $\bar{R}^2$, Y_2 again tends to be more useful than either Y_1 or Y_4 from which it may be construed that it is, indeed, advisable to split the income variable. Two additional points may be made. Firstly, the income elasticity of demand for spirits is significantly greater than unity and is always much greater than the corresponding elasticity for beer.[10] Secondly, the value of the Durbin-Watson statistic remains as a constant reminder of the existence of autocorrelation in both the beer and the spirits regressions.

Given that there are differences in savings behaviour between the agricultural and non-agricultural communities, we should ordinarily expect total consumption, which excludes savings, to perform even better than the split income variables. The fact that it does not, suggests that farmers have a different (lower) marginal propensity to consume beer out of income allocated to consumption expenditure than do people in the non-agricultural sector.

Other income variables

The purpose of the income variables discussed above was to gauge what might be referred to as ' direct ' income effects. However, there may be other effects. Alcohol consumption might vary, for example, in response to changes in farmers' income relative to non-agricultural income. On testing, this variable did not emerge as significant.

Another possible explanatory variable is the rate of change in income. Thus, a consumer's view of his present income might be influenced by whether it has been growing rapidly in the recent past or not. Consumption patterns may respond to income only after a lag. These considerations led us to test the rate of change in income variables y_1, $y_{1,\,t-1}$, y_2, and $y_{2,\,t-1}$.[11]

In the beer regressions, these variables generally emerged as non-significant—see, for example, Equation 8, Table 1. This is not to argue that the variables do not have a role to play but rather that the limitations of the data sample ensure that this role cannot be pin-pointed with any degree of assurance.

The corresponding results for spirits are more encouraging as can be seen by examining Equations 27, 28 and 29 of Table 2. In terms of the significance of their own *t*-ratios, the lagged rate of change in income variables would appear to be more important than the current rate of change variables. However, if one

[10] It may be noted that this is in agreement with Walsh and Walsh's conclusions (1970, p. 133).

[11] See notes on sources and methods.

inspects the overall fit of Equations 27 and 29, it becomes obvious that it is impossible to decide which lagged variable is appropriate. Further, when the dependency ratio (a variable about which more will be said later) is included as in Equation 31, Table 2, the value of the coefficients of these variables alters markedly. Perhaps, the only reasonable conclusion is that the coefficients of these lagged variables are positive rather than negative.

Accepting this, it is interesting to note that the corresponding coefficients of the current rate of change variables, although non-significant, were consistently negative in the regressions run. One way of interpreting this would be to argue that people do not adjust their consumption patterns instantaneously to a given change in income. Thus, if a given level of *per capita* income is the product of a recent increase in aggregate income, spirits consumption (and indeed, consumption expenditures in general) would tend to be lower than in the situation where that given level of *per capita* income has been experienced for some time. It is suggested that this relative negative impact on spirits consumption manifests itself in the negative coefficients of the current rate of change variables. Correspondingly, as the lag in consumer reactions is overcome, spirits consumption would tend to rise, resulting in the positive coefficients of the lagged rate of change in income variables. This line of reasoning is tenuous. It should be noted, for example, that the lag assumed here is a calendar year in length which is rather arbitrary.

Perhaps these results merely confirm that measured income, as gleaned from the available statistics, in the form of variables such as Y_2, is not an accurate measure of the consumer's evaluation of his true income. However, much work remains to be done in this area—for example, what is the most appropriate lag structure ?

8 Demographic and Related Variables

Theory offers no guidelines on how to allow for changes in family size and structure.[12] A useful variable in this context is the dependency ratio, changes in which may pick up the more significant changes in the structure of the population over the period under consideration. Conventionally, the ratio is defined in terms of the age distribution of a given population. However, since the relevant data are available only for census of population years, it proved impossible to estimate it in this manner. Accordingly, we followed Kennedy and Dowling (1970, p. 34) in using what they called the employment dependency ratio (D_1) and the labour force dependency ratio (D_2). The former is the inverse of the ratio of the employed to the unemployed population, while the latter is the inverse of the ratio of the labour force to the population not in the labour force. It should be noted that Kennedy and Dowling found the employment dependency ratio to be more useful than the labour force dependency ratio when explaining savings behaviour, although both were highly significant.

[12] This problem is dealt with in greater depth by Prais and Houthakker (1971).

Kennedy and Dowling obtained large negative coefficients in their paper on savings suggesting that, given *per capita* income, a rise in the dependency ratio exercises a substantial negative influence on the savings ratio. This result implies that, *ceteris paribus*, a rise in the dependency ratio is associated with a rise in total *per capita* consumption though this need not extend to all consumer goods. In fact, alcohol would probably be an exception since it is normally held that the old, the young and the housewives do not drink as much as employed persons. Thus, we would expect to find a negative coefficient, which is what we found—as shown by the following regressions, one each for beer and spirits, respectively:

$$(9)\quad X_1 = -1.957 + 0.690Y_2 - 0.619D_1$$
$$(-22.412)\quad(14.866)\quad(-4.832)$$
$$\bar{R}^2 = 0.947;\ SE = 0.0101;\ F = 189;\ \tau = 7;\ DW = 1.35;\ \chi^2\,(1) = 8.01$$

$$(30)\quad X_3 = -2.404 - 0.907P_2 + 1.750Y_2 - 1.365D_1$$
$$(-7.452)\quad(-4.282)\quad(22.955)\quad(-8.112)$$
$$\bar{R}^2 = 0.982;\ SE = 0.0127;\ F = 375;\ \tau = 13;\ DW = 2.12;\ \chi^2\,(3) = 1.4$$

In Equation 9 we observe that the coefficient of D_1 is significant and negative. Further, the existence of autocorrelation is no longer as pronounced. Referring back to Equation 4 it may be observed that there is a considerable improvement in the overall fit of the equation which implies that the variable is very important. As to the choice between D_1 and D_2, the former generally gave better results.

In regression Equation 30, the employment dependency ratio is again useful in that it is itself highly significant and also adds to the significance of the disposable income variable (Y_2). More important, perhaps, as will be seen from the Durbin-Watson statistic, the evidence of autocorrelation has disappeared. The conclusion must be that the dependency ratio is central to the correct specification of the spirits demand equation. It will be noted that the inclusion of D_1 also reduces the (own) price elasticity of demand for spirits to less than unity, a result more in line with the findings of Walsh and Walsh.

The value of the coefficient of D_1 in Equation 30 is greatly in excess of the corresponding value in Equation 9. Although this is not easily explained, it can be argued that it arises partly from changes in the distribution of income. Thus, if the income structure of a given population is altered in such a way as to result in a more equal distribution of *per capita* income the result is a fall in the share of total expenditure on those commodities with income elasticities greater than unity and a corresponding rise in the share of total expenditure on those goods with income elasticities less than unity. Increases in the dependency ratio, in addition to gauging the negative impact of changes in the proportion of the population of drinking age on alcohol consumption, may also measure changes in the relevant pattern of income distribution. Thus, given *per capita* income, a change in the dependency ratio corrects for changes in household size (including in this, changes in the proportion who are married) and is thus effectively a measure of alterations in the extent to which an employed person's income is re-distributed to dependants because of family commitments. On this basis, the discrepancy between the coefficients recorded above may be seen as a reflection of the different income elasticities of demand for beer and spirits.

Analogous to the splitting of the income variable, the employment dependency ratio was divided into an agricultural and a non-agricultural component. Primary interest centred on the latter. However, although it emerged as highly significant in all regression equations, it did not perform significantly better (or worse) than D_1. Accordingly, D_1 is retained throughout. On a more general level, we suggest that the dependency ratio should be considered in all time series demand models in Ireland.

To the extent that the dependency ratio corrects for the number of people of drinking age, it might be possible to eliminate it if the other variables are divided by the total number of ' drinkers ' rather than by total population. This has the advantage, where multicollinearity is present, of reducing the number of independent variables. It is not possible, however, to obtain reliable annual estimates of the number of ' drinkers ' in Ireland. By way of compromise, the variables were divided by an estimate of the number of people aged between fifteen and sixty-four.[13] The resulting regression equations, unfortunately, did not represent an improvement on the earlier results. Possibly this is due to inadequacies in the data, but it may also be, as argued above, that D_1 does more than correct for changes in the age structure of the population.

Other demographic variables

Total population and non-agricultural population were fitted as separate regressors as well as their rates of change. None of these variables was significant. However, the coefficient of the ratio of the non-agricultural population to total population was on occasion significant at the ten per cent level. Further, its coefficient was consistently positive which substantiates the thesis that the farming community on the aggregate has a lower marginal propensity to consume alcohol than the non-agricultural community.

Another variable which calls for comment is the non-agricultural unemployment rate (U):

$$\begin{aligned}(32)\ X_3 = &-2.224 \quad -0.945P_2 + 1.766Y_2 - 1.689D_2 - 0.161U_2 \\ &(-5.384)\ (-4.130) \quad (21.201) \quad (-7.525) \quad (-3.005)\end{aligned}$$

$$\bar{R}^2 = 0.981;\ SE = 0.0129;\ F = 275;\ \tau = 14;\ DW = 2.35;\ \chi^2\ (6) = 0.42$$

In this spirits regression equation the coefficient of the unemployment variable is negative and significant.[14] In the corresponding beer regression (Table 1, Equation 10) the coefficient is positive, though non-significant. However, if the

[13] This statistic is readily available for censal years, and for the intercensal years in the 1960s we relied on data provided by the C.S.O. For the earlier years of the period under consideration we had to prepare our own estimates based in part on observed trends in the total labour force and in part on interpolation.

