HM Revenue & Customs

Knowledge, Analysis & Intelligence

Econometric Analysis of Alcohol Consumption in the UK

James Collis
Andrew Grayson
Surjinder Johal

December 2010

HMRC Working Paper 10

Econometric Analysis of Alcohol Consumption in the UK

James Collis
Andrew Grayson
Surjinder Johal
HM Revenue & Customs
100 Parliament Street, London, SW1A 2BQ

December 2010

Abstract

The main objective of this study is to estimate the price elasticity of demand for alcohols in the UK. The elasticities will be used to capture the behavioural impact from changes in the rates of UK alcohol duties on tax revenue. We have used a Tobit model to estimate data from the Expenditure and Food Survey. The motivation for pursuing Tobit originated with the difficulties in dealing with the large numbers of zero consumption observations reported in the survey. The results appear to be robust. We have been able to determine a full set of elasticities for both the on-trade and the off-trade and across all five major product categories: giving a total of 10 own-price elasticities and a further 90 cross-price elasticities. The own-price elasticities are all negative and highly significant. The income elasticities also appear to be sound. The results in this study mark a major improvement in level of detail that HMRC is able to employ within its alcohol costings model.

This work has benefited a great deal from the assistance of the following people: Thomas McGregor, Sourafel Girma, Magdalena Czubek, Nikolaos Spyropoulos and Thanos Alifantis.

1. Introduction

UK households spend around £15 billion a year on the consumption of alcoholic drinks, around 18% of their total expenditure on food and drink (ONS, 2010). In 2009-10 the UK Government generated £9 billion in receipts from alcohol duties, around 2% of the Government's total revenue from taxation. Receipts are fairly evenly split between beer (£3.2 billion), wine (£2.9 billion) and sprits (£2.6 billion). Cider has traditionally been a small component of total duty receipts (£300 million).

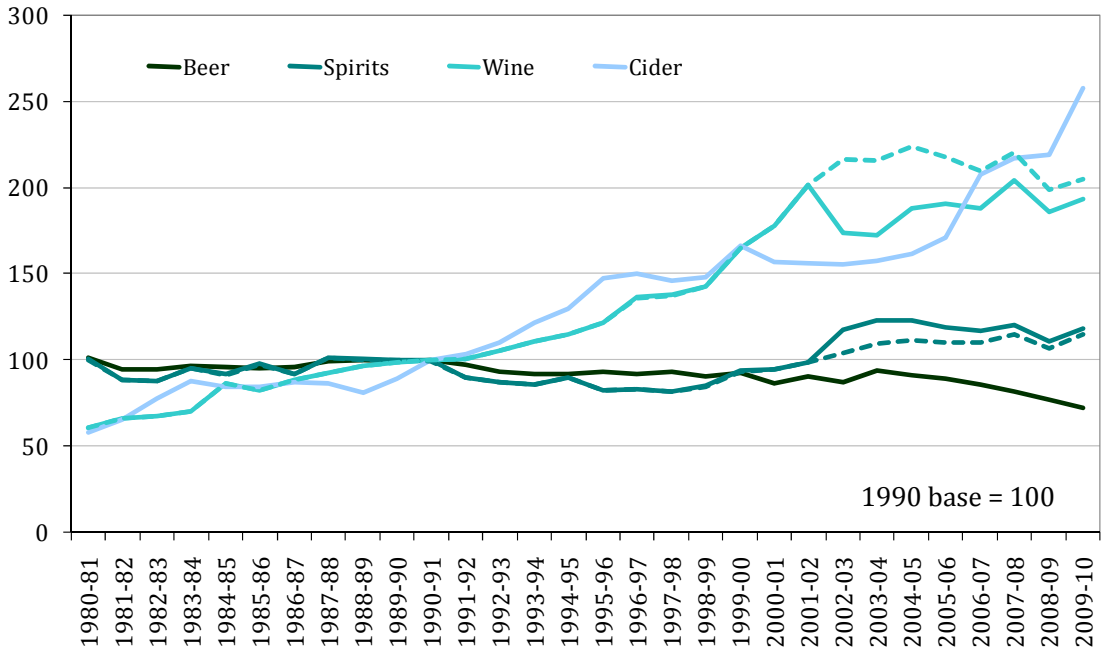
Figure 1 provides an indication of the change in drinking patterns over the past thirty years. The chart shows the trend in HM Revenue & Customs (HMRC) clearances for the four main alcohol groups. Clearances refer to all alcohol that has been cleared, after duty, by HMRC for consumption in the UK. To aid comparison across the types, the data is also indexed. It is clear that there has been a large and sustained increase in the consumption of wine and cider over this time period whilst there has been a steady decline in beer clearances. For most of the period up to 2000, spirits were also trending downward, since when they have risen quite significantly.

The other alcohol type studied in this paper is the 'ready-to-drink' (RTD) category. This covers a variety of drinks, often grouped together under the title of 'alcopops'. In tax terms, RTDs are captured in the wine and spirits categories. In 2002, some RTDs that were previously taxed at the wine duty rate were reclassified to fall under the spirits rate. This helps explain the dip in wine clearances and the spike in spirits clearances from that time. The dashed lines in the chart represent projections of the wine and spirits clearances if this reclassification had not taken place. Figure 7 in the Annex shows tax receipts across the different alcohols since 1993.

The other significant trend in recent decades has been the shift from buying and consuming drinks in pubs and restaurants (the on-trade) to buying them in off-licences and supermarkets (the off-trade) and consuming them at home. This is

true across all alcohol categories. The distinction between the on-trade and the off-trade is an important one. Whilst the amount of duty on a similar drink is the same whether it is sold in the on-trade or the off-trade, this does not mean that consumers will behave in the same way to a price change.

Figure 1 Indexed Alcohol Clearances



The main objective of this study is to estimate the price elasticity of demand for alcohols in the UK. HMRC uses these price elasticities within its alcohol costings model. The purpose of this model is to determine the impact on receipts from changes in the duty rates. It does this by determining the impact of the duty rate change on product prices and the resulting behavioural reaction from consumers. A duty increase will of course mean greater tax revenue for each unit that is sold. However, being a normal good, consumers will typically respond to a price rise by lowering their unit demand. The overall effect on tax revenue will be determined by the sum of these two opposing effects.

Price elasticities are only one of the inputs in the costings model. Other important parameters include the baseline forecast for alcohol receipts, the current duty and value added tax (VAT) rates, prices for the different alcohol products and other macroeconomic variables.

Previous HMRC estimates for alcohol demand were made by Chambers (1999) and Huang (2003). However, the scope of this study is wider than simply updating the results from those studies. For the first time we have been able to estimate a full set of demand elasticities across all five major product groups and for both the on-trade and the off-trade. This increased detail will allow for richer analysis of policy options than has previously been possible.

The structure of this paper is as follows: section 2 reviews some of the existing alcohol literature and summarises previous HMRC estimates; section 3 provides a comprehensive insight into the underlying data; section 4 describes the Tobit model and how it is used; section 5 investigates how we arrived at our final model; section 6 presents the main regression results in detail; section 7 presents the final set of elasticities and section 8 concludes.

2. The Literature

2.1 Demand For Alcohol

The demand for alcohol is influenced by a greater set of factors than many other consumption goods. As well as price and income, alcohol consumption is influenced by licensing restrictions, taxation, advertising restrictions, minimum age requirements, social factors, peer group pressure, habit formation, underlying health concerns, location, sex, age, religion, marital status, and so on. Cross-section analysis, as used in this study, is able to capture and control for this level of diversity. Time-series analysis, by its very nature, is based on aggregated data so will not be able to account for this level of detail.

In terms of the standard demand model though, econometric results suggest that alcohol behaves much like any other good and there is a substantial literature showing that the demand curve is downward sloping. Gallet (2007) and Wagenaar et al (2009) both report a price elasticity across all alcohols in the region of -0.5, which is quite inelastic. However, we would expect consumers to view different alcohols as reasonably close substitutes, so that price changes for

one category would have a larger impact on that product than for the market as a whole.

The underlying data source for the analysis in this paper is from the Expenditure and Food Survey (EFS). There are some well established difficulties with the reporting of alcohol consumption in survey data. In particular, there is evidence that respondents tend to under-report the amount of alcohol that is consumed. According to Midanik (1982), survey data might only be capturing around half the actual consumption level. Other than under-reporting, household-based surveys may also have a somewhat biased sample. This would be a particular concern if the types of transient people omitted from surveys were also significant consumers of alcohol. The impact of these measurement issues, if not controlled for, can be significant. However, non-linear estimation techniques such as those employed in this paper, can be used to control for this (see, for example, Atkinson et al, 1990).

2.2 Econometric Estimations

There is fairly conclusive and longstanding evidence that price has a negative impact on alcohol consumption in the UK. From Table 1, we can also see that the general pattern is that beer is the most inelastic of the three main alcohol products. The mean and median elasticities for wine are higher than spirits (see Table 2). One of the reasons for this second point is probably that most of the studies are based on historical data, whilst the growth in the demand for wine is a relatively recent phenomenon. We would probably now expect the demand for spirits to be more elastic than wine. Figures 2 to 4 show the distribution of elasticities across beer, wine and spirits.

Fogerty (2004), Gallet (2007) and Wagenaar et al (2009) have all conducted extensive meta-analysis of alcohol demand estimations. Fogerty considers 64 studies across countries published between 1945 and 1993; Gallet covers results from 132 international studies from 1942 to 2002; Wagenaar et al (2009) looks at 112 studies from 1972 to 2007, again across multiple countries. There is quite a bit of overlap between the studies. Table 3 presents the summary information

presented in the three studies. As we can see, they are fairly similar to the findings for UK only studies.

Table 1 Estimated UK Price Elasticities for Beer, Wine and Spirits

Author	Data Period	Beer	Wine	Spirits
Baker and McKay (1990)	1970-1986	-0.88	-1.37	-0.94
Baker et al (1990)	1970-1986	-0.99	-0.92	-1.12
Blake and Nied (1997)	1952-1992	-0.95	-1.32	-0.93
Chambers (1999)	1963-1998	-0.60	-1.20	-0.40
Clements and Selvanathan (1987)	1955-1975	-0.19	-0.23	-0.24
Clements et al (1997)	1955-1985	-0.44	-0.57	-0.72
Crawford and Tanner (1995)	1974-1994	-0.67	-1.40	-1.20
Crawford et al (1999)	1978-1996	-0.75	-1.70	-0.86
Crooks (1989)	1970-1988	-1.05	-2.42	-0.91
Cuthbertson and Ormerod (1991)	1965-1989	-0.30	-0.49	-0.30
Duffy (1983)	1963-1978		-1.00	-0.77
Duffy (1987)	1963-1983	-0.29	-0.77	-0.51
Duffy (1991)	1963-1983	-0.09	-0.75	-0.86
Duffy (2002)	1963-1999	-0.39	-0.14	-0.67
Duffy (2003)	1963-1996	-0.41	-0.79	-1.36
Godfrey (1988)	1956-1980		-0.67	-0.72
Godfrey (1988)	1956-1980		-0.95	-1.49
HM Treasury (1980)	1980	-0.20	-1.10	-1.60
Huang (2003)	1970-2002	-0.48 *		-1.31
		-1.03 **		
Jones (1989)	1964-1983	-0.40	-0.94	-0.79
Jones (1989)	1964-1983	-0.27	-0.77	-0.95
McGuinness (1983)	1956-1979	-0.30	-0.17	-0.38
Moosa and Baxter (2002)	1964-1995	-3.20	-2.30	
Prest (1949)	1870-1938	-0.66		-0.57
Salisu and Balasubramanyam (1997)	1963-1993	-0.10	-1.16	-0.66
Selvanathan (1988)	1955-1985	-0.13	-0.37	-0.32
Selvanathan (1989)	1955-1975	-0.25	-0.22	-0.20
Selvanathan (1991)	1955-1985	-0.13	-0.40	-0.31
Selvanathan and Selvanathan (2005)	1955-2002	-0.27	-0.35	-0.56
Stone (1945)	1920-1938	-0.73		-0.72
Stone (1951)	1920-1948	-0.69	-1.17	-0.57
Walsh (1982)	1955-1975	-0.13	-0.28	-0.47
Wong (1988)	1920-1938	-0.25	-0.99	-0.51

* is on-trade whilst ** is off-trade

Table 2 Summary Statistics from UK Alcohol Studies

	Beer	Wine	Spirits
Median	-0.40	-0.86	-0.72
Mean	-0.56	-0.90	-0.75
Maximum	-0.09	-0.14	-0.20
Minimum	-3.20	-2.42	-1.60
Std Deviation	0.57	0.57	0.37

Table 3 Summary Statistics from Studies Across All Countries

	Beer	Wine	Spirits
Fogerty Median Elasticity	-0.28	-0.76	-0.59
Fogerty Mean Elasticity	-0.38	-0.77	-0.70
Gallett Median Elasticity	-0.36	-0.70	-0.68
Wagenaar et al Mean Elasticity	-0.46	-0.69	-0.80

Gallet also investigates how the price elasticity varies across a range of different factors, comparing each to a baseline of a simple OLS regression on beer. The findings are summarised below.

- Wine and spirits are consistently more elastic than beer. The difference between beer and the other two is broadly the same.
- Semi-log functional forms tend to produce more inelastic results than linear models. Double-log functional forms are not significantly different from the baseline.
- Regressions based on demand systems built on AIDS, Rotterdam or hybrid of the two are more inelastic.
- Addiction or hurdle models are also not significantly different to the baseline.
- There is no significant difference between time series data and panel data though studies based on aggregated country level data tend to produce more elastic results than when more disaggregated data is used.

- Compared to OLS, other estimation methods - two stage least squares (2SLS) and three stage least squares (3SLS) produce more elastic price elasticities.

- However, a single equation maximum likelihood estimation (MLE) tends to result in more inelastic elasticities than OLS.

- Full information maximum likelihood (FIML), generalised least squares (GLS) and generalised method of moments (GMM) are not significantly different to OLS.

- The short run elasticity is more inelastic than the long run.

Whilst there was no significant gender difference, age was certainly an important factor. Once age was introduced as a variable, results tended to be more inelastic. However, the findings were slightly unusual in that the difference for younger drinkers was greater than for older drinkers. The author speculates this might be explained by younger drinkers choosing more price inelastic products (beer) than older drinkers (wine and spirits). Presumably, it might also be affected by different social patterns.