[14] D_2 (the labour force dependency ratio) has been included here rather than D_1. This results from the fact that the inclusion of D_1 and U together would involve double-counting as D_1 contains U implicitly.

dependent variable X_1 is replaced by X_2 (bulk barrels) as in Equation 17, Table 1, the unemployment variable becomes very significant! These results might be interpreted by viewing U as yet another attempt to refine our income data. Thus, an increase in the unemployment rate is a proxy for a deteriorating economic situation. Given that spirits is income elastic whereas beer is not, it may be that there is a switching effect from spirits to beer consequent upon an increase in unemployment. Again, however, caution must be exercised since there is strong evidence of multicollinearity, which is particularly prevalent in Equation 32 above.

10 Other Variables

The estimates of alcohol consumption used in this paper include drinking by tourists in Ireland and exclude drinking by Irish people abroad. Tourist expenditure might, therefore, constitute an important explanatory variable, both because of the importance of the industry in Ireland and because tourists may be expected to spend relatively heavily on commodities such as alcohol. This latter consideration may be particularly significant in the case of cross-border traffic where such factors as the licensing laws on both sides of the border become relevant.[15]

Two main tourist variables were tested, namely, real tourist receipts and real net tourist receipts. However, the results were disappointing—the coefficients were consistently negative and in some of the beer regressions were significantly so. But serious multicollinearity was clearly present and the simple correlation coefficients between the tourist variables and other explanatory variables (especially income) were generally high, which alone provides grounds for suspicion. But the fact remains that we could not establish that tourist drinkers had any significant effect in accounting for the rapid rise in alcohol consumption in the 1960s.

It is sometimes maintained that alcohol consumption in general, and beer consumption in particular, responds positively to a particularly warm summer. To allow for this, a variable was derived based on the mean temperature for the summer months. Its coefficient was positive as expected but was generally non-significant and fluctuated considerably in value. Given these results, and the fact that the derivation of the variable is arbitrary, we concluded that it was not possible to establish any significant effect.

11 The Relative Regressions

Multicollinearity ensures that certain of the estimated co-efficients cannot be interpreted unambiguously. Efforts to overcome this problem led to some regressions being run on the ratio of beer (standard barrels) to spirits (proof gallons) consumption. It should be observed immediately that this is in no sense an exercise in demand theory and that, further, the double-logarithmic formulation would make the resulting coefficients tend towards equality with the

[15] See Kennedy and Dowling (forthcoming) for further discussion of tourist trends.

difference between the corresponding coefficients in the beer and spirits regressions above.[16] However, these regressions can be used as a test for consistency, with the additional hope that they may cast further light on what might be deemed subsidiary regressors, such as the unemployment rate. X_6 is the new dependent variable:

$$(36)\quad X_6 = \underset{(8.436)}{5.192} - \underset{(-9.697)}{0.770Y_2} + \underset{(4.151)}{0.834D_1} - \underset{(-2.359)}{0.796y_{2,t-1}}$$

$$\bar{R}^2 = 0.916;\ SE = 0.015;\ F = 78;\ \tau = 12;\ DW = 2.21;\ \chi^2\,(3) = 5.47$$

$$(37)\quad X_6 = \underset{(16.941)}{3.596} - \underset{(-9.154)}{0.850Y_2} + \underset{(4.979)}{1.284D_2} + \underset{(2.512)}{0.162U}$$

$$\bar{R}^2 = 0.907;\ SE = 0.016;\ F = 69;\ \tau = 10;\ DW = 1.74;\ \chi^2\,(3) = 2.47$$

The coefficients of Y_2, D_1 and D_2 are much as would be expected in the light of the earlier work—the coefficient of Y_2 is perhaps a bit low while that of D_2 is on the high side. The performance of the other variables is also illuminating. Thus, the coefficient of $y_{2,t-1}$ is negative suggesting that the lagged rate of change of income variable can be associated with a fall in the ratio of beer over spirits consumption. This, in turn, can be said to reflect the disparate *income* elasticities of the two commodities which, in turn, implies that one is indeed handling at a remove a genuine income effect, as was argued earlier.

The coefficient of the unemployment variable is also instructive. It was maintained above that a rise in the unemployment rate could induce a shift from spirits consumption to beer consumption. The positive and significant coefficient in Equation 37 above substantiates this.

12 Choice of Dependent Variable

Some of the issues involved in choosing between the various dependent variables introduced earlier will now be discussed. One such issue concerns the relative performance of the two beer consumption variables expressed in physical quantity terms (standard barrels, X_1, and bulk barrels, X_2). To the extent that specific gravity is a measure of alcohol content and, therefore, provides some indication of quality, it could be argued that the standard barrel, which corrects the many varieties of beer for different specific gravities, represents a quality-corrected measure of consumption. On the other hand, it may not be either an adequate or an entirely relevant measure of quality. Referring to Table 1, a direct comparison between the performance of the two different dependent variables is afforded by examining Equations 4 and 9, where consumption is based on standard barrels, and Equations 13 and 15, where it is based on bulk barrels. Such a comparison reveals that the regressors explain a greater propor-

[16] On a more theoretical level, the application of ordinary least squares (O.L.S.) involves making implicit assumptions about the error term. If the original error terms in the beer and spirits demand functions are assumed to be additive in the logs and to meet basic O.L.S. requirements, then a sufficient condition for our composite error term in the relative regressions to meet the same requirements is that the original error terms be distributed independently of each other. We make such an assumption.

tion of the variation of X_1 than of X_2. Further, it should be noted that when X_2 replaces X_1 as the dependent variable, the parameter estimates tend to be unstable and, in particular, the coefficient values recorded in Equation 15 are not as would be expected in the light of earlier work. While it should be emphasised that these are purely statistical considerations, it is suggested that, in the absence of other criteria, they would tend to favour the use of X_1 over X_2.

This comparison may not be fair. Specifically allowance should be made for the fact that X_1 has already been corrected for changes in the average specific gravity of beer by including the latter as a separate regressor in the corresponding regression equation where X_2 is the dependent variable. It may be noted, as an aside, that in those regression equations where X_1 is the dependent variable, our use of the beer retail price variable P_1, was inadequate in that it was not corrected for changes in alcohol strength.[17] The results are given in Equations 14 and 16 where S refers to the average specific gravity. It is very difficult in this case to choose between the two dependent variables. In Equation 16 (which superficially appears to be a good fit), there is evidence of multicollinearity and the values of the estimated coefficients have changed considerably when compared with the corresponding coefficients in Equation 15. Further, problems arise when one tries to rationalise the coefficient of the specific gravity variable. Thus, when Stone employed the same variable in his study on beer consumption, he argued that the coefficient should be positive since ' other things, including price, being equal, people will drink more beer when it is strong rather than weak ' (1945, p. 315). However, a change in specific gravity has two effects on aggregate beer consumption as measured by bulk barrels. The first effect, mentioned by Stone above, is that, to the extent that an increase in alcohol strength is perceived by the consumer, it can be viewed as being analogous to a reduction in beer price. The second and more direct effect derives from the fact that an increase in specific gravity implies that fewer bulk barrels of beer have to be consumed to ensure the same level of alcohol intake. If this was the only force in operation one would expect the S variable to have a negative elasticity equal to unity. However, to the extent that the first effect, which presumably has a positive impact on consumption, exists, this conclusion is modified and although the resulting elasticity would most likely be negative, its absolute value would then be less than unity.

There is a further consideration which suggests that the variable should be treated with caution. Thus, according to reliable trade sources, both the alcohol content and, more significantly, the specific gravity, of the most popular ale brand are considerably less than those of lager and stout. The average specific gravity of total beer consumption in any given year, therefore, depends on the proportion of ale, lager and stout in the total. However, specific gravity is then no longer a true independent variable in that it is determined by the composition of beer consumption and to that extent is not a factor explaining beer consumption. This argues for the necessity of going beyond the single-equation model.

[17] However, we allowed for this in some equations by including specific gravity as a separate regressor. The resulting price coefficient (P_1) remained non-significant.

Nevertheless, even if these arguments justify a negative coefficient, the value of the coefficient still appears far too high. We tend on balance, therefore, to favour the use of X_1 which has the advantage of containing S implicitly, reducing the number of independent regressors. This is to be welcomed in view of the multicollinearity encountered earlier. It must be emphasised, however, that this whole discussion is predicated on the assumption that the average consumer is sensitive to alcohol strength. This may not be the case. Thus, within an historical context, it should be noted that brewers have on occasion passed on increases in duties by lowering the specific gravity, rather than increasing the price, of their brews (Dingle 1972). This suggests that they felt the consumer to be less sensitive to changes in the strength of beer than to price changes.

As a corollary of the above considerations concerning the nature of the specific gravity variable, however, a certain ambiguity attaches to the interpretation of the coefficients of the variables in the beer regressions. Gorman observes (1959, p. 475) in his discussion on homogeneous separability that ' we must never group luxuries, near-luxuries and necessities together ' when trying to estimate income elasticities. It can be argued that the commodities grouped under the heading ' beer ' violate this rule—the response of lager consumption to a given change in income probably differs considerably from the response of stout consumption to the same income change. The implicit assumption of homogeneity of demand over the various beer categories may be unwarranted, but was unavoidable due to an unfortunate lack of data. The results must, therefore, be treated with caution. It should be noted that these considerations are of less importance in the case of spirits.

Although it does not solve those problems arising from the heterogeneity of the products within our commodity classifications, an alternative way of estimating consumption, namely by using deflated expenditure data as in Chart II, may be more useful. Thus, as Wold points out (1963, p. 219), the relevance of physical quantity data is inversely related to the degree of variation in quality and variety of the good under consideration—estimates of quantity consumed could conceal significant alterations in the structure of market demand, alterations which might emerge in the expenditure data. It should be noted that there are grounds for maintaining that income elasticities relating to physical quantity are less than the corresponding elasticities relating to deflated expenditure. Thus, assuming a positive quality elasticity, as soon as a commodity is available in a number of varieties, consumers may shift their attention to more expensive varieties as income rises. This, in turn, implies that the deflated expenditure income elasticity is greater than the physical quantity income elasticity.

The following two regression equations may be compared with Equations 9 and 30 above—X_4 and X_5 are deflated expenditure on beer and spirits, respectively:

$$(20)\quad X_4 = -0.889 + 0.861Y_2 - 0.745D_1$$
$$(-6.693)\quad (12.198)\quad (-3.829)$$
$$\bar{R}^2 = 0.925;\ SE = 0.0155;\ F = 130;\ \tau = 6;\ DW = 1.07;\ \chi^2(1) = 8.01$$

[L3]

$$(34)\quad X_5 = -1.602 \quad -0.842P_2 + 1.841Y_2 - 1.344D_1$$
$$(-3.555)\ (-2.848) \qquad (17.305)\ \ (-5.724)$$
$$\bar{R}^2 = 0.971;\ SE = 0.0178;\ F = 232;\ \tau = 11;\ DW = 2.32;\ \chi^2\,(3) = 1.4$$

The most obvious point to note is the reassuring similarity of these results to those recorded earlier, although there is a tendency for the regressors to explain a greater proportion of the variation of the physical quantity than of the deflated expenditure variables. This tendency is hardly so marked as to warrant our strongly favouring one formulation of the dependent variable over the other. It may also be observed that the income elasticities in both expenditure regressions exceed the corresponding elasticities in the quantity regressions, as expected.

13 First Difference Results

First difference equations are a useful device for checking the stability of ordinary regression results, particularly if the presence of multicollinearity is suspected. Unfortunately, in the case of the beer regressions this usefulness was severely limited as can be seen from the following equation, where the first differences are the first differences of the logarithms:

$$(38)\quad \triangle X_1 = 0.00229 + 0.563\ \triangle Y_2 - 0.541\triangle D_1$$
$$(0.366) \qquad (1.745) \qquad (-0.973)$$
$$\bar{R}^2 = 0.322;\ SE = 0.0119;\ F = 5.75;\ \tau = 13;\ DW = 2.63;\ \chi^2\,(1) = 15.41$$

Although this equation was one of the more successful first difference results for beer it is far from satisfactory. However, some comfort can be derived from the knowledge that the coefficients of the income and dependency ratio variables are similar to those estimated earlier.

The corresponding regression equations for spirits are more interesting:

$$(39)\quad \triangle X_3 = -0.0005 + 1.687\triangle Y_2 - 1.222\triangle P_2 + 0.521\triangle y_{2,\,t-1} - 0.734\triangle D_1$$
$$(-0.004) \qquad (3.195) \qquad (-3.420) \qquad (1.575) \qquad (-0.842)$$
$$\bar{R}^2 = 0.754;\ SE = 0.0176;\ F = 16.3;\ \tau = 13;\ DW = 2.38;\ \chi^2\,(6) = 8.46$$

While the absolute values of many of the coefficients are not as would be expected, the signs of all of the coefficients concur with our earlier results. A subsidiary point to be noted is the relatively poor performance of the dependency ratio variable (D_1). Unfortunately, this was found generally to be the case in the first difference regressions. However, the performance of the other variables is gratifying and they corroborate some of the conclusions arrived at earlier. On this point, it is observed that the coefficient of $y_{2,\,t-1}$ is positive.

14 The Houthakker-Taylor Model

As was pointed out above, the classical theory of consumer demand is essentially static. It, therefore, loses relevance if the utility of the commodity under consideration extends beyond the purchase period. For many goods such is clearly the case. It was in order to meet this contingency that Houthakker and Taylor developed a dynamic model of consumer demand (1970, pp. 9-26).

This model attempts to allow for the fact that consumption of a commodity may depend on existing ' stocks ' of that commodity. Specifically, their basic premise is that ' current behaviour depends on all past values of the predetermined variables, though more on recent values than on very remote ones ' (*op. cit.* p. 10). Thus, they postulate that, for an individual:

$$\text{(II)}\ q(t) = \alpha + \beta s(t) + \gamma y(t) + \eta p(t) \text{ and}$$

$$\text{(III)}\ \dot{s}(t) = q(t) - \delta s(t)$$

where q(t) is the rate of demand at time t, y(t) refers to the rate of income and p(t) to price at that same time, while $\dot{s}$(t) refers to the inventory or stock of the good being held by the individual. $\dot{s}$(t) is the rate of change of this stock variable, while δ is the constant depreciation rate associated with the stock.

In the case of consumer durables, one would expect the ' β ' coefficient to be negative. However, Houthakker and Taylor endow the consumer with a memory and argue that his current behaviour will be influenced by his past behaviour. This effect manifests itself in the phenomenon of ' habit formation or inertia.' An extreme example of this is provided by the case of tobacco consumption—the consumer is much more likely to smoke in the current period if he has been smoking in previous periods. Habit formation would also appear to be relevant when considering alcohol consumption. Where habit formation exists, we would expect the ' β ' coefficient to be positive. The question immediately arises of how one can measure an unobservable psychological stock. Houthakker and Taylor show (1970, pp. 10-13) that it is possible to eliminate the stock variable from the basic equation and derive a finite approximation to the resulting model. The approximation has the following form:

$$\text{(IV)}\ q_t = A_0 + A_1 q_t - 1 + A_2 \triangle Y_t + A_3 Y_{t-1} + A_4 \triangle P_t + A_5 P_{t-1}$$

Primary interest centres on the structural rather than the estimated parameters of this reduced form. However, they can be easily recovered.[18] The

[18] Specifically they are:

$$\alpha = \frac{2A_0(A_2-\frac{1}{2}A_3)}{A_3(A_1+1)}$$

$$\beta = \frac{2(A_1-1)}{A_1+1} + \delta$$

$$\gamma = \frac{2(A_2-\frac{1}{2}A_3)}{A_1+1}$$

$$\eta = \frac{2(A_4-\frac{1}{2}A_5)}{A_1+1}$$

$$\delta = \frac{A_3}{A_2-\frac{1}{2}A_3} = \frac{A_5}{A_4-\frac{1}{2}A_5}$$

δ is here over-identified.

introduction of a stochastic error term does, however, pose problems. If the stochastic term introduced into relation II is non-autocorrelated, then the error term in the estimating Equation IV *is* autocorrelated (Houthakker and Taylor 1970, p. 23). It follows that the least squares estimates will not even be consistent because of the presence of lagged values of the dependent variables in Equation IV.[19] This is further aggravated by the fact that, on those occasions where lagged values of the endogenous variable are included in the regression equation, the Durbin-Watson statistic is asymptotically biased towards the no-autocorrelation value (Nerlove and Wallis 1966). Houthakker and Taylor attempted to correct for this and concluded that, on the assumption of zero residual autocorrelation, the expected value of the Durbin-Watson statistic lies between 2.8 and 3.0.

With these reservations in mind, consider the following regression equation for beer:

$$(40)\quad X_{1,\,t} = \underset{(0.833)}{0.0306} + \underset{(3.441)}{0.7138}X_{1,\,t\text{-}1} + \underset{(2.004)}{0.00076}\triangle Y_{2,\,t} + \underset{(1.821)}{0.00030}Y_{2,\,t\text{-}1}$$

$$\bar{R}^2 = 0.946;\ SE = 0.008;\ F = 124;\ DW = 2.2;\ \chi^2\,(3) = 1.35$$

$$\alpha = 0.07249;\ \beta = 0.1577;\ \delta = 0.4918;\ \gamma = 0.000712;\ \varepsilon_\gamma = 0.4475;$$

$$\gamma' = 0.00105;\ \varepsilon_\gamma{}' = 0.6588$$

A few words of explanation are required. X_1 refers to beer consumption (standard barrels); t is a time subscript; the income variable (Y_2) is non-agricultural income which, on testing, again emerged as the most useful income-expenditure variable; α, β, γ and δ are the structural coefficients as defined above, γ' refers to the long-run income coefficient, the derivation of which can be obtained in Houthakker and Taylor (1970, p. 18). Basically, it allows for adjustments in stocks consequent upon a price-income change. Finally, ε refers in general to an elasticity, with the subscript denoting the specific elasticity in question. It should be noted that, in order to meet the requirements of the Houthakker-Taylor model, the linear, rather than the double-logarithmic form, has been applied.