Selvanathan and Selvanathan (2007) examine whether there is a difference between countries. They find, as one might expect, that the greater the relative level of consumption in a country the lower the price elasticity. They also report that the relative share of a product within total consumption also affects its elasticity. In UK terms, this does seem to fit the pattern where beer, the most popular alcoholic beverage, is the most inelastic. Fogerty (2004) also shows that there is an inverse relationship between volume of consumption and elasticity.

Wagenaar et al (2009) also present the results of 10 studies that focus on the price elasticity of heavy drinkers. As we would expect, the mean elasticity for this sub group is markedly lower at -0.28.

Figure 2 Histogram of the Distribution of Beer Elasticities

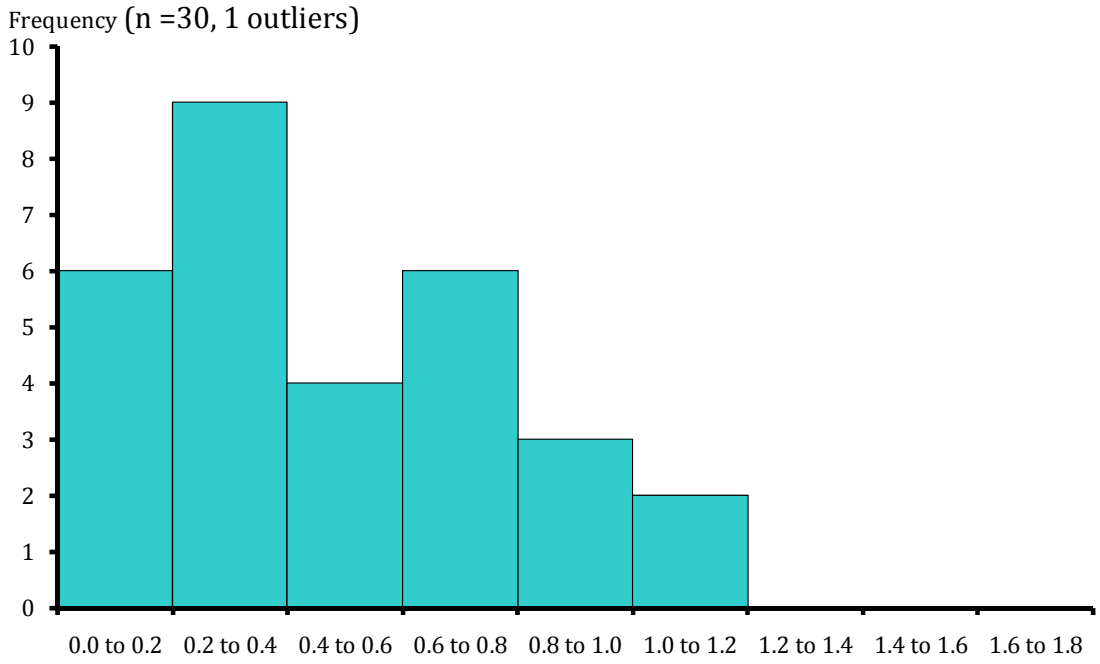


Figure 3 Histogram of the Distribution of Wine Elasticities

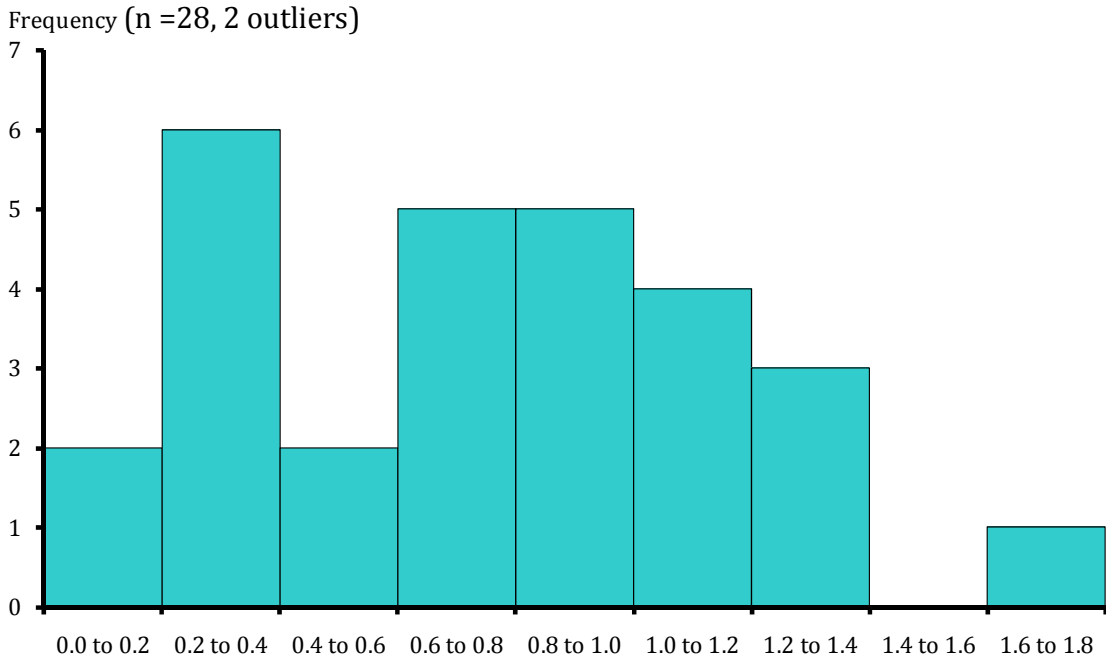
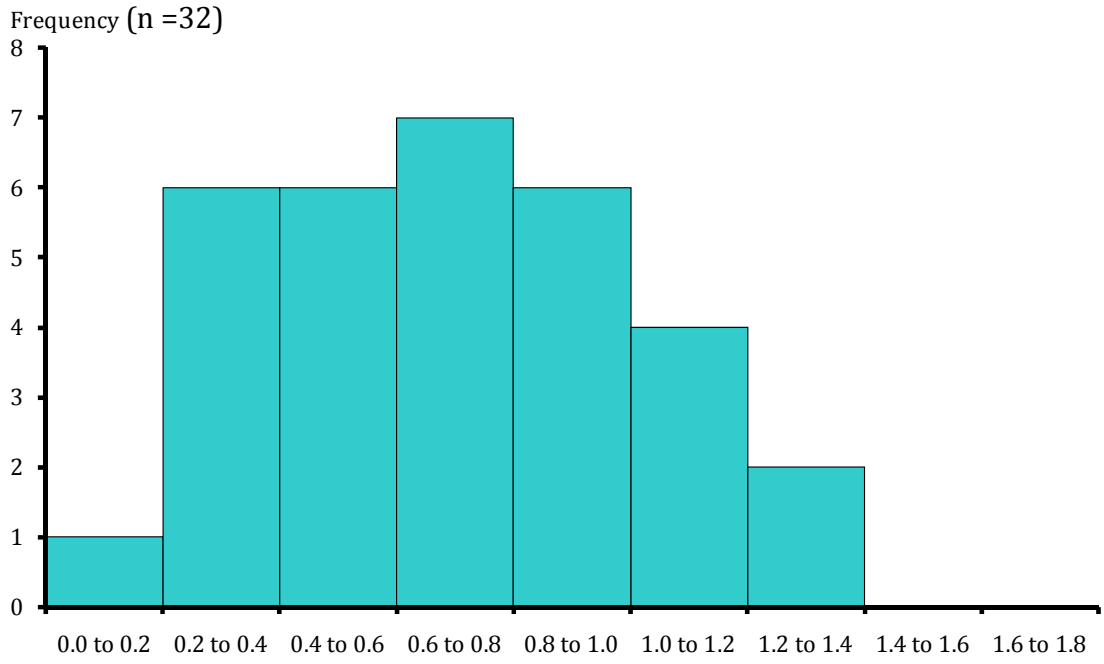


Figure 4 Histogram of the Distribution of Spirits Elasticities



2.3 Previous HMRC Studies

Chambers (1999) modelled the demand for beer, wine and spirits using a dynamic AIDS error correction model. There was no explicit coverage of cider; instead, cider was subsumed into the wine category. RTDs were also excluded though these were a minor market over the time period of the study. The focus of the study was not just restricted to estimating price elasticities of alcohol; it also covered the demand for tobacco as well as developing a forecasting model. The model used consumer expenditure data from the ONS and receipts data from HM Customs & Excise (HMCE). The data time period was from 1963 to 1998.

The estimated own price elasticity for beer was -0.6, -0.4 for wine and -1.2 for spirits. The signs for all three are as we would expect. Comparing these to the information in Table 2, we can see that the beer estimate lies broadly in the middle of the distribution of elasticities across different studies, whilst wine is at the lower end of the distribution and spirits at the higher end. The estimation of cross price elasticities is generally mixed, both in terms of the sign, which is

often negative, and the magnitude, which for some exceeds the own price elasticity. The income elasticities across the three sectors are all positive.

Huang (2003) was the most recent attempt to model alcohol demand. This used an error correction model and also used a combination of data from the ONS and HMCE but covering the period 1970 to 2002. This separated the beer estimation into the on-trade and the off-trade and also estimated spirits. However, the own price wine elasticity in the study is taken from the literature rather than directly estimated. Once again, there is no coverage of cider or RTDs. This model was also used for forecasting purposes.

The estimated own price elasticity for on-trade beer was -0.48 whilst that for off-trade beer was -1.03. The first is within the central range of the distribution in Table 2 whilst the second is at the high end. However, we would expect elasticities within the off-trade to be generally higher than the on-trade. A consumer has a far greater choice of outlets and also a much wider range within those outlets, so price competition will tend to be keener. The own price elasticity for spirits was -1.31, similar to that of Chambers. Once again, the estimation of cross prices was mixed, both in terms of the sign and size of the coefficient. The income elasticity was positive for all products.

3. Data

3.1 Expenditure and Food Survey

The data set used in this analysis is from the Expenditure and Food Survey (EFS). The EFS is an annual survey of around 7,000 randomly selected households in the United Kingdom. It records volumes purchased and expenditure on a range of goods, via a diary system over a two week period. This dataset is appealing to use because it contains a great deal of microeconomic data at the household level.

The EFS includes a number of alcohol categories which we group into five drink types: beer, wine, cider, spirits, and RTDs. Each of these are separated into the

on-trade (those purchased in pubs, hotels and restaurants) and the off-trade (those purchased in supermarkets and off-licences), giving ten categories overall. A further category, 'a round of drinks' was excluded given the difficulty in categorising it. In addition, the EFS also contains information on various household characteristics. The variables used for this analysis are listed in Table 4.

Table 4 List of Variables

Alcohol Variables	Alcohol Types
expenditure	beer (on & off)
expendtiture share*	wine (on & off)
volume	cider (on & off)
price*	spirits (on & off)
	ready-to-drinks (on & off)

Income & Expenditure Variables	Other Variables
gross normal wage of main earner	household size
gross normal household income	socio-economic group
gross current household income	government office region
normal disposable household income	survey month, quarter, year
total household non-alcohol expenditure	drink prevalence*

*derived variable

Prices are derived by dividing expenditure on each alcohol type by the volumes purchased by each household. The expenditure share for each alcohol type is computed by dividing through by total household expenditure. We also derive 'drink prevalence', defined as the number of alcohol types consumed over household size. This variable is intended to distinguish between different types of drinkers.

There are further variables within the EFS that have not been included in our dataset. These include tobacco expenditure and health expenditure. Arguably these might have been of interest but we have limited ourselves to the data in Table 4 due to our specific focus on price elasticities rather than wider factors. This keeps the analysis tractable as well as reducing the degrees of freedom in the regression analysis.

The response rate to the EFS is around 55%. This still gives us sufficient data points, as we can see in Table 5. However, there are some weaknesses with the

dataset. Firstly, the analysis is only relevant to this sub-sample of the population. Whilst the population is large, there may be some selection bias. Secondly, and this is really a corollary of any selection bias, there is an apparent underreporting of alcohol consumption. Roughly 30% of households in the dataset report no alcohol consumption, much more than the usual estimates of 10%-15% of UK households that are teetotal (Mintel 2009, NHS 2010). Past research has found evidence that the apparent underreporting may be due in part to the exclusion of a minority of very heavy drinkers from the dataset (Kemsley et al, 1980). However, as we are primarily interested in average consumer responses, this is of less concern for our analysis. Finally, the survey reports purchasing of alcohols rather than physical consumption. Some goods, such as a bottle of spirits, tend to be purchased irregularly and drunk over a longer period of time. However, we would expect such irregularities to largely even out over the population.

There are around 1,750 households that respond to the survey each quarter. We use data from 2001-02 to 2006. The following table gives the breakdown of responses across years and quarters.

Table 5 Number of Quarterly Observations

	Survey Quarter				
	1	2	3	4	Total
2001/02	1806	1883	1915	1866	7470
2002/03	1683	1769	1716	1753	6921
2003/04	1791	1726	1746	1783	7046
2004/05	1596	1768	1703	1727	6794
2005/06	1645	1633	1690	1814	6782
2006	1692	1659	1578	-	4929
Total	10213	10438	10348	8943	39942

As the majority of the survey is in financial years, quarter 1 (Q1) refers to April to June, and so on. In 2006 the survey changed from financial years to calendar. As such a quarter of data is common to both 2005/06 and 2006. This is controlled for to avoid any double counting. The numbers of observations are fairly evenly spread, suggesting no bias toward particular periods in time.

3.2 Alcohol Consumption

Tables 6 and 7 display the pattern of alcohol consumption over the six years of our study. As we would expect, the trend is similar between volumes and expenditures. The patterns are broadly in line with what we would expect. Growth in wine consumption in both the on-trade and the off-trade; growth in the off-trade at the expense of the on-trade; a sharp upturn in cider during the mid-part of the decade; decline in RTD consumption.