On a general level the equation is a good fit, although the value of the Durbin-Watson statistic leaves something to be desired in the light of earlier discussion. Further, the χ^2 statistic again indicates the presence of multicollinearity. The value of β is positive, pointing to the existence of habit formation. This is an intuitively satisfying result. δ is also positive, as would be expected: however, the value of this coefficient is considerably less than the value recorded by Houthakker and Taylor in their regression equation for alcoholic beverages—a high value of δ emphasises the non-durability of the good under consideration

[19] Houthakker and Taylor recommend tackling the existence of auto-correlation by using three pass least squares (3 PLS) instead of ordinary least squares. Wallis has pointed out that the assumptions behind 3 PLS are highly restrictive and that, therefore, the method has but limited applicability. The interested reader might refer to Taylor and Wilson (1964), Wallis (1967).

(1970, p. 61). The short-run income elasticity, although a bit on the low side at 0.45, is similar in magnitude to the result recorded in Equation 4 above, where the dependency ratio is also excluded. The corresponding long-run elasticity is higher, an interesting result which highlights the relevance of the stock variable.

The price variables, as can be seen from Equation 41, Table 3, had nothing significant to add to Equation 40 above. It should be noted, however, that the coefficients of the price variables were consistently negative in the regressions run, a more acceptable result than that observed in the earlier part of the paper. The dependency ratio D_1 was also included in the estimating equation. That this is a valid exercise can be seen by examining Houthakker and Taylor's regression equation for alcoholic beverages where they include the percentage of the population over eighteen as a separate regressor (1970, p. 61). This resulted in the following equation:

$$(42)\quad \underset{}{X_{1,\,t}} = \underset{(3.457)}{0.237} + \underset{(0.851)}{0.194\, X_{1,\,t\text{-}1}} + \underset{(1.725)}{0.00053\, \Delta Y_{2,\,t}} + \underset{(4.034)}{0.00091\, Y_{2,\,t\text{-}1}} \underset{(-\,3.333)}{-\,0.09996\, D_1}$$

$$\bar{R}^2 = 0.966;\ SE = 0.0065;\ F = 148;\ DW = 1.84;\ \chi^2\,(6) = 0.247$$

The D_1 variable performs quite well here—the implied elasticity of $-\,0.493$ is not too unreasonable in the light of earlier work. However, the structural coefficients, when recovered, tended to be meaningless—e.g. $\beta = 10$. Further, the Durbin-Watson statistic points to autocorrelation which, in conjunction with the low value of the χ^2 statistic, implies that this equation is of little value for deriving structural parameters.

The following is an example of a corresponding spirits regression equation:

$$(45)\quad X_{3,\,t} = \underset{(1.602)}{0.155} + \underset{(3.860)}{0.742\, X_{3,\,t\text{-}1}} + \underset{(4.125)}{0.0029\, \Delta Y_{2,\,t}} + \underset{(1.785)}{0.0009\, Y_{2,\,t\text{-}1}} \underset{(-\,3.152)}{-\,0.0042\, \Delta P_{2,\,t}} \underset{(-\,1.828)}{-\,0.0024\, P_{2,\,t\text{-}1}}$$

$$\bar{R}^2 = 0.965;\ SE = 0.0151;\ F = 117;\ DW = 2.10;\ \chi^2\,(10) = 0.1605$$

$$\alpha = 0.482;\ \beta \doteqdot 0.29;\ \delta \doteqdot 0.6;\ \gamma = 0.0028;\ \eta = -\,0.0035;$$

$$\gamma' = 0.0035;\ \eta' = 0.0058;\ \varepsilon_\gamma = 1.644;\ \varepsilon_\eta = -\,1.043;$$

$$\varepsilon_\gamma{}' = 2.058;\ \varepsilon_\eta{}' = -\,1.738$$

X_3 is our spirits variable (proof gallons). Price variables (as defined in the earlier part of the paper) have been included, which accordingly increases the number of structural parameters and elasticities (both short and long run) – η and η' are, respectively, the short run and long run price coefficients associated

TABLE 3: Parameter Estimates for Beer and Spirits Regression

Equation	Dependent	Intercept	Dependent lagged	$\Delta Y_{2,t}$	$Y_{2,t-1}$	$\Delta P_{1,t}$	$P_{1,t-1}$	$\Delta P_{2,t}$
40	X_1	0.0306	0.714	0.0008	0.0003			
		(0.833)	(3.441)	(2.004)	(1.821)			
41	X_1	0.049	0.827	0.0009	0.0006	–0.001	–0.001	
		(1.253)	(3.849)	(2.041)	(2.457)	(–1.569)	(–1.519)	
42	X_1	0.237	0.194	0.0005	0.0009			
		(3.457)	(0.851)	(1.725)	(4.034)			
43	X_1	0.228	0.291	0.005	0.001	–0.007	–0.0005	
		(3.281)	(1.137)	(1.602)	(4.149)	(–1.322)	(–0.851)	
44	X_3	–0.030	0.798	0.003	0.0004			
		(–1.340)	(4.579)	(3.894)	(1.345)			
45	X_3	0.155	0.742	0.003	0.0009			–0.004
		(1.602)	(3.860)	(4.125)	(1.785)			(–3.152)
46	X_3	0.286	0.130	0.003	0.002			
		(2.269)	(0.427)	(3.547)	(2.929)			
47	X_3	0.585	–0.175	0.002	0.003			–0.003
		(3.643)	(–0.518)	(3.465)	(3.736)			(–2.517)

TERMINOLOGY

Reduced Form Variables

X_1 = Beer consumption *per capita* (standard barrels)

X_3 = Spirits consumption *per capita* (proof gallons).

$Y_{2,t-1}$ = non-agricultural real personal disposable income *per capita*, lagged

$\Delta Y_{2,t} = Y_{2,t} - Y_{2,t-1}$

$P_{1,t-1}$ = Index of beer price relative to the price of personal consumption expenditure, lagged

$\Delta P_{1,t} = P_{1,t} - P_{1,t-1}$

$P_{2,t-1}$ = Index of spirits price relative to the price of personal consumption expenditure, lagged

$\Delta P_{2,t} = P_{2,t} - P_{2,t-1}$

D_1 = Employment Dependency Ratio

EQUATIONS 1949-1970 HOUTHAKKER-TAYLOR MODEL

$P_{2,t-1}$	D_1	$\bar{R}^2$	S.E.	F	D.W.	IZ'ZI	$\chi^2(v)$	Equation
		0.946	0.008	124	2.2	0.068	1.35(3)	40
		0.949	0.008	79	2.31	0.0027	0.05(10)	41
	−0.100 (−3.333)	0.966	0.007	148	1.84	0.013	0.25(6)	42
	−0.092 (−2.909)	0.965	0.007	98	1.93	0.0005	0.009(15)	43
		0.948	0.0184	128	2.40	0.092	1.85(3)	44
−0.002 (−1.828)		0.965	0.015	117	2.10	0.009	0.16(10)	45
	−0.274 (−2.536)	0.960	0.016	127	1.84	0.008	0.15(6)	46
−0.004 (−3.201)	−0.300 (−3.067)	0.977	0.012	150	1.67	0.0006	0.01(15)	47

TABLE 4: PARAMETER ESTIMATES FOR BEER AND SPIRITS REGRESSION

Equation	Dependent	Intercept	Dependent lagged	$Y_{2,t} + Y_{2,t-1}$	$P_{1,t} + P_{1,t-1}$	$P_{3,t} + P_{3,t-1}$	D_1	θ
48	X_1	0.054 (1.619)	0.554 (3.092)	0.0002 (3.453)				0.574
49	X_1	0.074 (2.017)	0.642 (3.377)	0.0003 (3.246)	–0.0004 (–1.250)			0.436
50	X_1	0.245 (4.421)	0.163 (0.960)	0.0005 (5.859)			–0.103 (–3.874)	1.439
51	X_1	0.244 (4.317)	0.212 (1.095)	0.0005 (5.373)	–0.0002 (–0.565)		–0.098 (–3.496)	1.301
52	X_3	–0.051 (–1.952)	0.542 (2.814)	0.0005 (3.177)				0.594
53	X_3	0.281 (2.545)	0.296 (1.647)	0.001 (4.762)		–0.002 (–3.069)		1.087
54	X_3	0.396 (3.534)	–0.209 (–0.893)	0.002 (5.531)			–0.376 (–4.054)	3.058
55	X_3	0.669 (6.735)	–0.386 (–2.291)	0.002 (9.078)		–0.002 (–4.462)	–0.352 (–5.416)	4.51

TERMINOLOGY

Reduced Form Variables

X_1 = Beer consumption *per capita* (standard barrels)

X_3 = Spirits consumption *per capita* (proof gallons)

$Y_{2,t} + Y_{2,t-1}$ = Sum of current and lagged non-agricultural real personal disposal income *per capita*

$P_{1,t} + P_{1,t-1}$ = Sum of current and lagged indices of beer prices relative to the price of personal consumption expenditure

$P_{3,t} + P_{3,t-1}$ = Sum of current and lagged indices of spirits prices relative to the price of personal consumption expenditure

EQUATION 1949-1970 BERGSTROM (FLOW ADJUSTMENT) MODEL

ξ	μ	ζ	R^2	SE	F	DW	IZ'ZI	$\chi^2(v)$	Equation
0.122	0.001		0.943	0.008	176	1.83	0.118	2.45(1)	48
0.207	0.0018	–0.0022	0.945	0.008	121	1.94	0.006	0.12(3)	49
0.292	0.0011		0.967	0.006	209	1.78	0.027	0.52(3)	50
0.309	0.0012	–0.00038	0.966	0.006	151	1.84	0.001	0.02(6)	51
–0.112	0.0023		0.921	0.023	123	1.61	0.141	2.96(1)	52
0.399	0.003	–0.0064	0.945	0.019	121	1.64	0.023	0.45(3)	53
0.478	0.0025		0.956	0.017	154	1.32	0.019	0.37(3)	54
0.483	0.0028	–0.0029	0.979	0.012	242	1.97	0.003	0.06(6)	55

Structural Parameters

θ = adjustment coefficient

ξ = intercept

μ = income variable coefficient

ζ = own-price coefficient

with the structural equation. Further, due to over-identification, it was necessary to approximate δ by a simple averaging process. As the value of δ affects the value of β, the approximate nature of the β estimate presented here should also be recognised.

The overall fit of the equation is again quite satisfactory—three of the variables are highly significant. However, the value of the χ^2 statistic is very low. As far as individual coefficients are concerned, β is again positive as expected. The short run income and price elasticities at 1.6 and -1.0 respectively are of the right order of magnitude in the light of earlier work. The corresponding long-run elasticities are again considerably greater in absolute terms, particularly so in the case of the price elasticity. An attempt was then made to introduce the dependency ratio into Equation 45. The resulting equation was, however, untenable—individual elasticities seemed highly implausible and the Durbin-Watson statistic was a low 1.67.

The primary value of the equations presented immediately above is that they emphasise the necessity of considering dynamic elements even when examining the demand functions of non-durable goods—the presence of positive β coefficients provides clear proof of the worth of the approach. Further, it may be observed that the substantive conclusions arrived at in earlier sections of the paper still stand and, in particular, that the demand for spirits is considerably more income elastic than the demand for beer. Given this latter finding, it would appear that the use of total alcohol as a dependent variable—as in the Houthakker-Taylor study (1970, p. 61), is inappropriate.

15 The Bergstrom (Flow Adjustment) Model

Houthakker and Taylor experienced difficulties when they applied the basic dynamic equation described above to some commodities. To counter these difficulties, an alternative model—the Bergstrom model—was fitted (Houthakker and Taylor 1970, pp. 26-9). This alternative formulation was also tested here.

In the Bergstrom model, as Houthakker and Taylor remark (1970, p. 26), ' the dynamics of consumption are viewed as an attempt on the part of consumers to bring their actual consumption closer to some desired level ' where the desired level is determined by such factors as the consumer's income and the price of the good in question. Thus we have:

$$\text{(V)}\quad \frac{dq}{dt} = \theta\,(\hat{q} - q)$$

$$\text{(VI)}\quad \hat{q} = \xi + \mu y + \zeta p$$

where $\hat{q}$ is the desired level of consumption and q is the actual level; y refers to income-expenditure, p to own price; θ is the adjustment coefficient gauging the rate at which the discrepancy between desired and actual levels of consumption is closed. From this, they derive the estimating equation:

$$\text{(VII)}\ q_t = A^*_0 + A^*_1 q_{t-1} + A^*_2 (Y_t + Y_{t-1}) + A^*_3 (P_t + P_{t-1})$$

from which it is possible to recover the original coefficients. Although this equation may be run in double-logarithmic form, the linear form is used here. Thus, a representative beer regression result is:

$$\text{(48)}\ \underset{}{X_{1,t}} = \underset{(1.619)}{0.0544} + \underset{(3.092)}{0.554\, X_{1,\,t-1}} + \underset{(3.453)}{0.00023\, (Y_{2,\,t} + Y_{2,\,t-1})}$$

$$\bar{R}^2 = 0.943;\ SE = 0.0084;\ F = 176;\ DW = 1.83;\ \chi^2\,(1) = 2.45$$

The dependent variable is again *per capita* consumption of beer (standard barrels) and the income variable is non-agricultural income as defined earlier (price has again been excluded). From this equation we obtained the following:

$$\hat{q} = 0.122 + 0.001\ y$$

with $\theta = 0.57$ and $\varepsilon_{\mu} = 0.647$. This is quite satisfactory. In particular, the income elasticity is, at 0.65, much in line with our earlier experience. Further, we now have the additional information that the value of the adjustment coefficient (θ) is quite high indicating a fairly rapid response to the emergence of any discrepancy between desired and actual levels of consumption.

A corresponding spirits regression equation is:

$$\text{(53)}\ X_{3,\,t} = \underset{(2.545)}{0.281} + \underset{(1.647)}{0.296\, X_{3,\,t-1}} + \underset{(4.762)}{0.001\, (Y_{2,\,t} + Y_{2,\,t-1})} \underset{(-3.069)}{-0.0022\, (P_{2,\,t} + P_{2,\,t-1})}$$

$$\bar{R}^2 = 0.945;\ SE = 0.0189;\ F = 121;\ DW = 1.64;\ \chi^2\,(3) = 0.45$$

whence it follows that:

$$\hat{q} = 0.399 + 0.003\ y - 0.006\ p$$

with $\theta = 1.09$; $\varepsilon_{\eta} = 1.7$; $\varepsilon_{\eta} = -1.9$.

The price elasticity of -1.9 is high by reference to earlier estimates whereas the income elasticity of 1.7 is of the right order of magnitude. The value of the adjustment coefficient is not only greater than that recorded in the beer regression above but is also marginally in excess of unity suggesting over-compensation. However, in view of the presence of multicollinearity, it is perhaps only safe to conclude that spirits consumption responds more rapidly than beer consumption to any inconsistency between desired and actual levels of consumption.

16 Prediction of Consumption in 1971

The various models introduced above were used as predictors of consumption in 1971. The resulting predictions, which may be compared with the outcome, are presented in Table 5.

TABLE 5: Consumption of beer (standard barrels *per capita*) and spirits (proof gallons *per capita*) in 1971.

	Amount	Percentage Change on 1970
Actual		
Beer	0.441	+ 5.9
Spirits	0.584	+ 7.0
Double—logarithm A		
Beer (Equation 9)	0.398	— 4.3
Spirits (Equation 30)	0.551	+ 0.9
Double—logarithm B		
Beer (Equation 9)	0.420	+ 1.0
Spirits (Equation 30)	0.572	+ 4.8
First differences (double-log)		
Beer (Equation 38)	0.421	+ 1.2
Spirits (Equation 39)	0.569	+ 4.2
Houthakker-Taylor		
Beer (Equation 40)	0.421	+ 1.2
Spirits (Equation 45)	0.582	+ 6.6
Bergstrom		
Beer (Equation 48)	0.422	+ 1.6
Spirits (Equation 53)	0.573	+ 4.9

Notes—The double logarithm B calculations differ from the double logarithm A calculations in that, in the latter, the predictions are based on actual consumption in 1970 rather than on predicted consumption in 1970.

The predictions of beer consumption are uniformly poor while those of spirits consumption, although not so deficient, still leave much to be desired. The predictions based on the Houthakker-Taylor model are markedly superior to those based on the double-logarithmic formulation (Type A). However, the bad forecasting power of the double-logarithmic equations appears, on this occasion, to be due to the large discrepancy which emerged between actual and estimated consumption for 1970. This problem may be alleviated by using the double logarithmic formulation (Type B), which corrects for the 1970 discrepancy.

Predictions based on this latter method are, of course, similar to predictions based on first difference equations. Neither the Houthakker-Taylor nor the Bergstrom formulations are so seriously affected by these considerations since the presence of lagged values of the dependent variable amongst the regressors would tend to correct for any difference between predicted and actual consumption in 1970. Further, too much store should not be placed on the results for one year. Although the Houthakker-Taylor model here appears to be more useful as a predictor, it is still argued that the double-logarithmic equations introduced in the first part of the paper were more useful as indicators of the relevant parameters in empirical demand analysis. Finally, it should be noted that, on examining other equations, it emerged that the poor prediction results presented in Table 5 are not contingent on either the choice of equation or the choice of dependent variable.