Table 6 Mean Volumes by Survey Year

	On-Trade					Off-Trade				
	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
2001/02	2696	90	89	94	154	1797	1113	264	183	90
2002/03	2564	91	88	88	156	1767	1111	232	189	85
2003/04	2449	93	85	94	118	1901	1182	296	189	93
2004/05	2247	99	76	85	86	1797	1237	248	184	64
2005/06	2152	99	68	87	71	1737	1251	237	179	52
2006	2009	104	118	79	48	1927	1260	275	201	67

Table 7 Mean Expenditures by Survey Year

	On-Trade					Off-Trade				
	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
2001/02	995	220	34	201	95	304	542	34	238	28
2002/03	969	240	34	193	100	301	559	30	248	28
2003/04	950	245	33	207	79	326	591	38	243	29
2004/05	901	276	31	192	62	304	657	33	239	20
2005/06	896	274	30	204	51	293	678	32	232	17
2006	865	294	57	196	36	333	693	41	263	21

Tables 24, 25 and 26 in the Annex provide some descriptive statistics for expenditure, volumes and expenditure shares for each of the ten alcohol categories. The mean expenditures show that consumers on average spend the most on on-trade beer and off-trade wine. However, due to its more voluminous nature, the greatest quantity of both off-trade and on-trade sales are beer.

The percentiles, by volume, expenditure and expenditure share, show that a very large proportion of households have zero purchases for the majority of alcohol types. As the medians are all zero, no alcohol type is purchased by 50% or more of the sample. In fact only on-trade beer and off-trade wine are purchased by more than 25% of the sample. This means that most households consume only a

small number of different types of alcohol. These zero purchases will have important consequences for the type of regression analysis that is appropriate to use and therefore warrant further investigation.

Some of the shares of total expenditure are surprisingly large. The maximum expenditure share value for almost all alcohols is greater than 50%. In fact, beer in both the on-trade and off-trade exceeds 90%. Even at the 99th percentile there are some rather large expenditure shares. On-trade beer has a particularly high 99th percentile, with 1% of households spending over a third of their outgoings on this. This could be due to irregularities either within household spending or the data. An alternative explanation could be that it is households with high alcohol consumption combined with low total expenditures.

In the regression analysis we focus on volumes and expenditure shares as the two dependent variables. Table 8 shows the correlation coefficient between the two across the ten different alcohol types. As we would expect, there is a strong positive correlation between the two.

Table 8 Correlation Between Volumes and Expenditure Share

	On-trade					Off-trade				
Volume	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
Expenditure Share	0.8007	0.7060	0.7944	0.7269	0.8250	0.7583	0.7855	0.7848	0.7565	0.7544

3.3 Zero Purchases

Table 9 shows the number of observations that report positive consumption for each alcohol category. As would be expected, there are fewer households consuming cider and ready-to-drinks than beer wine and spirits. Off-trade RTDs has the fewest observations, 1,481 overall. Whilst this is only 4% of the dataset it is still a sufficient number to conduct regression analysis.

Table 9 Total Positive Observations by Alcohol

Alcohol	On-trade Observations	%	Off-trade Observations	%
Beer	16,305	41%	9,950	25%
Wine	7,967	20%	14,027	35%
Cider	1,732	4%	2,139	5%
Spirit	6,114	15%	5,491	14%
RTD	2,435	6%	1,481	4%

Like the overall figures, the positive observations for each alcohol are relatively evenly spread across quarters. However, there is some indication of seasonality. For example, more households purchase off-trade spirits in the winter months.

The number of drink types purchased by each household is explored further in Table 10. 31% of households report no alcohol purchases over the survey period. 54% purchase between 1 and 3 alcohol types, leaving only 15% that purchase more than 3 alcohol types.

Table 10 Observations by Number of Alcohol Types Purchased

Number of Alcohol types	Observations	Percent	Cumulative Percent
0	12,238	30.64%	30.64%
1	8,927	22.35%	52.99%
2	7,424	18.59%	71.58%
3	5,375	13.46%	85.03%
4	3,385	8.47%	93.51%
5	1,683	4.21%	97.72%
6	652	1.63%	99.35%
7	201	0.50%	99.86%
8	49	0.12%	99.98%
9	5	0.01%	99.99%
10	3	0.01%	100.00%

Tables 9 and 10 highlight just how many households have zero purchases of several alcohol products. To use standard OLS regression techniques, the dataset would need to be reduced to remove some of the observations. However, this would lead to a significant reduction in the dataset (i.e. just removing those households consuming zero would exclude over 30% of the data). Hence this would involve a significant selection bias. Furthermore, we would risk excluding

those households that, whilst not currently purchasing a given alcohol, would be willing to do so at lower prices. Therefore an alternative method is required.

3.4 Alcohol Prices

For now, to get a better feel for the data, we censor out the zero purchases (for the regression analysis they are retained). Table 27 in the Annex provides some basic statistical analysis for prices.

The prices show broadly sensible patterns with average on-trade prices always higher than average off-trade prices. They also show a fair degree of variation. Whilst there is some variation by regions, the main reason for the variation is likely one of product mix. This is the dispersion in prices between value products and premium brands. At the extremes there are potentially some outliers. Some of the maxima and minima are excessive. However the 1st and 99th percentiles seem plausible, showing that only a small proportion of the data is questionable.

In order to better understand the prices, Table 11 shows the mean prices grossed up to give the price of a typical item for each alcohol category.

Table 11 Mean Prices by Typical Item

Alcohol	p/ml	Typical measure	Price
Beer On-trade	0.41	568 ml pint	£2.32
Wine On-trade	3.10	175 ml glass	£5.42
Cider On-trade	0.42	568 ml pint	£2.41
Spirit On-trade	3.72	25 ml measure	£0.93
RTD On-trade	0.68	275 ml bottle	£1.88
Beer Off-trade	0.20	500 ml can	£0.98
Wine Off-trade	0.53	750 ml bottle	£4.00
Cider Off-trade	0.16	500 ml can	£0.81
Spirit Off-trade	1.39	700 ml bottle	£9.70
RTD Off-trade	0.36	275 ml bottle	£1.00

These average typical item prices appear realistic. The off-trade prices particularly so, with typical measures of beer cider and RTDs costing around £1, a bottle of wine £4 and a bottle of spirits just under £10. The on-trade prices for beer and cider seem sensible, with a pint costing over £2. However a measure of

sprits for £1 might be slightly low, and perhaps the small glass of wine for over £5 is fairly high. However, the latter will be partially explained by pricier restaurant sales.

Where an alcohol type has not been purchased by a household there is no expenditure and zero quantity so there is no price. We approximate the price that they would have paid, if they had chosen to purchase, as the average price paid within that region, year and household size.

Table 12 shows the correlations between prices. These are generally positive, which we would expect and quite small, which is perhaps slightly surprising. This suggests there are some factors affecting prices that are specific to different alcohol types.

Table 12 Correlation Coefficients Between Prices

	On-trade					Off-trade				
Price	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
Beer On	1									
Wine On	0.1350	1								
Cider On	0.2523	0.1312	1							
Spirits On	0.0550	0.0441	0.0286	1						
RTDs On	0.1755	0.1198	0.1979	0.0851	1					
Beer Off	0.1081	0.0631	0.0852	0.0520	0.0732	1				
Wine Off	0.1360	0.1036	0.1560	0.0463	0.1053	0.1040	1			
Cider Off	0.0502	0.0641	0.1404	0.0276	0.0287	0.0643	0.0506	1		
Spirits Off	0.0337	0.0648	0.0183	0.0250	0.0333	0.0676	0.0979	0.0758	1	
RTDs Off	-0.0353	0.0153	-0.0550	0.0523	-0.0145	0.0600	0.0181	0.0412	0.0169	1

Table 13 shows the correlation coefficients between volume and price, and expenditure share and price. The own-price coefficients for volumes are all negative, as we would expect. For expenditure shares, the own price coefficients vary in sign. The probable explanation for this is that, following a change in the relative price level, the expenditure share on alcohol might increase even though the volume has decreased.

Table 13 Correlations of Prices to Volume and Expenditure Share

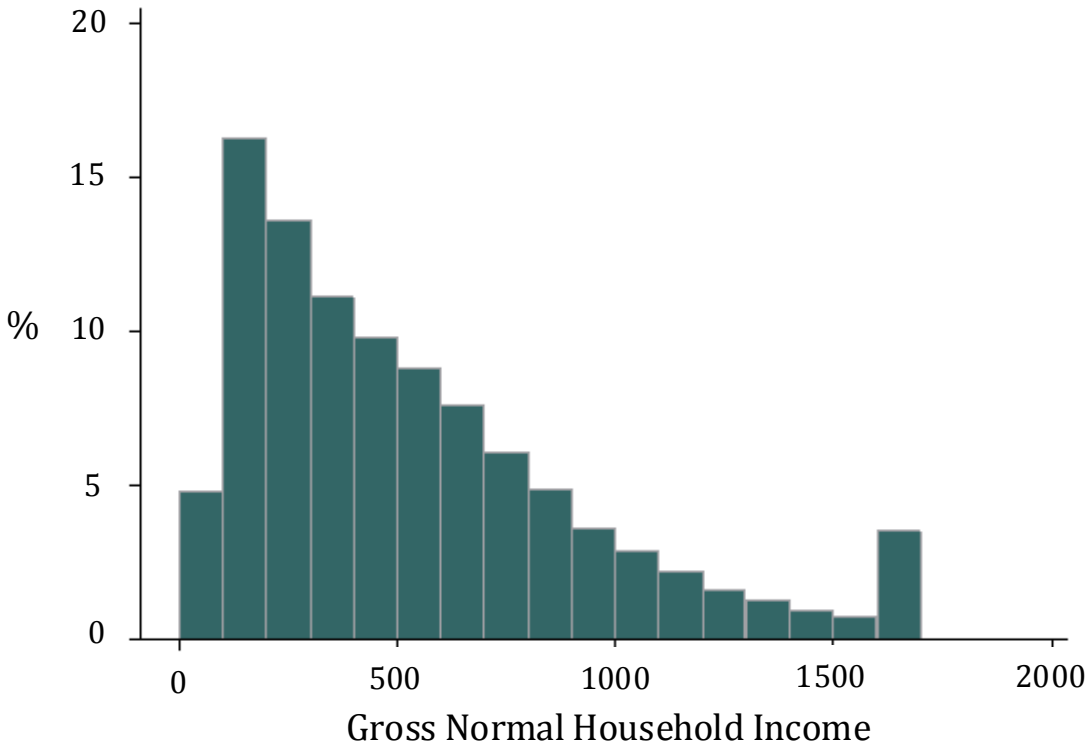
	On-trade					Off-trade				
Price	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
Volume	-0.0962	-0.0824	-0.0169	-0.1674	-0.0386	-0.2108	-0.0385	-0.1085	-0.0847	-0.0621
Expenditure Share	-0.0510	0.2230	0.0106	0.0078	0.0256	-0.0706	0.0950	-0.0462	0.0202	0.0118

3.5 Income and Expenditure

It is important to identify the purchasing power of each household. There are a range of possible variables we can use, listed at the beginning of this section. As data on all the households is required, the gross normal wage of the main earner is not suitable as it has a zero entry for 40% of households. Furthermore, the disposable income field contains several negative figures which could yield spurious results.

This leaves gross normal weekly household income and gross current weekly household income. Since the survey changed to calendar years in 2006 both these income fields have been top-coded (as can be seen in Figure 5). This means that all the values above a threshold (of £1,644) are set to that limit. To keep the data consistent we apply this maximum to all previous years as well. Top coded data could bias the results of regression analysis. However, as only a relatively small proportion of households (3.2%) are top coded the effect should be small. There is little difference between normal weekly household income and gross current weekly household income, with normal income being preferred. It is assumed that spending habits will not change dramatically to fit with short term variations in income, particularly for the more affluent.

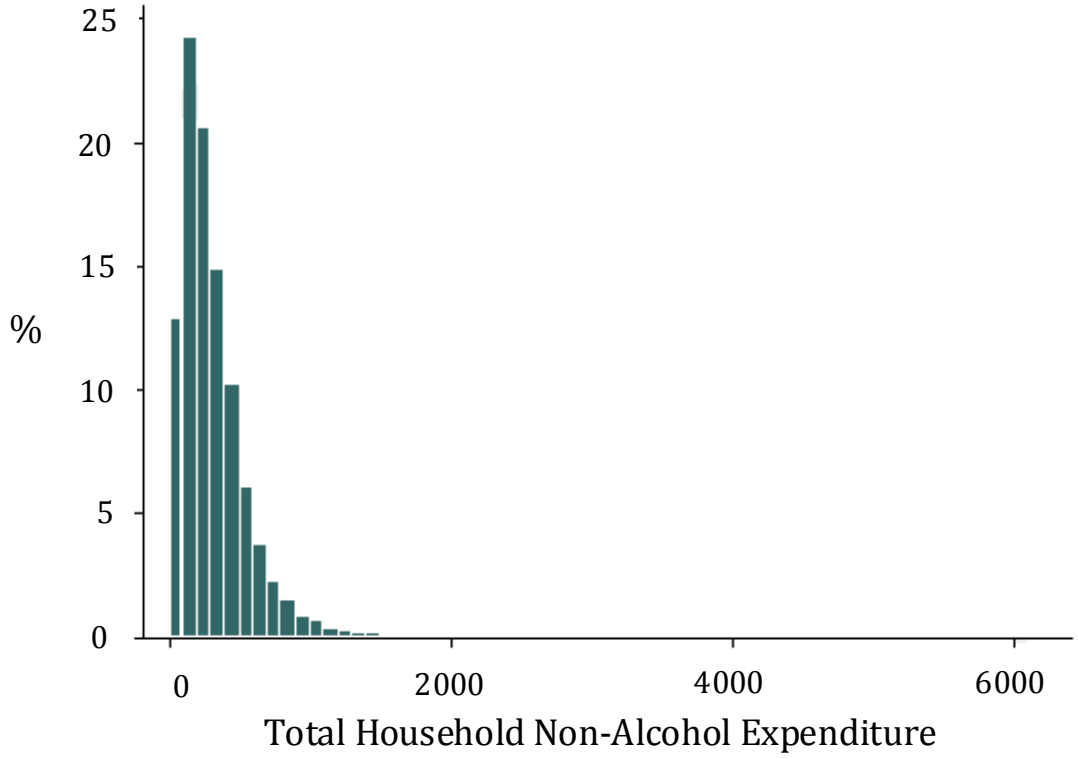
Figure 5 Gross Normal Weekly Household Income



An alternative to income is to use total household non-alcohol expenditure per week as a proxy. Alcohol expenditure has to be excluded so that all else can be held constant in our regression analysis. This is discussed further in section 5.4. Unlike the income variables it does not have an upper bound. This causes the large tail seen in Figure 6. The majority (97.6%) of households report between £0 and £1000 expenditure. 2.1% of households spend between £1000 and £2000, whilst there is a long tail of 0.2% of households spending over £2000, with one household reporting expenditure exceeding £6000.