17 Conclusion

Some of the findings uncovered in this paper may be considered a further substantiation of Walsh and Walsh's earlier work. The evidence suggests that the (own) price elasticity of demand for spirits is significant at about −0.9 whereas the corresponding elasticity for beer is not significant. One implication of this is that if the authorities are concerned about tax revenue, given that the proportion of the retail price devoted to taxation is roughly the same for both commodities, they should concentrate on taxing beer rather than spirits. However, it is a corollary of the relatively small (own) price elasticity of demand for beer that such a policy would also result in a more rapid rise in the proportion of the average consumer's budget being devoted to alcohol consumption than would be the case if spirits consumption were taxed more heavily. The social ramifications of this repercussion could be undesirable particularly in view of the fact that, as Walsh and Walsh (1970) remark, beer is the poor man's drink.

It also emerged in the course of the work that the relevant disposable income elasticities, both of which are significant, are such as to suggest that beer consumption does not react strongly to income changes whereas spirits consumption does. From this it may be construed that, as income rises in the future, spirits consumption will tend to increase more rapidly than beer consumption. The health implications of such a trend might be viewed with considerable disquiet in some quarters.[20]

Considerable effort has been devoted to alleviating the many problems implied by aggregation, both over individuals and over commodities. Thus, it is asserted that the division between agricultural income and non-agricultural income is advisable and that, further, variables such as the dependency ratio have a crucial role to play in demand analysis. It has also been argued that the definition of the dependent variable is not a matter of indifference. Further, the recurrent role of the dynamic aspects of demand analysis is impressive. This is epitomised by the presence of phenomena such as habit formation.

[20] See Walsh and Walsh (1973) for a further discussion of this subject.

APPENDIX TABLE A: Data for Regression Equations[1]

	X_1	X_2	X_4	X_3	X_5	Y_1	Y_2	Y_3	Y_4	y_1	y_2	P_1	P_2	D_1	D_2	U	S
	Standard brls.	Bulk brls.	£	Proof gals.	£	£	£	£	£	%	%	1958 = 100				%	
1948	0.302	0.398	8.58	0.294	4.04	144.0	157.0	114.9		105.03	102.75	97.33	91.77				
1949	0.302	0.394	8.50	0.303	4.17	155.4	167.2	128.5	144.4	107.92	106.50	93.81	94.02	1.43	1.32	9.0	1042.21
1950	0.302	0.382	8.24	0.328	4.52	158.3	175.1	119.5	148.6	101.87	109.72	91.75	96.52	1.42	1.32	7.5	1043.49
1951	0.322	0.400	8.61	0.332	4.57	158.0	173.2	122.2	149.1	98.81	98.91	92.69	97.69	1.43	1.35	7.3	1044.30
1952	0.301	0.369	7.94	0.260	3.58	158.4	168.0	135.6	143.7	100.25	97.00	101.77	104.52	1.47	1.35	9.1	1045.02
1953	0.297	0.362	7.80	0.267	3.69	164.5	171.9	146.4	148.5	103.85	102.32	102.28	103.47	1.53	1.40	9.6	1045.12
1954	0.297	0.361	7.85	0.289	3.89	164.7	177.0	134.3	151.2	100.12	102.97	101.75	102.87	1.53	1.39	8.1	1045.29
1955	0.306	0.370	8.26	0.296	4.14	171.2	180.5	148.0	160.0	103.95	101.98	100.16	100.43	1.55	1.42	6.8	1045.56
1956	0.310	0.370	8.24	0.283	3.94	168.9	184.6	129.7	157.0	98.66	102.27	100.55	102.14	1.58	1.44	7.7	1046.03
1957	0.300	0.358	8.28	0.266	3.76	170.2	180.9	142.7	154.8	100.77	98.00	100.81	101.42	1.66	1.48	9.2	1046.13
1958	0.293	0.348	8.03	0.276	3.93	167.3	183.7	125.5	161.0	98.30	101.55	100	100	1.67	1.50	8.6	1046.28
1959	0.303	0.359	7.96	0.288	4.09	177.9	192.8	139.3	163.1	106.34	104.95	101.60	100.86	1.68	1.52	8.0	1046.05
1960	0.307	0.364	8.49	0.307	4.23	186.7	203.4	142.9	173.0	104.95	105.50	102.70	107.89	1.68	1.53	6.7	1046.50
1961	0.327	0.387	8.93	0.365	4.73	198.2	216.4	150.0	179.3	106.16	106.39	101.20	107.90	1.68	1.54	5.7	1046.49
1962	0.328	0.391	8.93	0.346	5.52	204.2	223.6	151.1	185.2	103.03	103.33	112.14	113.44	1.67	1.54	5.7	1046.10
1963	0.336	0.407	9.12	0.367	5.35	208.1	230.4	146.1	191.4	101.91	103.04	113.60	113.52	1.67	1.54	6.1	1045.38
1964	0.348	0.426	9.51	0.398	5.62	222.5	242.6	164.6	199.0	106.92	105.30	117.59	112.51	1.67	1.55	5.7	1044.93
1965	0.351	0.435	9.59	0.412	6.01	223.5	244.5	160.9	199.9	100.49	100.78	118.84	112.57	1.69	1.57	5.6	1044.32
1966	0.353	0.449	9.86	0.406	5.67	226.4	252.3	148.1	203.9	101.32	103.21	123.47	115.70	1.71	1.58	6.1	1043.26
1967	0.359	0.461	10.30	0.412	5.93	233.8	257.4	160.2	209.8	103.26	102.01	126.38	116.37	1.73	1.59	6.7	1042.83
1968	0.374	0.484	11.12	0.457	6.76	251.7	274.9	177.9	226.1	107.67	106.78	125.78	111.53	1.73	1.58	6.7	1042.47
1969	0.402	0.527	11.53	0.510	7.35	261.9	289.4	172.1	233.6	104.06	105.30	135.53	113.50	1.72	1.58	6.4	1041.94
1970	0.416	0.550	12.17	0.594	8.21	268.4	296.1	173.1	238.3	102.46	102.31	135.93	113.73	1.76	1.60	7.2	1041.64

[1] See Notes on Sources and Methods following for the explanation and derivation of these variables.

APPENDIX TABLE B: Correlation Matrix of Variables[1] (1949-70)

	X_1	X_2	X_4	X_3	X_5	X_6	Y_1	Y_2	Y_3	Y_4	y_1	$y_{1,\,t-1}$	y_2	$y_{2,\,t-2}$	P_1	P_2	D_1	D_2	U
X_2	0.98																		
X_4	0.99	0.98																	
X_3	0.97	0.96	0.97																
X_5	0.97	0.95	0.97	0.99															
X_6	−0.91	−0.91	−0.91	−0.98	−0.96														
Y_1	0.94	0.88	0.94	0.93	0.94	−0.87													
Y_2	0.95	0.89	0.94	0.94	0.95	−0.89	0.997												
Y_3	0.82	0.75	0.81	0.77	0.78	−0.69	0.90	0.87											
Y_4	0.94	0.88	0.94	0.93	0.94	−0.88	0.996	0.997	0.88										
y_1	0.21	0.23	0.26	0.28	0.25	−0.32	0.29	0.26	0.43	0.27									
$y_{1,\,t-1}$	0.31	0.32	0.32	0.43	0.41	−0.50	0.26	0.29	0.11	0.27	0.11								
y_2	0.23	0.23	0.27	0.36	0.32	−0.45	0.32	0.33	0.26	0.33	0.75	0.46							
$y_{2,\,t-1}$	0.44	0.42	0.44	0.54	0.53	−0.59	0.38	0.40	0.23	0.39	0.20	0.73	0.32						
P_1	0.91	0.87	0.90	0.86	0.88	−0.77	0.96	0.95	0.89	0.95	0.16	0.15	0.17	0.21					
P_2	0.76	0.66	0.72	0.72	0.74	−0.65	0.88	0.88	0.82	0.87	0.12	0.15	0.13	0.23	0.89				
D_1	0.63	0.50	0.63	0.60	0.62	−0.53	0.82	0.81	0.76	0.82	0.17	−0.01	0.24	0.14	0.78	0.80			
D_2	0.71	0.58	0.70	0.69	0.71	−0.63	0.88	0.88	0.79	0.88	0.20	0.06	0.26	0.22	0.82	0.86	0.98		
U	−0.58	−0.47	−0.53	−0.66	−0.66	0.74	−0.67	−0.69	−0.53	−0.68	−0.22	−0.45	−0.37	−0.63	−0.52	−0.70	−0.53	−0.65	
S	−0.69	−0.82	−0.73	−0.70	−0.68	0.68	−0.52	−0.52	−0.40	−0.51	−0.23	−0.28	−0.21	−0.23	−0.55	−0.23	−0.05	−0.11	0.06

[1] See Notes on Sources and Methods following for the explanation of these variables.

Note: The correlations are based on the logarithmic rather than the linear form of the variables.

In conclusion, it is argued that this paper represents something of an addition to the practical type of knowledge required for the successful estimation of demand equations in Ireland. It also spells out, perhaps in greater detail than is normal, the theoretical underpinnings of the estimating equations used. Some important deficiencies remain, however. Mention has already been made of the statistical problems posed by multicollinearity. To this might be added the fact that it proved impossible to take account of the effect of advertising expenditure. Moreover a single equation model of consumer demand may be inadequate. Nonetheless, it is felt to be a step in the right direction.

Notes on Sources and Methods

X_1: Beer *per capita* (standard barrels)

The Revenue Commissioners make available estimates of the quantities of beer 'retained for home use' in each *fiscal* year. Source: *Annual Reports of the Revenue Commissioners*, 1950-1970. A simple averaging process was employed to translate these estimates to a calendar year basis. Thus, for example, consumption in the calendar year 1949 was defined to be equal to one quarter of consumption in the fiscal year 1948-49 plus three quarters of consumption in the fiscal year 1949-50.

The Revenue Commissioners also supplied us with a quarterly series dating back to 1960—quarterly data are not available for earlier years. The annual figures derived from this series do not differ much in absolute terms from our estimates. Further, on the few occasions on which a discrepancy does emerge—the most significant being estimated spirits consumption in 1962—there are grounds for believing that this may have been the product of stockbuilding in anticipation of budget changes. Such a phenomenon has little to do with alcohol *consumption* by individuals. Further, on inspecting regression results run for the decade 1960-70, it emerged that the coefficient values and the significance levels of the regressors were substantially unaffected by the choice between the two series. Accordingly, the series based on the averaging process is used throughout.

The basic unit of measurement of beer used by the Revenue Commissioners is the 'standard barrel', i.e. thirty-six gallons at a gravity of 1055°. Since specific gravity is the most reliable indicator of relative alcohol content, the use of the standard barrel represents an attempt to express a variety of beers in terms of a single alcohol strength. The population figures used here and elsewhere to derive *per capita* data are April (mid-year) estimates. Source: *Report on Vital Statistics* and *Census of Population* series.

X_2: Beer *per capita* (bulk barrels)

This represents the quantity of beer 'retained for home use' before correction for alcohol content. It is estimated here by reconverting the quantity of standard barrels (X_1) using the estimate of the average specific gravity of beer as provided by the Revenue Commissioners each year.

X_3: Spirits *per capita* (proof gallons)

This variable, which measures the physical quantity of spirits consumed per head in a calendar year, was derived in a manner strictly analogous to X_1 above.

Source: *Annual Reports of the Revenue Commissioners*, 1950-1970.

X_4: Deflated expenditure on beer *per capita*

The C.S.O. made available estimates of personal expenditure (in current prices) on beer for each year from 1953. This was deflated by the current retail beer price index, the derivation of which is described below. Estimates were derived for the years 1949 to 1953 by imputing to the deflated expenditure data the same annual rates of change as had actually occurred in the physical quantity series (standard barrels) in those years.

X_5: Deflated expenditure on spirits *per capita*

This was estimated in precisely the same way as X_4 above.

X_6: Ratio of beer consumption (standard barrels) to spirits consumption (proof gallons)

This is the ratio of X_1 to X_3.

Y_1: Total real personal disposable income *per capita*

Total personal disposable income per head deflated by the implicit price of personal consumption.

Source: *National Income and Expenditure* (*N.I.E.*) 1969 and 1970.

Y_2: Non-agricultural real personal disposable income *per capita*

This was defined as total personal disposable income less farmers' personal income, deflated by the implicit price of personal consumption and divided by the estimated non-agricultural population. The latter is taken to be total population less estimated farm population (see below for the estimation of the latter). This variable *includes* income received by farmers from non-agricultural sources. It may be noted that in Ireland farmers generally do not pay income tax on income from agriculture.

Source: *N.I.E.* 1969 and 1970.

Y_3: Farmers' real personal income *per capita*

Farmers' personal income is defined to be equal to income from agriculture minus payments to farm employees and contributions to social insurance. This was deflated by the implicit price of personal consumption and divided by the estimated farm population. Estimates of the latter are available for Census of Population years. Estimates for intercensal years were based on changes in total population and in the estimated number of family farm workers, this last series being obtained from the C.S.O. Thus, population declined less rapidly than employment and we used this fact to correct our estimates of the decline in farm population implied by the fall in family farm workers.

Source: *N.I.E.* 1969 and 1970, *Census of Population*, and *Report on Vital Statistics.*

Y_4: Volume of consumption *per capita*

This is total personal expenditure on consumer goods and services deflated by the implicit price of personal consumption, expressed in *per capita* terms.

Source: *N.I.E.* 1969 and 1970.

y_1: Rate of change in total real personal disposable income *per capita*

Annual percentage changes of Y_1. For the logarithmic equations we added 100 to the percentage rate of change before taking the logarithm. The percentage rate of change was estimated in the logarithmic equations by taking the difference between, in this case log $Y_{1,\,t}$ and log $Y_{1,\,t\text{-}1}$.

$y_{1,\,t\text{-}1}$: y_1 lagged one year.

y_2: Rate of change in non-agricultural real personal disposable income *per capita*

Annual percentage changes of Y_2. See note on y_1.

$y_{2,\,t\text{-}1}$: y_2 lagged one year

P_1: Beer price (four quarter average) divided by the implicit price of personal consumption

The C.S.O. made available quarterly retail price indices dating from 1953 for various categories of beer. Using the weights assigned to these various categories in the Consumer Price Index, a weighted price index was derived for beer which was then averaged over the quarters to yield an annual beer price index. For the years 1949 to 1953, estimates of the retail price of a pint of stout, together with the timing of changes in that price, were obtained from trade sources, whence a price index, based on a quarterly average, was constructed. The price index was divided by the implicit price of personal consumption.

Source: *Irish Trade Journal and Statistical Bulletin*, December 1953, and *Irish Statistical Bulletin*, March 1969, for weights of various categories of beer.

P_2: Spirits price (four quarter average) divided by the implicit price of personal consumption.

Derived analogously to P_1 above.

D_1: Employment dependency ratio

Total population less the employed labour force divided by the employed labour force.

Source: *Report on Vital Statistics, Review of 1970 and Outlook for 1971.*

D_2: Labour force dependency ratio.

Total population less the total labour force divided by the total labour force.

Source: *Report on Vital Statistics, Review of 1970 and Outlook for 1971.*

U: Non-agricultural unemployment rate.

The unemployment rate is the number of insured persons on the Live Register as a percentage of insurance cards exchanged.

Source: *Trend of Employment and Unemployment* and *Irish Statistical Bulletin.*

S: Specific gravity of beer

The Revenue Commissioners supplied estimates of the average specific gravity of beer in each *fiscal* year. These estimates were translated into estimates on a calendar year basis by means of the same averaging process used in the derivation of the physical quantity data above.

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CHART I — Consumption of beer and spirits (quantity)