As we would expect, there is a fairly strong correlation between income and expenditure, a coefficient value of 0.63.

Figure 6 Total Household Non-Alcohol Expenditure per week



3.6 Other variables

There are a variety of other variables within the dataset that can be used to account for differences amongst households. There is information within the dataset on the household demographic. These include the size and location of the household and the socio-economic group of the household reference person. Dummy variables can be used for these to control for the variation across households.

The household size will have an impact on the expenditure and income of the household, as well as the purchasing of alcohol. However, this field also includes children. Ideally we would want to identify only those of drinking age. An alternative field is the number of economically active people within the household. This would still fail to identify all those of drinking age as pensioners, for instance, would be excluded.

Tables 28 and 29 in the Annex show how household volumes and expenditures vary by Government Office Region. Consumption of beer is highest in the north of England, whilst wine is consumed more in the south. The greatest consumption of spirits is in Scotland.

Alcohol consumption will also vary across different household socio-economic groups. The socio-economic group of the household is defined as that of the household reference person – this is the person whose name the property or rental agreement is in, with the highest income. There are many socio-economic groups within the dataset. So, for simplicity of analysis, these are pooled from 41 categories into 6. The amalgamations are shown in the Annex (Table 32). Tables 30 and 31 show how volumes and expenditure vary by socio-economic groups. Of those in work, wine is consumed most by higher skilled and RTDs are preferred by lower skilled. Beer, cider and spirits are consumed most by medium skilled workers. Students have the highest on-trade consumption in alcohol categories except for wine, though their off-trade consumption is relatively small. Overall consumption for the 'not classified' group and the unemployed is very low across the board.

We have created an additional variable named 'drink prevalence'. This measure is derived as the number of different types of alcohol purchased divided by the household size. The intention is to be better able to distinguish between different types of drinkers. This is important since behaviours will not be consistent across all consumers. Household size is taken into account to give the number of drink types per household member. This variable can be thought of as a proxy for a household's underlying preference for consuming alcohol. The distribution of this variable can be seen in Figure 8 in the Annex.

Tables 14 shows the correlation coefficients between drink prevalence and the income and expenditure variables. There is little correlation between both, though they are positive.

Table 14 Correlation of Prevalence to Income and Expenditure

Drink Prevalence	
Total Household Non-Alcohol Expenditure	0.0714
Gross Weekly Income	0.1307

Table 15 shows that drink prevalence shows a fairly weak but positive correlation with both the two dependent variables. There is little correlation between price and drink prevalence.

Table 15 Correlation of Prevalence to Consumption and Price

	On-trade					Off-trade				
Drink Prevalence	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
Expenditure Share	0.2944	0.3386	0.1238	0.2615	0.1338	0.2189	0.3146	0.1014	0.2231	0.1008
Volume	0.2834	0.2984	0.1251	0.2141	0.1159	0.2238	0.2848	0.1126	0.2389	0.0999
Price	0.0179	-0.0208	-0.0180	-0.0007	-0.0071	0.0068	0.0283	0.0052	0.0008	0.0047

Alcohol consumption will also vary depending on the time of year, with some products more seasonal than others. Also there will be differences between years, such as if there is a major sporting event (eg. a football world cup) or a particularly warm summer. Dummies for years and quarters can be used to compensate for this.

4. Methodology

With the large number of observed zeros in the data set, it is difficult to use a standard ordinary least squares (OLS) regression to analyse the interactions between consumption and prices. Fitting a simple OLS regression is likely to yield inconsistent and biased results. As discussed in Greene (2000), the OLS estimators are almost always biased downward. Applying OLS to the positive observations would not be a satisfactory solution either since the problem of inconsistency would remain. This approach would also introduce an element of selection bias.

4.1 Tobit Model

One method to cope with the problem of the zero observations is to employ a standard Tobit model (Tobin, 1958). Amemiya (1984) and Breen (1996) provide useful background about the use of Tobit models. Though often referred to as a censored regression model, it might be more accurate in this instance to refer to it as a corner solution model (Wooldridge, 2002). The dependent variable, *y*, is an observable individual choice that can take on the value of 0 with a positive probability but is a continuous random variable over strictly positive values. For some individuals the optimal choice will indeed be the corner solution *y*=0. Conventional regression models fail to account for the qualitative difference between the zero and non-zero observations.

The Tobit model expresses the behaviour of the observed dependent variable y_i, in terms of an underlying (non-observed) latent variable, y_i^* so that

$$y_i^* = \mathbf{X}_i\boldsymbol{\beta} + u_i \qquad (1)$$

The error term, u_i, is assumed to be independently normally distributed with mean zero and variance σ^2. $\mathbf{X}_i$ is a vector of the independent variables and $\boldsymbol{\beta}$ is the vector of the coefficients. The latent variable y_i^* has a normal, homoskedastic distribution with linear conditional mean, and y_i has a continuous distribution over strictly positive values. Without these assumptions the maximum likelihood estimators are inconsistent.

If we assume that the data is censored at 0 then the observed dependent variable is

$$\begin{aligned} y_i &= y_i^* \qquad \text{if } y_i^* > 0 \\ y_i &= 0 \qquad \text{if } y_i^* \le 0 \end{aligned}$$

This formulation allows us to separate observed zeros into 'genuine' zeros and censored data. In terms of alcohol consumption, this is distinguishing between

those that do not drink at all to those whose alcohol consumption is not captured in the survey data, for whatever reason.

From the standard likelihood function for the censored normal distribution we can derive the log-likelihood function for the Tobit model

$$\ln L = \sum_{y_i>0} \left\{ -\ln \sigma + \ln \phi \left(\frac{y_i - \mathbf{X}_i\boldsymbol{\beta}}{\sigma} \right) \right\} + \sum_{y_i=0} \ln \left\{ 1 - \Phi \left(\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma} \right) \right\} \quad (2)$$

where ϕ and Φ represent, respectively, the density function and cumulative density function from the standard normal distribution. This log-likelihood function is the sum of two distinct parts. The first part corresponds to the classical regression for the observed uncensored (positive) values. The second part corresponds to the binomial probit with relevant probabilities for the censored (zero) values. Though this function is a mixture of discrete and continuous distributions it has been shown that it can be used for maximum likelihood estimations without the loss of any of the regular properties. (Amemiya, 1973).

4.2 Expected Values

Whereas the OLS estimation generates only a single conditional mean, there are three different means in the Tobit model. These provide the expected values for the latent variable y_i^*,

$$E[y_i^*] = \mathbf{X}_i\boldsymbol{\beta} \quad (3)$$

the unconditional dependent variable y_i,

$$E[y_i] = \Phi \left(\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma} \right) \left[\mathbf{X}_i\boldsymbol{\beta} + \sigma\lambda(\alpha) \right] \quad (4)$$

and the uncensored conditional dependent variable, $y_i \mid y_i > 0$

$$E[y_i \mid y_i > 0] = \mathbf{X}_i\boldsymbol{\beta} + \sigma\lambda(\alpha) \quad (5)$$

The second of these presents the expected value of the dependent for all the observed values, both positive and zeros, whilst the third focuses on just the positives. From both (4) and (5) λ is defined as

$$\lambda(\alpha) = \phi\left(\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma}\right) \Big/ \Phi\left(\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma}\right)$$

which is the inverse Mills ratio, the ratio of the standard normal density function to the cumulative density function. This can be thought of as the probability of being uncensored multiplied by the expected value of the dependent variable, given that it is uncensored. For alcohol, it is inversely related to the probability of being a drinker. A negative sign indicates that those individuals who have a higher probability of being a drinker are also likely to consume more.

4.3 Marginal Effects and Elasticities

There are also three distinct marginal effects that we might be interested in. These represent the effects on the different dependent variables from changes in $\mathbf{X}_i$. The marginal effect on the latent dependent variable for a change in x_k is

$$\frac{\partial E[y_i^*]}{\partial x_k} = \beta_k, \tag{6}$$

that on the unconditional dependent variable is

$$\frac{\partial E[y_i]}{\partial x_k} = \beta_k \left\{\Phi\left(\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma}\right)\right\}, \tag{7}$$

whilst for the uncensored conditional dependent variable it is

$$\frac{\partial E[y_i \mid y_i > 0]}{\partial x_k} = \beta_k \left\{1 - \lambda(\alpha)\left[\frac{\mathbf{X}_i\boldsymbol{\beta}}{\sigma} + \lambda(\alpha)\right]\right\} \tag{8}$$

Equations (6) to (8) describe how a unit change in the value of the independent variable x_k affects the three different dependent variables. In (6) it is simply the value of the regression coefficient β_k. In (7) and (8) we can see that the

magnitude of β_k is dampened by the bracketed terms. The term in (7) represents the estimated probability of observing an uncensored observation. As the number of censored observations falls, (7) moves towards the coefficient value. Equation (7) can also be rewritten as

$$\frac{\partial E[y_i]}{\partial x_k} = P(y_i > 0)\frac{\partial E[y_i \mid y_i > 0]}{\partial x_k} + E[y_i \mid y_i > 0]\frac{\partial P(y > 0)}{\partial x_k} \tag{9}$$

which enables one to see that a change in x_k affects both the conditional mean of y_i^* in the positive part of the distribution but also the probability that the observation will fall in that part of the distribution (McDonald and Mofitt, 1980).

Though elasticities could be computed for all three of these marginal effects, a decision needs to be made over which is the most appropriate for our purposes. The latent dependent variable might be of interest if we are interested in the marginal propensity to consume alcohol. Since that is not really the focus of this analysis, we do not discuss that any further.

The marginal effect on the unconditional y_i would be the most appropriate if we were mainly concerned with factors affecting the actual amount of alcohol consumed by all observed individuals. From (7) we can derive the elasticity as

$$\varepsilon_{y_i,x_k} = \frac{\partial E[y_i]}{\partial x_k}\left[\frac{x_k}{E[y_i]}\right] \tag{10}$$

The marginal effect on the conditional dependent variable from (8) would be the most appropriate if the major area of interest was limited those with positive alcohol consumption. The elasticity from this is

$$\varepsilon_{y_i,x_k|y_i>0} = \frac{\partial E[y_i \mid y_i > 0, \mathbf{X}_i]}{\partial x_k}\left[\frac{x_k}{E(y_i \mid y_i > 0, \mathbf{X})}\right] \tag{11}$$

We argue that, for our purposes, (10) most accurately captures the marginal impact on total alcohol consumption from changes in price.

4.4 Alternative Methodologies

There is a view that, for this kind of demand modelling, there should be a separation between the binary decision whether to consume or not and the second decision over how much to consume. Tobit modelling requires that zero consumption observations represent corner solutions and also that the same set of variables determine the probability of choosing to drink as well as the amount to drink. Both of these have been accused of being restrictive (Yen and Jensen, 1996, Sigelman and Zeng, 1999).

An alternative approach would have been to pursue a double-hurdle model (Cragg, 1971). This allows an individual to make two distinct choices: the participation decision and the consumption decision. The double-hurdle model observes positive alcohol consumption only if the individual is a potential drinker and that they actually consume. This is different from the selection model of Heckman (1979) in which the participation decision is independent of the consumption decision. That allows for the zero consumption observations to also capture potential drinkers. Tobit is nested within both the double-hurdle and Heckman models.

The practical rationale for the separation between the two choices is that the participation decision is likely to be influenced by a group of factors – religion, health concerns, social stigma, legal status – that might not be captured in the consumption decision.

We have not pursued these alternative approaches in this paper. The first reason is mainly to do with expediency. The dataset that we are working with simply does not have the level of detail that we require to model a two-stage decision process. For example, we do not have information on religion. However, if the participation decision is of less importance than the consumption decision and that the large number of zeros are mostly a reflection of infrequent drinking rather than abstinence, then the Tobit approach remains valid.

5. Model Selection

As previously discussed, to deal with the large proportion of households reporting zero consumption in the EFS dataset, we utilise a Tobit model approach. We model the following relationship:

$$q_i^* = f(p_i, \mathbf{P}_{\_\mathbf{i}}, y, \mathbf{X}, yr, qtr) \tag{12}$$

$$q_i = \begin{cases} q_i^* & \text{if } q_i^* > 0 \\ 0 & \text{if } q_i^* \leq 0 \end{cases}$$

where q_i is demand for alcohol i measured as a volume. An alternative specification uses expenditure share, $\hat{q}_i$ as the dependent variable. The own-price for each alcohol i is p_i whilst the vector $\mathbf{P}_{\_\mathbf{i}}$ represents prices for the other nine alcohol types. It is straightforward to transform the regression coefficients for each of these into the elasticities that we require.

Income is measured by y though once again, there is an alternative specification using total non-alcohol expenditure, $\tilde{y}$. Other explanatory variables are represented by the vector $\mathbf{X}$; these include region, socioeconomic group and household characteristics. Finally there are year and quarter dummies, yr and qtr respectively. These control for any time specific variations in the pooled dataset, which is pooled across a number of different years, and is also heavily seasonal.

5.1 Models for Discussion

Equation (12) presents our general framework but, as we've already discussed, we have experimented with different alternatives for some of the variables. Through this experimentation we arrived at the set of eight models described in Table 16. Those labelled *a* use a semi-log functional form whilst those labelled *b* are linear. Models 1 and 2 use volume, q_i as the dependent variable whilst 3 and

4 use expenditure share, $\hat{q}_i$. Finally, models 1 and 3 use income, y as an explanatory variable whilst 2 and 4 use total non-alcohol expenditure, $\tilde{y}$.

Essentially there are three decisions that need to be made. Firstly, the choice of functional form, secondly the choice of dependent variable and thirdly, whether to proceed with income or expenditure as an independent variable.

Table 16 Models Under Consideration

MODEL 1a	**MODEL 1b**
$q_i = f(\ln p_i, \ln \mathbf{P}_{\_\mathbf{i}}, \ln y, \ln \mathbf{X}, yr, qtr)$	$q_i = f(p_i, \mathbf{P}_{\_\mathbf{i}}, y, \mathbf{X}, yr, qtr)$
MODEL 2a	**MODEL 2b**
$q_i = f(\ln p_i, \ln \mathbf{P}_{\_\mathbf{i}}, \ln \tilde{y}, \ln \mathbf{X}, yr, qtr)$	$q_i = f(p_i, \mathbf{P}_{\_\mathbf{i}}, \tilde{y}, \mathbf{X}, yr, qtr)$
MODEL 3a	**MODEL 3b**
$\hat{q}_i = f(\ln p_i, \ln \mathbf{P}_{\_\mathbf{i}}, \ln y, \ln \mathbf{X}, yr, qtr)$	$\hat{q}_i = f(p_i, \mathbf{P}_{\_\mathbf{i}}, y, \mathbf{X}, yr, qtr)$
MODEL 4a	**MODEL 4b**
$\hat{q}_i = f(\ln p_i, \ln \mathbf{P}_{\mathbf{i}}, \ln \tilde{y}, \ln \mathbf{X}, yr, qtr)$	$\hat{q}_i = f(p_i, \mathbf{P}_{\mathbf{i}}, \tilde{y}, \mathbf{X}, yr, qtr)$

Each of the eight models also include the ten price variables, the time dummies, and the vector of other independent variables. Whilst the independent variables are important to each of the models, they do not significantly affect our choice between different models. So, purely for this section, where we are funnelling down to our chosen final model, we do not report their results. They are covered in detail in section 6. Regression outputs for each alcohol from the eight models are given in the Annex (Tables 33 to 42, own price variables are shaded).

5.2 Functional Form

It is difficult to formally compare the overall explanatory power of different specifications of the Tobit model as the pseudo-R-squared is not as informative with Tobit as the OLS R-squared. However, comparing the log-likelihoods of different specifications gives some indication. The log-likelihoods are fairly similar for both functional forms across the different models. For models 1 and

2, the log-likelihood is always higher for the semi-logarithmic form. This is again the case for models 3 and 4, with the exception of model 3 for on-trade wine. However, these comparisons are not really conclusive as to which functional form is preferable.

However, comparing the t-tests, we can see that the regressions with the logged prices appear to give a superior set of results in terms of own-price coefficients (we compare the own-prices in the first instance as these are of primary importance for this paper). For models with the semi-log form (models 1a to 4a), all the own-price elasticities are significant at the 1% level, and almost all significant at 0.1%.

With linear prices, there is no major drop off in the results for beer. However, for the other four alcohols, results are markedly worse than with the semi-log functional form. For models 1b and 2b, on-trade cider, on-trade RTDs and off-trade RTDs are insignificant at 5%. For models 3b and 4b the results appear particularly unreliable with a linear functional form. Spirits, cider and RTDs are insignificant at 5% for both the on-trade and the off-trade. Furthermore, there are quite a number of positive own-price coefficients – wine, spirits and RTDs for both the on-trade and the off-trade, and cider in the on-trade.

Cross-price effects are notoriously difficult to estimate with great accuracy, but, intuitively we would expect that the magnitude of the own-price effect should be greater than the cross-price effect. Again, this appears to be the case for beer in both the linear and semi-log functional forms. It is also almost universally the case for each of the other categories under the semi-log form, the one exception being on-trade wines in models 3a and 4a. However, this rule of thumb is consistently violated under the linear form.

It seems fairly clear from this deliberation that the semi-logarithmic functional form clearly outperforms the linear form. For this reason we can reject models 1b, 2b, 3b and 4b.

5.3 Dependent Variable

Two alternative dependent variables are compared: the volume of each alcohol purchased and the expenditure share of each alcohol out of total expenditure. Models 1 and 2 use volume; models 3 and 4 use expenditure share.

Comparing the log-likelihoods, the regressions with expenditure share as the dependent variable always have higher log-likelihoods. In this respect, these regressions appear to perform better.

Comparing the own-price coefficients, there is not a great deal to distinguish between the two specifications. Coefficients are all negative and highly significant. The t-test results are similar for both.

In terms of signs and significance, there is little difference when we look at the cross-price coefficients. If we compare the magnitude of own own-price coefficients to cross-price then, again, there is not a great deal to separate the two. However, as before, the cross price between on-trade wine expenditure share and the price of on-trade beer seems high.

There is not a great deal to choose between the two dependent variables at this stage. On balance our judgement is that expenditure share is giving marginally more sensible results. Therefore we tend to favour models 3 and 4 over 1 and 2.

5.4 Income or Expenditure

It is likely that both income and total non-alcohol expenditure have a strong effect on alcohol consumption. We would expect consumption of most alcohols, as normal goods, to generally be positively related with both.

There are a number of measures of income in the dataset, of which we believe gross normal weekly income to be the most relevant. Regressions with alternative measures yield very similar results. Total household non-alcohol expenditure can also be used as an alternative to income. Expenditure levels may reflect slightly different household characteristics to current income, such as stocks of wealth. However, as the two are correlated, we would not want to

include both. In order to make *ceteris paribus* interpretations from the regressions, we exclude alcohol expenditure from total expenditure. Otherwise we cannot hold total expenditure constant when assessing the effect of price changes on consumption of a given alcohol. Hence we use total non-alcohol expenditure in our regressions. Models 1 and 3 include income whilst models 2 and 4 include total non-alcohol expenditure.

The first thing to note is the coefficients of the respective variables. For models 1, 2 and 3 they are all positive and highly significant. For model 4, there seems to be an issue with off-trade beer and off-trade cider.

The log-likelihoods of equivalent models with either variable are fairly similar, making it difficult to draw any strong conclusions from them. Similarly, the coefficients from the price variables are extremely similar, which is somewhat reassuring.

One issue to bear in mind when using total non-alcohol expenditure is its interaction with expenditure share. It is possible to have a scenario where higher total expenditure could cause the *share* of expenditure on an alcohol to go down, even if the *level* of expenditure on that alcohol has increased. It is also possible that the non-alcohol expenditure variable is picking up some substitution effects. For a given level of total expenditure, alcohol expenditure has to fall if non-alcohol expenditure increases.

Whilst the difference in model performance is fairly small, we favour the use of income over total non-alcohol expenditure for two reasons. Firstly, we think it is more directly capturing the impact on alcohol sales. Secondly, it does also perform marginally better.

Now that we have evaluated all 8 models across the three decision points, this leaves us with model 3a as our chosen model. However, we have also produced results for model 1a as a useful benchmark to test it against.

6. Regression Analysis

In this section we first look in more detail at the full regression output, including the extra explanatory variables that we have hitherto omitted from discussion. We then conduct post estimation testing of the validity of the assumptions of the Tobit model for our regressions – normality, homoskedasticity and use of the 'one-step' approach. We then conduct further robustness checks of the results.

6.1 Regression Output

As discussed, the model performs best when we use the semi-logarithmic functional form with expenditure shares as the dependent variable and income amongst the independent variables (i.e. model 3a in the previous discussion). Thus our full model is as follows:

$$\hat{q}_i = f(\ln p_i, \ln \mathbf{P_i}, \ln y, \textit{drink\_prev}, \textit{gor}, \textit{sociog}, \textit{yr}, \textit{qtr}) \qquad (13)$$

The regression outputs for each alcohol type are given in Table 17 (own-price coefficients are shaded). The top half of the table is the same as that previously discussed (see Tables 33 to 42 in the Annex) but we now also include the output for the additional explanatory variables. These are *gor*, which represents Government Office Region and *sociog*, which refers to socio-economic group. The final variable, *drink_prev,* is 'drink prevalence'. Each of these was defined and discussed in section 3.

The price and income effects have already been discussed in section 5 so we focus here on the outputs that we did not previously report.

The drink prevalence coefficients are highly significant for each alcohol type. If we think of drink prevalence as a proxy for an underlying preference for consuming alcohols, a positive coefficient would be expected for each alcohol. This is indeed the case.

The year dummies exclude year 1. The majority of the year dummies are statistically significant for on-trade beer, on-trade spirits, and RTDs in both the

on-trade and the off-trade. These coefficients are always negative and generally larger for later years. This is consistent with an apparent decrease in the proportion of household expenditure on these alcohols over the period. There are fewer significant results for the year dummies for the remaining alcohol types. However, the significant and positive coefficient for year 6 cider in both trades is worthy of note as this is consistent with reported growth in the cider sector over the period. The quarter dummies exclude the 1st quarter (as financial years are used this is April to June). T-tests give mixed results with the significance of different quarters varying across alcohol types. The quarter with most statistically significant coefficients is quarter 3 (October to December), suggesting alcohol consumption in this quarter is most distinct from that in quarter 1, as we would expect.

For the regional dummies, the comparison region is London. As with the time dummies, the significance of each region dummy varies depending on which alcohol type it is regressed on. All of the regional dummies are statistically significant for the regressions for on-trade beer and off-trade cider, suggesting these alcohols have particularly distinct consumption patterns across regions. London typically spends relatively less on alcohol than the other regions, particularly for beer and cider. Expenditure on beer is particularly high in the North-East and Yorkshire, both for the on-trade and the off-trade. Wales and East and West Midlands also have high expenditure for on-trade beer. Cider expenditure is more concentrated in the South West, Wales, East Midlands and West Midlands. Northern Ireland and Scotland are well above the baseline for expenditure on spirits, again in the on-trade and the off-trade.

The socio-economic group dummies use medium skilled as the comparison group. The higher and lower skilled dummies are statistically significant for almost all of the regressions. The student dummy is significant and positive for all on-trade alcohols, but not significant for the off-trade alcohols except from beer. The unemployed dummy follows the opposite pattern and is significant for four of the off-trade alcohols but only for RTDs in the on-trade.