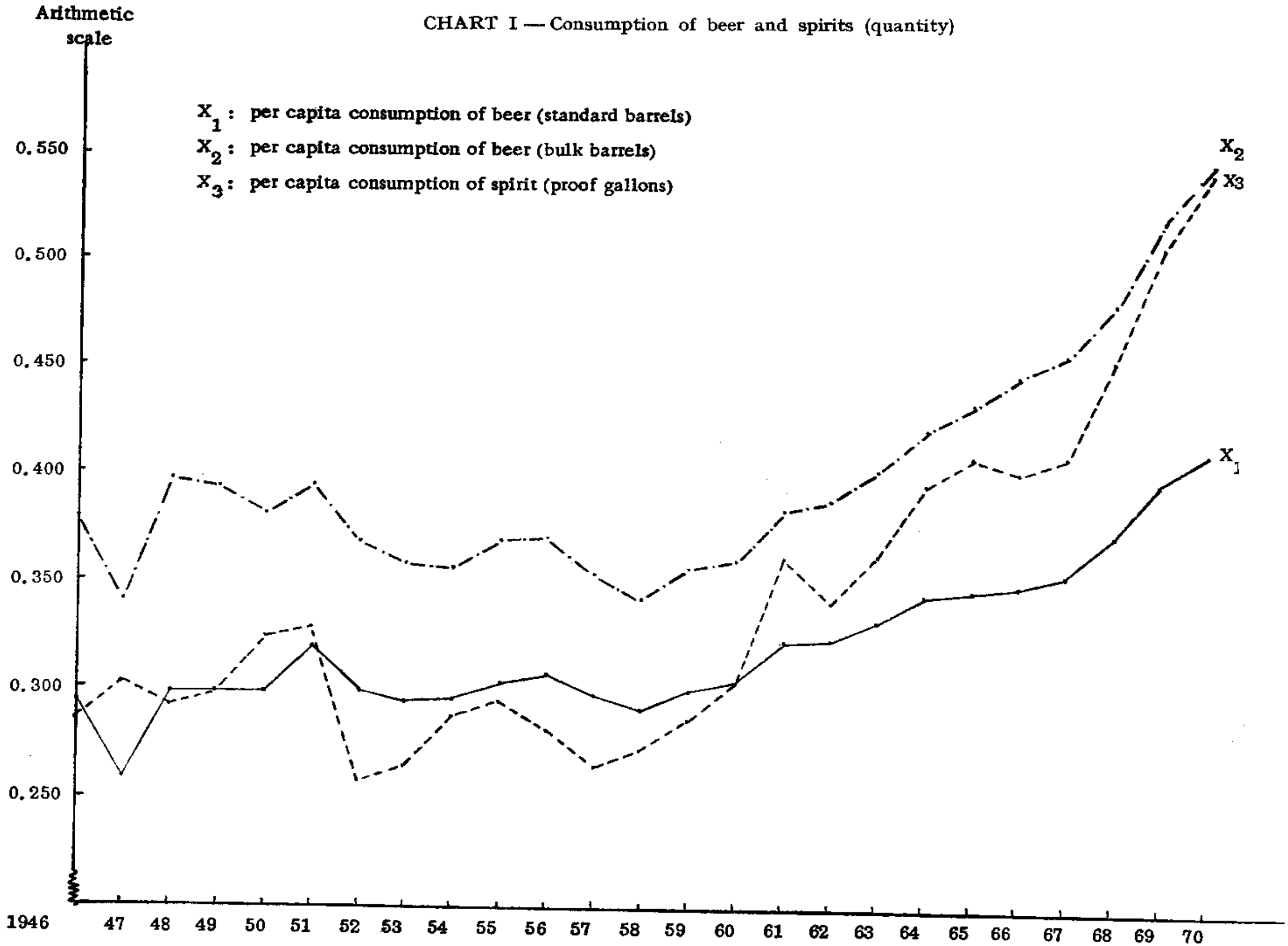


CHART II — Expenditure on beer and spirits in constant (1958) prices

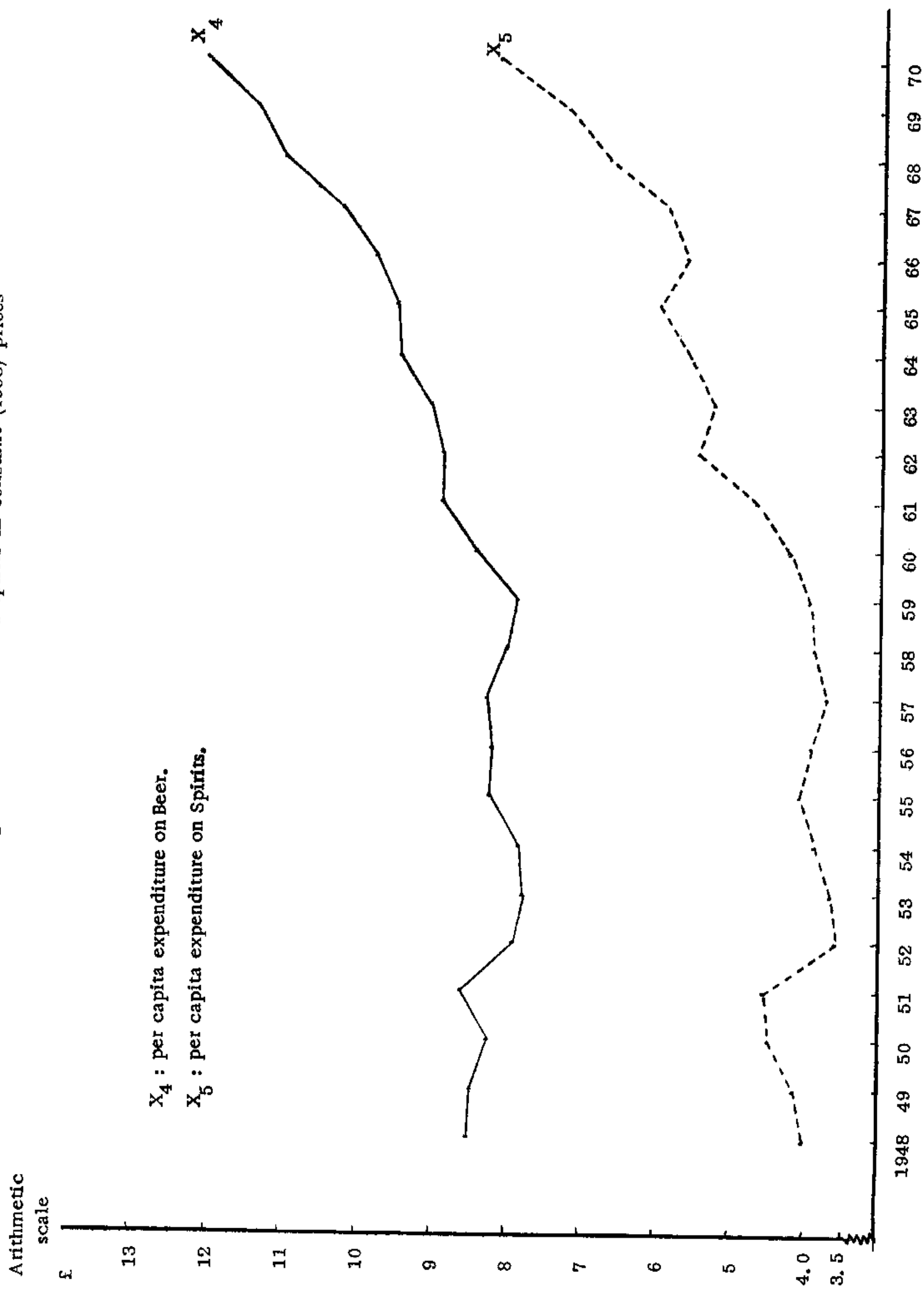
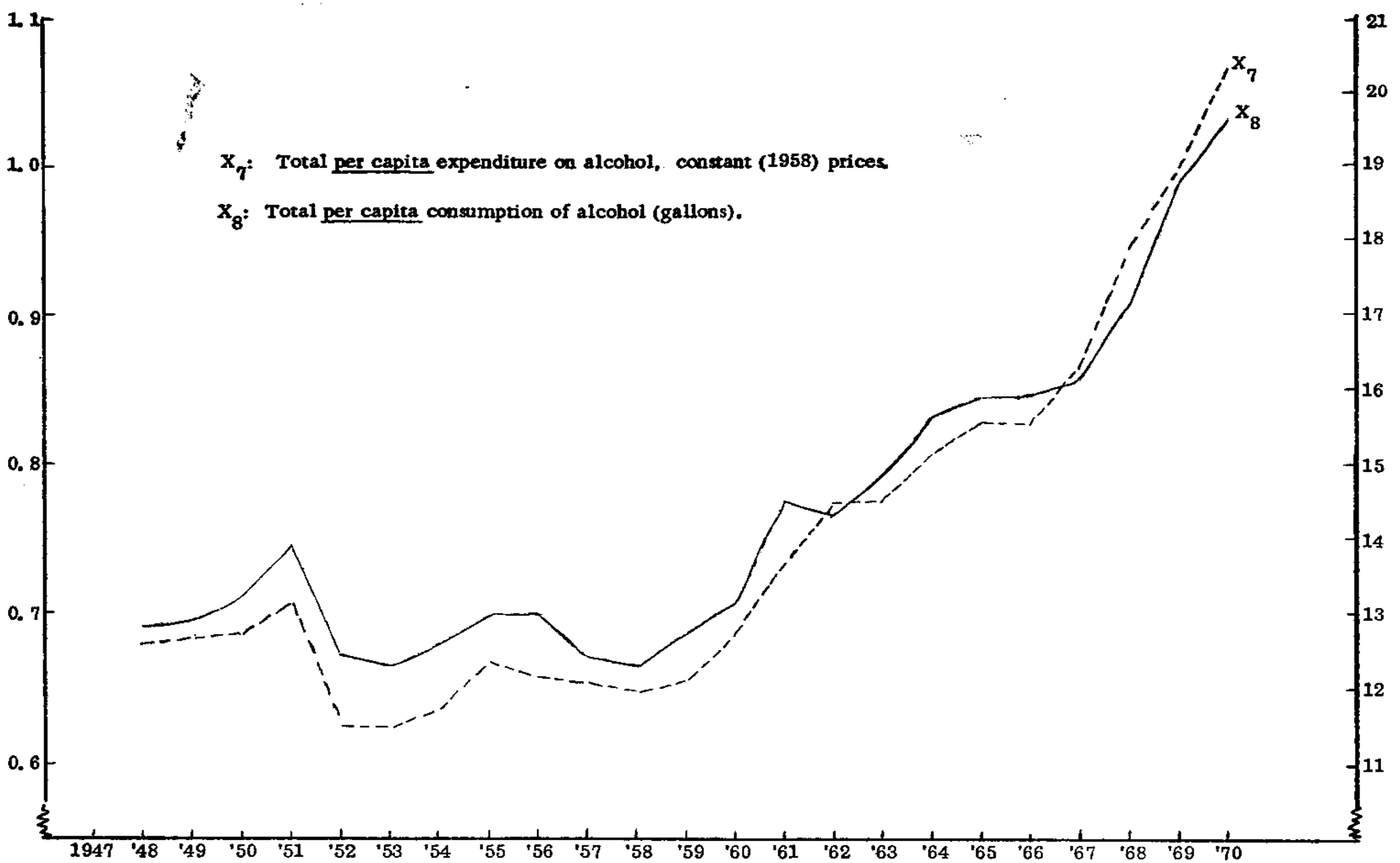


CHART III — Total consumption of alcohol



Note: To obtain total consumption of alcohol in gallons use was made of the fact that a standard barrel of beer contains 1.730 gallons of pure alcohol while a proof gallon of spirits contains 0.5725 gallons of pure alcohol.