Table 17 Regression Outputs for Chosen Model

	On-trade					Off-trade				
regressors	$\hat{q}$ (beer)	$\hat{q}$ (wine)	$\hat{q}$ (cider)	$\hat{q}$ (spirit)	$\hat{q}$ (RTD)	$\hat{q}$ (beer)	$\hat{q}$ (wine)	$\hat{q}$ (cider)	$\hat{q}$ (spirit)	$\hat{q}$ (RTD)
lnP(beer on)	**-0.059*** **	0.013***	-0.011*	0.001	0.006	-0.008**	0.008**	0.002	-0.008	0.003
	-0.004	*-0.002*	*-0.004*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.004*	*-0.005*	*-0.003*
lnP(wine on)	-0.004*	**-0.011*** **	-0.002	0.003*	0.000	0.009***	0.003*	0.008***	0.020***	0.006***
	-0.002	*-0.001*	*-0.002*	*-0.001*	*-0.002*	*-0.001*	*-0.001*	*-0.002*	*-0.002*	*-0.001*
lnP(cider on)	0.012*	0.002	**-0.022** **	0.007	0.008	0.011**	0.006	-0.002	0.009	0.003
	-0.005	*-0.003*	*-0.007*	*-0.004*	*-0.005*	*-0.004*	*-0.003*	*-0.006*	*-0.007*	*-0.004*
lnP(spirits on)	-0.010***	-0.001	-0.008***	**-0.034*** **	-0.018***	0.003**	0.007***	0.005**	0.005*	-0.001
	-0.002	*-0.001*	*-0.002*	*-0.002*	*-0.002*	*-0.001*	*-0.001*	*-0.002*	*-0.002*	*-0.001*
lnP(RTDs on)	-0.004	0.006*	-0.006	-0.002	**-0.024*** **	-0.002	0.008*	-0.005	-0.002	-0.005
	-0.005	*-0.002*	*-0.005*	*-0.003*	*-0.005*	*-0.003*	*-0.003*	*-0.005*	*-0.006*	*-0.004*
lnP(beer off)	-0.014***	0.005***	0.002	0.002	-0.004	**-0.046*** **	0.001	-0.012***	-0.019***	-0.005*
	-0.003	*-0.002*	*-0.003*	*-0.002*	*-0.003*	*-0.003*	*-0.002*	*-0.004*	*-0.004*	*-0.003*
lnP(wine off)	-0.002	0.003	-0.003	-0.003	-0.012***	-0.016***	**-0.025*** **	-0.026***	-0.005	-0.014***
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.002*
lnP(cider off)	-0.003	0.007***	-0.009*	0.001	0.002	0.001	0.009***	**-0.038*** **	0.003	-0.001
	-0.003	*-0.002*	*-0.004*	*-0.002*	*-0.003*	*-0.002*	*-0.002*	*-0.005*	*-0.004*	*-0.003*
lnP(spirit off)	0.004	0.004*	-0.003	-0.004	-0.003	-0.009***	0.002	-0.010**	**-0.051*** **	-0.009**
	-0.004	*-0.002*	*-0.004*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.004*	*-0.005*	*-0.003*
lnP(RTD off)	0.001	0.002	-0.001	0.005*	-0.001	0.002	-0.002	-0.002	-0.001	**-0.017*** **
	-0.003	*-0.002*	*-0.003*	*-0.002*	*-0.003*	*-0.002*	*-0.002*	*-0.003*	*-0.004*	*-0.003*
lnincome	0.024***	0.022***	0.017***	0.016***	0.018***	0.009***	0.020***	0.005***	0.018***	0.005***
	-0.001	*-0.001*	*-0.002*	*-0.001*	*-0.001*	*-0.001*	*-0.001*	*-0.001*	*-0.002*	*-0.001*
drink_prevalence	0.068***	0.032***	0.030***	0.036***	0.025***	0.034***	0.043***	0.025***	0.059***	0.014***
	-0.001	*-0.001*	*-0.002*	*-0.001*	*-0.001*	*-0.001*	*-0.001*	*-0.001*	*-0.001*	*-0.001*
year 2	-0.005*	0.000	0.001	-0.003	-0.001	-0.002	0.002	0.001	-0.003	-0.003
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.002*
year 3	-0.010***	0.000	-0.003	-0.005**	-0.011***	-0.003	0.002	0.001	0.001	-0.005*
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.002*
year 4	-0.010***	0.003*	0.002	-0.006**	-0.013***	-0.005*	0.004*	0.001	-0.003	-0.009***
	-0.003	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.002*
year 5	-0.010***	0.001	0.003	-0.004	-0.022***	-0.005*	0.005**	0.003	-0.007*	-0.015***
	-0.003	*-0.001*	*-0.003*	*-0.002*	*-0.003*	*-0.002*	*-0.002*	*-0.003*	*-0.004*	*-0.002*
year 6	-0.015***	-0.003	0.015***	-0.010***	-0.036***	-0.003	0.001	0.010**	-0.007	-0.014***
	-0.003	*-0.002*	*-0.004*	*-0.002*	*-0.004*	*-0.002*	*-0.002*	*-0.003*	*-0.004*	*-0.003*
quarter 2	-0.002	-0.001	0.004	-0.001	-0.003	-0.003*	-0.001	0.002	0.001	0.002
	-0.002	*-0.001*	*-0.002*	*-0.001*	*-0.002*	*-0.001*	*-0.001*	*-0.002*	*-0.003*	*-0.002*
quarter 3	-0.013***	-0.002	-0.006**	-0.003*	-0.007***	-0.004**	0.009***	0.001	0.035***	0.001
	-0.002	*-0.001*	*-0.002*	*-0.001*	*-0.002*	*-0.001*	*-0.001*	*-0.002*	*-0.003*	*-0.002*
quarter 4	-0.001	0.002	-0.004	0	-0.008***	-0.009***	0.002	-0.002	0.003	-0.008***
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.001*	*-0.002*	*-0.003*	*-0.002*
north east	0.040***	0.001	0.023***	-0.005	0.017***	0.011***	0.002	0.016**	0.002	-0.004
	-0.005	*-0.003*	*-0.005*	*-0.003*	*-0.005*	*-0.003*	*-0.003*	*-0.005*	*-0.006*	*-0.004*
north west	0.027***	0.001	0.005	-0.001	0.008*	0.010***	0.007**	0.014**	0.019***	0.002
	-0.004	*-0.002*	*-0.004*	*-0.003*	*-0.004*	*-0.003*	*-0.002*	*-0.004*	*-0.005*	*-0.003*
yorkshire	0.038***	0.000	0.010*	-0.004	0.008*	0.012***	0.002	0.013**	0.001	0.002
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.005*	*-0.005*	*-0.003*
east midlands	0.028***	-0.001	0.017***	-0.006*	0.004	0.004	0.009***	0.016***	0.005	0.002
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.004*	*-0.005*	*-0.003*
west midlands	0.029***	-0.005**	0.025***	-0.006*	0.008*	0.004	0.005	0.025***	0.010	0.002
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.004*	*-0.005*	*-0.003*
eastern	0.007*	-0.002	0.001	-0.008***	0.003	0.004	0.008***	0.016***	-0.004	0.003
	-0.003	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.002*	*-0.004*	*-0.005*	*-0.003*
south east	0.010**	0.000	0.007	-0.008***	0.001	0.001	0.008***	0.013**	-0.001	0.007*
	-0.003	*-0.002*	*-0.004*	*-0.002*	*-0.003*	*-0.002*	*-0.002*	*-0.004*	*-0.005*	*-0.003*
south west	0.011**	0.001	0.029***	-0.006*	0.000	0.000	0.014***	0.019***	0.010	0.001
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.002*	*-0.004*	*-0.005*	*-0.003*
wales	0.026***	-0.002	0.030***	-0.005	0.005	0.007*	0.006	0.029***	0.004	0.004
	-0.005	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.003*	*-0.005*	*-0.006*	*-0.004*
scotland	-0.003	-0.007***	0.005	0.021***	-0.003	0.008**	0.003	0.018***	0.043***	0.003
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.002*	*-0.005*	*-0.005*	*-0.003*
northern ireland	0.017***	0.002	0.018***	0.030***	0.034***	0.000	0.001	0.012*	0.020***	0.010**
	-0.004	*-0.002*	*-0.005*	*-0.003*	*-0.004*	*-0.003*	*-0.002*	*-0.005*	*-0.005*	*-0.003*
higher skilled	-0.014***	0.003**	-0.011***	-0.010***	-0.019***	-0.006***	0.003*	-0.008**	-0.019***	-0.008***
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.002*	*-0.003*	*-0.003*	*-0.002*
lower skilled	0.013***	-0.007***	0.004	0.005**	0.013***	0.009***	-0.013***	0.010***	0.015***	0.007***
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.002*	*-0.002*	*-0.001*	*-0.002*	*-0.003*	*-0.002*
not classified	-0.020***	0.002	-0.011***	-0.007***	-0.025***	-0.014***	0.003	-0.006**	0.042***	-0.013***
	-0.002	*-0.001*	*-0.003*	*-0.002*	*-0.003*	*-0.002*	*-0.001*	*-0.002*	*-0.003*	*-0.002*
student	0.017*	0.010**	0.038***	0.045***	0.047***	-0.012*	-0.005	-0.003	-0.004	0.004
	-0.007	*-0.004*	*-0.007*	*-0.006*	*-0.005*	*-0.005*	*-0.005*	*-0.010*	*-0.010*	*-0.006*
unemployed	0.000	0.001	0.010	0.006	0.025**	0.018***	-0.007	0.025***	0.018*	0.011*
	-0.007	*-0.004*	*-0.008*	*-0.006*	*-0.008*	*-0.005*	*-0.005*	*-0.007*	*-0.009*	*-0.005*
constant	-0.309***	-0.160***	-0.306***	-0.147***	-0.219***	-0.230***	-0.203***	-0.313***	-0.378***	-0.158***
	-0.015	*-0.010*	*-0.029*	*-0.011*	*-0.016*	*-0.010*	*-0.010*	*-0.020*	*-0.019*	*-0.013*
sigma	0.118***	0.049***	0.069***	0.063***	0.067***	0.074***	0.075***	0.071***	0.118***	0.048***
	-0.002	*-0.001*	*-0.006*	*-0.002*	*-0.003*	*-0.002*	*-0.001*	*-0.004*	*-0.003*	*-0.002*
log-likelihood	2047.940	4780.142	-1533.566	990.368	-1669.577	1463.045	5995.506	-2028.987	-4041.956	-1372.803

**p<0.05 **p<0.01 ***p<0.001*

In addition to simple t-tests for individual variables, likelihood-ratio tests can be used to assess whether extra variables jointly add explanatory power to the model. Tests for the joint inclusion of drink prevalence, socio-economic group and Government Office Region in each of the ten regressions are given in Table 18.

These all find that the variables jointly add a statistically significant improvement to the model.

Table 18 Test for Joint Inclusion of Additional Variables

	On-trade					Off-trade				
	Beer	Wine	Cider	Spirits	RTDs	Beer	Wine	Cider	Spirits	RTDs
LR ratio chi^2(17)	7950.37	6759.43	1681.52	5583.09	1790.16	4303.04	6987.43	1209.06	3911.08	774.29
prob > chi^2	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

6.2 Normality, Homoskedasticity and Model Specification

It is necessary to assess whether the underlying assumptions of the Tobit model hold with the functional form and choice of variables used. The Tobit estimates will be inconsistent if the distribution of the residuals is not normal or if the model suffers from heteroskedasticity (Amemiya, 1984). If these problems are severe then it may be necessary to extend the Tobit model to a more generalised form that allows different distributions of the residuals (see for example Atkinson et al, 1990), or to explore a two-step approach. However if the departures from the standard Tobit assumptions are moderate, then the Tobit model is likely to still provide good estimates of the coefficients (Wooldridge, 2003).

A simple plot is very informative about the distribution of the residuals. Residual plots for regressions with each alcohol are given in Figures 9 to 18 in the Annex. The plots show clearly that the errors appear to approximate to normality well for regressions with each of the ten alcohol types. Whilst there is a slight skew in some of the residuals, this is not sufficiently severe to justify the use of alternative assumptions over the residuals.

It is also necessary to explore whether the Tobit specification is, in general, appropriate to our dataset. As we discussed in section 4, a two-step model separates the binary choice and the quantitative decision, whilst Tobit implicitly assumes that coefficients have closely related effects in both. If we believe the coefficients to have different effects in the two decision processes, then the Tobit model would be a less appropriate specification to use.

Wooldridge proposes an informal evaluation of the general appropriateness of the Tobit model. This is conducted by comparing the estimated coefficients from a probit regression to those from the Tobit model. The estimated Tobit coefficients, $\hat{\beta}$, must be divided by the estimated parameter $\hat{\sigma}$ to make this comparison possible. As we saw in section 4, whilst this parameter does not affect the sign of the estimated marginal effect, it does impact its magnitude.

If the assumptions of the Tobit model are valid, then the probit coefficients should be largely equivalent to the modified Tobit coefficients $\hat{\beta}/\hat{\sigma}$. This informal test gives an indication of whether the assumptions of normality and homoskedasticity may hold and whether the Tobit model is generally appropriate to use.

The two sets of coefficients are presented from the regressions for each alcohol type in Table 43 in the Annex. Whilst the two sets of results will never be identical because of sampling error, the coefficients should not be significant and opposite in sign. If they are, then this is an indication of probable misspecification.

If at least one of the Tobit or Probit coefficients is not significant then both are shaded grey, whilst those where the coefficients have the opposite sign are highlighted in red. As we can see, there are no cases where the coefficients are both significant and opposite in sign. A handful of results have opposite signs but these are not statistically significant and all are close to zero in value. The magnitudes of the two sets of coefficients are generally very similar in all of the

regressions. This informal test supports the assumptions within the Tobit framework of our model and indicates that it is appropriately specified.

Formal testing of the assumptions of the Tobit model is not straightforward. The conventional implementation of normality and heteroskedasticity tests can not be implemented in Tobit. The post estimation tests are invalid for censored data because the fitted values and residuals do not share the same properties as the OLS counterparts. Formally testing the assumptions in a Tobit context involves bespoke implementation of the Lagrange Multiplier (LM) test using generalised residuals. The purpose is to derive an NR-squared statistic from a regression that involves regressing a constant with variables that are functions of the generalised residuals. Because of the complexity of this procedure, we do not discuss the details here (see Cameron & Trivedi, 2005). Implementation of this approach suggests that the assumptions of normality and homoskedasticity may not hold in our regressions.

This is a potential weakness in the model to which there are two common remedies: moving to a two-part approach or use a selection model (for more details see Cameron & Trivedi, 2005). A two-step procedure would require a meaningful choice variable in the first stage. It is likely that social characteristics such as religion drive the decision not to drink at all rather than price. Hence as we do not have information on these characteristics in our dataset, and for the reasons discussed earlier, a two-step model would not be appropriate. Therefore, in the absence of an acceptable alternative, and because Tobit still provides good estimates provided deviations from the assumptions are not too severe, we conclude that the Tobit model remains the most appropriate specification to use.

6.3 Stability Across Time

As a robustness check of the model, we have conducted regressions for each year in isolation and also for truncated, five year datasets. Whilst the time dummies should control for any underlying changes over time, if the results are very unstable then it could be necessary to reconsider the use of the pooled cross-

section dataset. Own-price coefficients for regressions run in each of the six time periods are given in Table 19 below.

Table 19 Individual Year Regressions

Own-price coefficients

	On-trade					Off-trade				
	Beer	Wine	Cider	Spirits	RTD	Beer	Wine	Cider	Spirits	RTD
2001-02	-0.052***	-0.011***	-0.021	-0.031***	-0.031**	-0.048***	-0.023***	-0.058***	-0.077***	-0.022**
2002-03	-0.064***	-0.010***	0.000	-0.028***	-0.038**	-0.050***	-0.024***	-0.056***	-0.045***	-0.015*
2003-04	-0.065***	-0.013***	-0.021	-0.035***	-0.031*	-0.042***	-0.029***	-0.031**	-0.054***	-0.039***
2004-05	-0.052***	-0.008**	-0.028	-0.035***	0.002	-0.041***	-0.025***	-0.042***	-0.053***	-0.021*
2005-06	-0.069***	-0.016***	-0.013	-0.044***	-0.027	-0.047***	-0.020***	-0.054***	-0.046***	-0.005
2006	-0.057***	-0.014***	-0.023	-0.041***	-0.030	-0.052***	-0.027***	-0.027**	-0.045***	-0.017
average	-0.060	-0.012	-0.018	-0.036	-0.026	- 0.047	- 0.025	- 0.045	- 0.053	- 0.020
All years	-0.059***	-0.011***	-0.022**	-0.034***	-0.024***	-0.046***	-0.025***	-0.038***	-0.051***	-0.017***

**p<0.05 **p<0.01 ***p<0.001*

The results are generally very stable over time. For all alcohol types, the average of the individual year coefficients is close to the overall coefficients using the complete dataset. On and off-trade beer, wine and spirits have very consistent coefficients across time. All of these estimates are very close to one another across the years and very close to the estimate using the full dataset. The only exception for these alcohols is off-trade spirits, where the 2001-02 coefficient stands out as higher than the estimates in subsequent years. The coefficients for cider and RTDs are less consistent over time. This is likely to be largely the result of there being far fewer data points for these drink types, making reliable results more difficult to obtain in individual years. On-trade cider does not produce statistically significant results at the 5% level for individual years. However, with the exception of 2002-03, the estimated coefficients are broadly in line with our estimates using all years of data. Off-trade cider results are always statistically significant but with some fluctuation in the magnitude of the coefficients. On-trade RTDs have fairly consistent results with the exception of one outlier; in this case the 2004-05 coefficient is marginally positive but insignificant at 5%. Off-trade RTDs have two insignificant results and some fluctuation across years, but are all negative in sign. Overall, the coefficients are widely stable across years and, with the use of time dummies, we are content that the pooled dataset is sufficiently homogenous to produce reliable results for the period as a whole.

Table 20 Regressions without First and Last Four Quarters

Own-price coefficients

	On-trade					Off-trade				
	Beer	Wine	Cider	Spirits	RTD	Beer	Wine	Cider	Spirits	RTD
Remove:										
First 4 Quarters	-0.061***	-0.011***	-0.022**	-0.035***	-0.022***	-0.046***	-0.026***	-0.034***	-0.045***	-0.017***
Last 4 Quarters	-0.059***	-0.011***	-0.023**	-0.033***	-0.025***	-0.045***	-0.025***	-0.038***	-0.051***	-0.018***
All years	-0.059***	-0.011***	-0.022**	-0.034***	-0.024***	-0.046***	-0.025***	-0.038***	-0.051***	-0.017***

Table 20 further tests stability by running the regression after removing the first and last four quarters' observations. It is clear that the results are very stable to this shortened data set, with coefficient values and test significance almost identical.

7. Results

7.1 Price Elasticities

Price elasticities have been derived using the chosen model and these are given in Table 21. The own-prices are all highly significant with the expected negative sign. The own-price elasticities of beer, wine and cider are higher in the off-trade than the on-trade. This perhaps reflects consumers being more likely to shop around in the off-trade. However, spirits has the opposite result with a higher elasticity in the on-trade. The RTD elasticities are very similar.

Table 21 Price and Income Elasticities

	On-trade					Off-trade				
regressors	$\hat{q}$(beer)	$\hat{q}$(wine)	$\hat{q}$(cider)	$\hat{q}$(spirit)	$\hat{q}$(RTD)	$\hat{q}$(beer)	$\hat{q}$(wine)	$\hat{q}$(cider)	$\hat{q}$(spirit)	$\hat{q}$(RTD)
lnP(beer on)	**-0.773*** **	0.542***	-0.423*	0.048	0.231	-0.195**	0.166**	0.055	-0.135	0.174
	-0.049	*-0.085*	*-0.172*	*-0.11*	*-0.155*	*-0.067*	*-0.053*	*-0.139*	*-0.087*	*-0.168*
lnP(wine on)	-0.056*	**-0.456*** **	-0.073	0.109*	0.001	0.226***	0.066*	0.286***	0.353***	0.317***
	-0.022	*-0.047*	*-0.075*	*-0.042*	*-0.065*	*-0.031*	*-0.028*	*-0.065*	*-0.041*	*-0.072*
lnP(cider on)	0.162*	0.089	**-0.854** **	0.222	0.293	0.260**	0.134	-0.077	0.168	0.19
	-0.067	*-0.107*	*-0.264*	*-0.123*	*-0.188*	*-0.089*	*-0.072*	*-0.21*	*-0.123*	*-0.229*
lnP(spirits on)	-0.131***	-0.022	-0.326***	**-1.153*** **	-0.678***	0.071**	0.156***	0.166**	0.094*	-0.047
	-0.023	*-0.038*	*-0.081*	*-0.055*	*-0.072*	*-0.028*	*-0.024*	*-0.057*	*-0.038*	*-0.077*
lnP(RTDs on)	-0.05	0.237*	-0.229	-0.063	**-0.906*** **	-0.037	0.161*	-0.167	-0.033	-0.258
	-0.06	*-0.097*	*-0.21*	*-0.114*	*-0.191*	*-0.076*	*-0.064*	*-0.161*	*-0.109*	*-0.212*
lnP(beer off)	-0.183***	0.218***	0.081	0.067	-0.135	**-1.105*** **	0.029	-0.427***	-0.346***	-0.298*
	-0.042	*-0.065*	*-0.127*	*-0.074*	*-0.106*	*-0.059*	*-0.046*	*-0.124*	*-0.074*	*-0.148*
lnP(wine off)	-0.03	0.105	-0.121	-0.099	-0.446***	-0.384***	**-0.538*** **	-0.905***	-0.086	-0.768***
	-0.031	*-0.056*	*-0.107*	*-0.057*	*-0.088*	*-0.044*	*-0.041*	*-0.096*	*-0.061*	*-0.118*
lnP(cider off)	-0.039	0.301***	-0.363*	0.036	0.086	0.029	0.187***	**-1.341*** **	0.048	-0.041
	-0.044	*-0.07*	*-0.147*	*-0.076*	*-0.114*	*-0.056*	*-0.046*	*-0.147*	*-0.077*	*-0.15*
lnP(spirit off)	0.056	0.168*	-0.107	-0.12	-0.106	-0.221***	0.043	-0.367**	**-0.899*** **	-0.506**
	-0.047	*-0.071*	*-0.142*	*-0.085*	*-0.134*	*-0.064*	*-0.054*	*-0.128*	*-0.086*	*-0.161*
lnP(RTD off)	0.011	0.073	-0.035	0.162*	-0.049	0.042	-0.045	-0.064	-0.018	**-0.932*** **
	-0.045	*-0.074*	*-0.133*	*-0.076*	*-0.119*	*-0.057*	*-0.045*	*-0.118*	*-0.073*	*-0.162*
lnincome	0.310***	0.899***	0.642***	0.548***	0.693***	0.219***	0.424***	0.169***	0.322***	0.263***
	-0.02	*-0.039*	*-0.075*	*-0.038*	*-0.054*	*-0.021*	*-0.02*	*-0.044*	*-0.029*	*-0.057*

**p<0.05 **p<0.01 ***p<0.001*

It is informative to compare the own-price elasticities with those from previous UK-based studies of beer, wine and spirits presented in Section 2 (Figures 2 to 4). It is not a direct comparison since the vast majority of the studies do not split into the on-trade and the off-trade but it is still interesting. Our estimation for wine seems fairly central in the distribution. Beer is above average though still within the distribution. Similarly, spirits is also above average but certainly not outside the expected parameters. One factor to bear in mind is that this study is using more recent data and therefore will be picking up some more recent market developments that the older studies are not. In particular, as consumer preferences continue to shift toward the off-trade, where the elasticities tend to be higher, we would expect the overall sector elasticities to also increase over time. In that context, perhaps it is not surprising that our beer and spirits estimates are above the average.

The own-price elasticities are generally higher than the cross-price, suggesting that the former is of primary importance – a sensible result. The cross-price elasticities are mixed with some insignificant results and some coefficients of either sign. It is likely that the cross-prices could be picking up factors beyond simple substitution or complimentarity effects that we have been unable to control for in the model. Therefore, whilst some of the individual elasticities

could appear counter-intuitive, when used as a full set we nonetheless end up with overall dynamic effects that are realistic. Furthermore, as the data used is based on the household, it is likely that complimentarity will sometimes occur. For example, if households make a collective decision of whether to go out for a drink in the on-trade, then they are likely to factor in the total price, rather than the price of a single product. If different members prefer different drinks, then the price of one drink type will affect household consumption of both types in the same direction.

As we discussed in section 5, there was not a great deal to choose between our chosen model and model 1a, which used volumes instead of expenditure shares. However, the elasticities generated from that model appear unduly high, given our knowledge of the market. Furthermore, there seems to be less separation than we would expect between the product categories.

In section 4 we argued that evaluating the marginal effects from the unconditional dependent variable was the correct procedure for this analysis. Just for completeness, we did also look at the elasticities generated from the conditional dependent variable (those with positive alcohol consumption) and, as expected, the results are very significantly lower. This seems to provide very strong evidence that we made the correct choice.

Table 22 shows the previous set of elasticities estimated by HMRC in 2003 for comparison. This previous work did not differentiate between on and off-trade other than for beer and did not estimate models for cider or RTDs. The own-price elasticity of wine was imposed from an average of the literature at the time (see Huang, 2003). As can be seen, our new estimates are higher for on-trade beer, similar for off-trade beer and lower for spirits and wine.

Table 22 Previous HMRC Elasticities

	Beer On	Beer Off	Spirits	Wine
Beer On	-0.48	0.06	-0.95	-0.71
Beer Off	0.43	-1.03	0.46	0.56
Spirits	-0.15	-0.29	-1.31	-0.33
Wine	-0.32	-0.07	0.3	-0.75
Income	-0.18	0.55	0.69	1.51

7.2 Income Elasticity

The income elasticities are all of the expected positive sign and all highly significant. They are smaller than the own-price elasticities in all but one instance, again suggesting that own-price is generally the key factor in determining consumption of any given alcohol type. Interestingly, the income elasticities are always higher in the on-trade for each regression. This is arguably a sensible result given the higher prices in the on-trade. Results are broadly in line with the median figures reported in Gallet (2007).

7.3 Ready Reckoner Costings

As previously discussed, the primary goal of this paper is to provide a set of elasticities that give reliable revenue costing estimates to inform the analysis of alcohol tax policy. HMRC and HMT regularly publish indicative Tax Ready Reckoner costings. These estimates are for the effect of a 1% nominal increase in duty levied on one type of alcohol on the tax revenue from all alcohols. Hence the revenue impact is not only from changes on the alcohol for which the duty rise is levied, but also other alcohol products where consumption changes as a result. The revenue effect also includes any changes in VAT collected as a result of behavioural responses in consumption. The last published revenue costing, HM Treasury and HM Revenue & Customs (2009), which used the previous set of elasticities was for Pre-Budget Report (PBR) 2009. A comparison between this and the results from the new elasticities is given below.

Table 23 Comparison of Ready Reckoner Costings

	Old Elasticities Revenue Impact (£m)			New Elasticities Revenue Impact (£m)		
1% change in duties	2010-11	2011-12	2012-13	2010-11	2011-12	2012-13
beer and cider	30	35	35	25	25	25
wine	20	25	25	25	25	25
spirits	5	neg	neg	10	10	10

For a straightforward comparison, we have maintained the underlying parameters from the previous costings and only changed the price elasticities. Comparing the two sets of costings we see that the revenue effects estimated with the elasticities from this paper are broadly in line with those from before. A 1% change in duties generates a moderately smaller change in revenues from beer and cider and slightly larger change from wine. The biggest difference is for the effect of a change in sprits duties, which is now somewhat larger. However, this change is mainly due not to the difference in the own-price elasticity of spirits but rather the cross-prices. Previously these were all negative for spirits. As discussed in Section 5, we feel that the updated cross-price elasticities are more in line with what we would expect.

As a final check, we ran the model to determine the elasticity across all alcohol consumption. We would expect this to be far less elastic than that for the individual products, given the scope for substitutability between them. The price elasticity we find is around -0.3, which is slightly lower than the figure we report from the literature (in section 2.1). This is further reassurance that the results outlined in this section are robust.

8. Conclusion

This research set out to update the set of price elasticities that are used by HMRC in its alcohol costings model. We have used a Tobit model to estimate data from the Expenditure and Food Survey. The motivation for pursuing the Tobit model originated with the difficulties in dealing with the large numbers of zero

consumption observations reported in the survey. Tobit is a well established way to deal with this issue.

The elasticities will be used to capture the behavioural impact on duty and VAT receipts from changes in the rates of UK alcohol duties.

Results appear to be robust. We have been able to determine a full set of elasticities for both the on-trade and the off-trade and across all five major product categories: giving a total of 10 own-price elasticities and a further 90 cross-price elasticities. This level of detail is important given the opportunity for consumers to switch between products. The own-price elasticities are all negative and highly significant. The cross-price elasticities are also a significant improvement over what we had prior to this work. The income elasticities also appear to be sound.

The results in this study mark a major improvement in level of detail that HMRC is able to employ within its alcohol costings model. They enable its analysts to provide a richer set of results with which to inform policy decisions.

References

Amemiya, T. (1973), "Regression analysis when dependent variable is truncated normal", *Econometrica*, Vol. 41, No. 6, pp. 997-1016.

Amemiya, T. (1984), "Tobit Models: A Survey", *Journal of Econometrics*, Vol. 24, Iss. 1-2, pp. 3-61.

Atkinson, A., Gomulka, J. & N. Stern (1990), "Spending on Alcohol: Evidence from the Family Expenditure Survey 1970-1983", *Economic Journal*, Vol. 100, pp. 808-827.

Baker, P. & S. McKay (1990), "The Structure of Alcohol Taxes: A Hangover from the Past?", *The Institute for Fiscal Studies*.

Baker, P., McKay, S. & E. Symons (1990), "The simulation of indirect tax reforms The IFS Simulation Program for Indirect Taxation (SPIT)", *The Institute for Fiscal Studies*.

Blake, D. & A. Nied (1997), "The demand for alcohol in the United Kingdom", *Applied Economics*, Vol. 29, Iss. 12, pp. 1655-1672.

Breen, R. (1996), "Regression Models: Censored, Sample Selected or Truncated Data", Sage University Paper Series: Quantitative Applications in the Social Sciences, no. 07-111.

Cameron, C. & P. Trivedi (2009), "Microeconomics Using Stata", *Stata Press*.

Chambers, M. (1999), "Consumers' Demand and Excise Duty Receipts Equations for Alcohol, Tobacco, Petrol and DERV", *Government Economic Service Working Paper*, HMT.

Clements, K. & E. Selvanathan (1987), "Alcohol consumption" In Thiel H. and Clements K.W., *Applied Demand Analysis: Results from System-Wide Approaches*, pp.185-264, Ballinger Publishing Company.

Clements, K., Yang, W. & S. Zheng (1997), "Is Utility Additive? The Case of Alcohol", *Applied Economics*, Vol. 29, Iss. 9, pp. 1163-1167.

Cragg, G. (1971), "Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods", *Econometrica*, Vol. 39, No. 5, pp. 829-844.

Crawford, I. & S. Tanner (1995), "Bringing It All Back Home: Alcohol Taxation and Cross-Border Shopping", *Fiscal Studies*, Vol. 16, No. 2, pp. 94 – 114.

Crawford, I., Smith, S. & S. Tanner (1999), "Alcohol taxes, tax revenues and the Single European Market", *Fiscal Studies*, Vol. 20, Iss. 3, pp. 287-304.

Crooks, E. (1989), "Alcohol Consumption and Taxation", *The Institute for Fiscal Studies*.

Cuthbertson, K. & P. Ormerod (1991), "A study of the demand for alcoholic drinks", *Henley Centre Report*.

Duffy, M. (1983), "The demand for alcohol drink in the United Kingdom, 1963-1978", *Applied Economics*, Vol. 15, pp. 125-140.

Duffy, M. (1987), "Advertising and the inter-product distribution of demand: a Rotterdam model approach", *European Economic Review*, Vol. 31, pp. 1051-1070.

Duffy, M. (1991), "Advertising and the consumption of tobacco and alcoholic drink: a system-wide analysis", *Scottish Journal of Political Economy*, Vol. 38, pp. 369-385.

Duffy, M, (2002), "On the estimation of an advertising-augmented, cointegrating demand system", Economic Modelling, Elsevier, Vol. 20, Iss. 1, pp. 181-206.

Duffy, M. (2003), "Advertising and food, drink and tobacco consumption in the United Kingdom: a dynamic demand system", *Agricultural Economics*, Vol. 28, Iss.1, pp. 51-70.

Fogarty, J. (2004), "The own-price elasticity of alcohol: a meta-analysis", *Working Paper*, University of Western Australia.

Gallet, C. (2007), "The demand for alcohol: a meta-analysis of elasticities", *The Australian Journal of Agricultural and Resource Economics*, Vol. 51, pp. 121-135.

Godfrey, C. (1988), "Licensing and the demand for alcohol", *Applied Economics*, Vol. 20, pp. 1541-1558.

Greene, W. (2000), "Econometric Analysis", *Prentice Hall*, 4th edition.

Heckman, J. (1979), " Sample selection bias as a specification error", *Econometrica*, Vol. 47, pp. 153-161.

HM Treasury (1980), "The Change in Revenue from an Indirect Tax Change", *Economic Trends*, March, pp. 97-107.

HM Treasury and HM Revenue & Customs (2009), "Tax ready reckoner and tax reliefs 2009", *HMT*.

Huang, C-D. (2003), "Econometric Models of Alcohol Demand in the United Kingdom", *Government Economic Service Working Paper*, No 140, HMCE.

Jones, A. (1989), "A systems approach to the demand for alcohol and tobacco", *Bulletin of Economic Research*, Vol. 41, pp. 3307-3378.

Kemsley, W., Redpath, R. & M. Holmes (1980), "Family Expenditure Survey Handbook", *London: HMSO*.

McDonald, J. & R. Moffitt (1980), "The Uses of Tobit Analysis", *The Review of Economic Studies*, MIT Press, Vol. 62, Iss. 2, pp. 318-321.

McGuinness, T. (1983), "The demand for beer, spirits and wine in the UK, 1956-1979", in Grant M., Plant M., and Williams A., *Economics and Alcohol*, pp. 238-242, Croom Helm.

Mintel (2009), "Lager, Market Intelligence, November 2009".

Moosa, I. & J. Baxter (2002), "Modelling the trend and seasonals within an AIDS model of the demand for alcoholic beverages in the United Kingdom", *Applied Econometrics*, Vol. 17, Iss. 2, pp. 95-106.

NHS (2010), "Statistics on Alcohol: England, 2010".

ONS (2010), "Consumer Trends 2010", available online.

Prest, A. (1949), "Some experiments in demand analysis", *The Review of Economics and Statistics*, Vol. 21, pp. 33-49.

Salisu, M. & V. Balasubramanyam (1997), "Income and Price Elasticities of Demand for Alcoholic Drinks," *Applied Economics Letters*, Vol. 4, Iss. 4, pp. 247-251.

Selvanathan, E. (1988), "Alcohol consumption in the UK, 1955-85: a system-wide analysis", *Applied Economics*, Vol. 20, pp. 1071-1086.

Selvanathan, E. (1991), "Cross-country consumption comparison: an application of the Rotterdam demand system", *Applied Economics*, Vol. 23, pp. 1613-1622.

Selvanathan, S. & E. Selvanathan (2005), "Empirical Regularities in Cross-Country Alcohol Consumption", *The Economic Record*, The Economic Society of Australia, Vol. 81, Iss. S1, pp. S128-S142.

Selvanathan, S. & E. Selvanathan, (2007), "Another look at the identical tastes hypothesis on the analysis of cross-country alcohol data", *Empirical Economics*, Vol. 32, pp. 185–215.

Sigelman, L. & L. Zeng (1999), " Analyzing censored and sample-selected data with Tobit and Heckit models", *Political Analysis*, Vol. 8, pp. 167-182.

Stone, R. (1945), "The analysis of market demand", *Journal of the Royal Statistical Society*, Vol. 108, pp. 208-382.

Stone, R. (1951), "The Role of Measurement in Economics", *Cambridge University Press*.

Tobin, J. (1958), "Estimation of relationships for limited dependent variables", *Econometrica*, Vol. 26, pp. 24-36.

Walsh, B. (1982), "The demand for alcohol in the UK: a comment", *Journal of Industrial Economics*, Vol. 30, pp. 439- 446.

Wong, A. (1988), "The Demand for Alcohol in the UK 1920-1938: An Econometric Study", *Discussion Paper No. 88.13.*, Department of Economics, The University of Western Australia.

Wooldridge, J. (2002), "Econometric Analysis of Cross Section and Panel Data", *MIT*.

Wooldridge, J. (2003), "Introductory Econometrics", *South-Western Educational* Publishing, 2nd edition.

Yen, S. & H. Jensen (1996), "Determinants of Household Expenditures on Alcohol", *Journal of Consumer Affairs*, Vol. 30, No. 1, pp. 48-56.

Annex

Figure 7 Alcohol Receipts, 1993-2010 (2009-10 Prices)

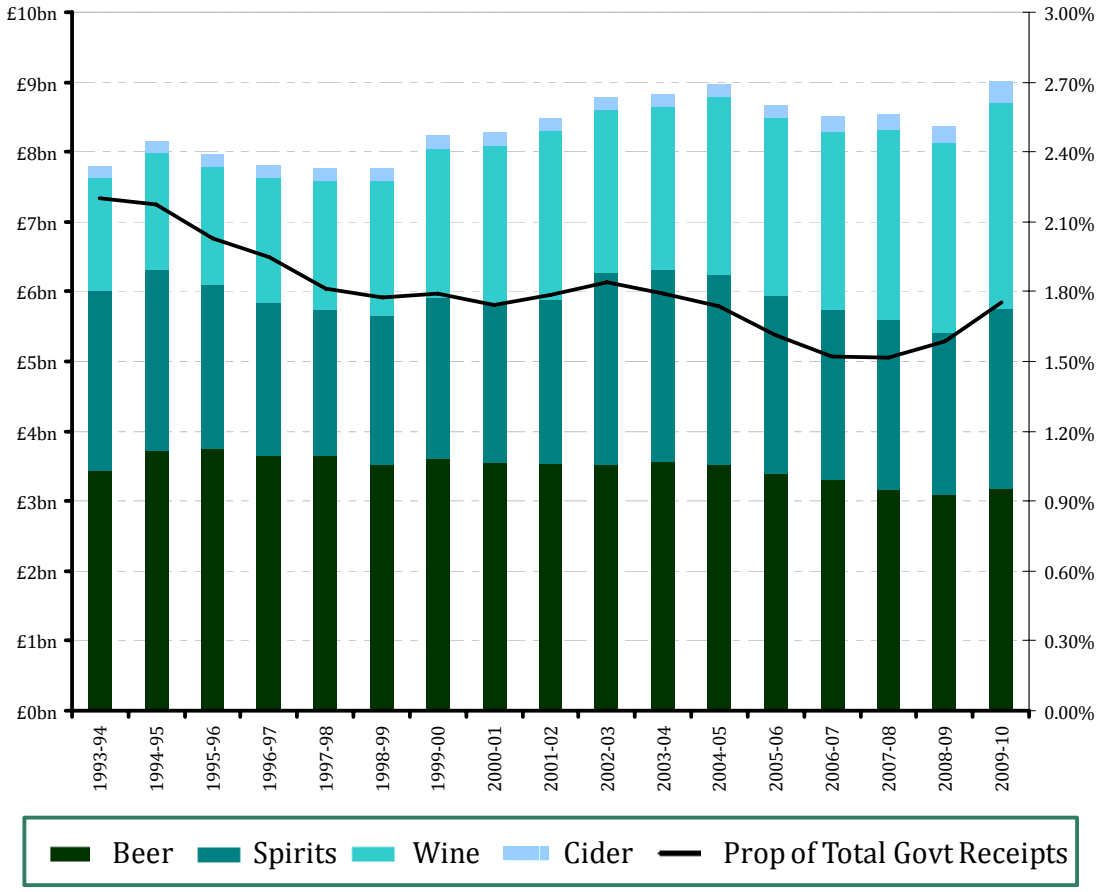


Table 24 Descriptive Statistics: Volumes (ml)

Alcohol	Mean	Standard Deviation	Median	75th Percentile	90th Percentile	95th Percentile	99th percentile	Maximum
Beer On	2,376	5,477	0	2,076	7,668	12,649	26,810	113,758
Wine On	96	324	0	0	300	600	1,400	21,150
Cider On	86	759	0	0	0	0	2,100	39,936
Spirit On	88	379	0	0	150	540	1,820	13,400
RTD On	109	718	0	0	0	330	2,970	35,310
Beer Off	1,816	5,091	0	0	6,000	10,560	23,600	198,240
Wine Off	1,188	2,794	0	1,400	3,750	6,000	13,000	81,000
Cider Off	258	1,797	0	0	0	750	7,147	56,000
Spirit Off	187	663	0	0	700	1,400	3,000	36,700
RTD Off	76	575	0	0	0	0	2,200	28,300

Table 25 Descriptive Statistics: Expenditure (p)

Alcohol	Mean	Standard Deviation	Median	75th Percentile	90th Percentile	95th Percentile	99th Percentile	Maximum
Beer On	934	2,159	0	860	3,020	4,960	10,320	46,817
Wine On	256	905	0	0	770	1,525	4,050	40,600
Cider On	35	315	0	0	0	0	940	15,991
Spirit On	199	794	0	0	495	1,200	3,900	21,680
RTD On	73	478	0	0	0	250	2,000	22,188
Beer Off	309	821	0	0	1,098	1,800	3,732	22,833
Wine Off	615	1,618	0	561	1,914	3,188	6,939	50,900
Cider Off	34	225	0	0	0	129	930	7,762
Spirit Off	243	848	0	0	898	1,599	4,076	28,571
RTD Off	24	176	0	0	0	0	799	7,451

Table 26 Descriptive Statistics: Expenditure Share

Alcohol	Mean	Standard Deviation	Median	75th Percentile	90th Percentile	95th Percentile	99th Percentile	Maximum
Beer On	2.8%	7.0%	0.0%	2.3%	8.7%	15.1%	35.0%	96.1%
Wine On	0.6%	1.9%	0.0%	0.0%	1.8%	3.6%	9.0%	66.2%
Cider On	0.1%	1.1%	0.0%	0.0%	0.0%	0.0%	2.4%	85.6%
Spirit On	0.5%	2.1%	0.0%	0.0%	1.2%	3.2%	9.5%	54.0%
RTD On	0.2%	1.1%	0.0%	0.0%	0.0%	0.6%	4.9%	62.4%
Beer Off	1.0%	3.1%	0.0%	0.0%	3.1%	5.5%	13.7%	90.3%
Wine Off	1.7%	4.0%	0.0%	1.7%	5.3%	8.5%	18.8%	84.7%
Cider Off	0.1%	1.2%	0.0%	0.0%	0.0%	0.3%	3.3%	56.8%
Spirit Off	0.8%	3.3%	0.0%	0.0%	2.2%	5.5%	15.8%	83.1%
RTD Off	0.1%	0.6%	0.0%	0.0%	0.0%	0.0%	2.2%	33.5%

Table 27 Descriptive Statistics: Prices (p/ml)

Alcohol	Mean	Standard Deviation	Minimum	Percentile 1st	Percentile 5th	25th	Median	75th	Percentile 95th	99th	Maximum
Beer On	0.41	0.11	0.08	0.18	0.25	0.34	0.40	0.46	0.58	0.75	3.22
Wine On	3.10	2.70	0.17	0.66	1.00	1.52	2.02	3.72	8.33	12.78	47.75
Cider On	0.42	0.13	0.10	0.15	0.25	0.36	0.41	0.47	0.63	0.92	2.50
Spirit On	3.72	4.39	0.28	0.78	1.11	1.63	2.15	4.40	10.33	16.00	160.00
RTD On	0.68	0.25	0.15	0.28	0.33	0.56	0.68	0.79	0.96	1.21	7.36
Beer Off	0.20	0.08	0.01	0.07	0.10	0.14	0.18	0.23	0.33	0.45	2.38
Wine Off	0.53	0.27	0.01	0.16	0.26	0.40	0.49	0.60	0.93	1.60	5.00
Cider Off	0.16	0.09	0.03	0.07	0.08	0.11	0.14	0.20	0.32	0.40	2.50
Spirit Off	1.39	0.59	0.09	0.39	0.67	1.05	1.28	1.59	2.36	3.50	9.26
RTD Off	0.36	0.17	0.02	0.07	0.16	0.27	0.35	0.43	0.60	0.90	2.49

for those purchsing each alcohol

Table 28 Mean Volumes Across Government Office Region

	On-Trade					Off Trade				
	Beer	Wine	Cider	Spirit	RTD	Beer	Wine	Cider	Spirit	RTD
North East	3,374	86	133	88	174	2,489	1,047	361	167	80
North West	2,895	101	64	96	133	2,305	1,226	266	221	81
Yorkshire	3,397	97	69	84	121	2,340	1,084	208	150	69
East Midlands	2,775	98	96	90	102	1,947	1,287	268	185	85
West Midlands	2,674	84	128	64	101	1,738	1,117	387	203	71
Eastern	1,906	95	45	72	89	1,745	1,249	224	147	73
London	1,844	123	46	91	78	1,294	1,121	141	146	50
South East	2,006	111	76	78	105	1,602	1,406	221	164	86
South West	2,081	107	139	90	93	1,606	1,441	298	200	74
Wales	2,670	85	192	74	101	2,064	1,124	489	180	71
Scotland	1,776	74	65	138	83	1,795	1,023	244	295	84
Northern Ireland	1,947	61	59	93	161	1,345	869	159	179	81
Overall	2,376	96	86	88	109	1,816	1,188	258	187	76

Table 29 Mean Expenditure Across Government Office Region

	On-Trade					Off Trade				
	Beer	Wine	Cider	Spirit	RTD	Beer	Wine	Cider	Spirit	RTD
North East	1,200	185	48	181	110	391	465	43	207	22
North West	1,063	239	25	200	86	380	612	35	284	25
Yorkshire	1,234	241	27	167	79	381	533	29	191	21
East Midlands	1,092	248	41	186	69	318	619	36	243	23
West Midlands	1,017	199	51	141	67	291	553	49	240	23
Eastern	797	251	19	156	62	300	641	30	190	23
London	821	429	21	243	54	246	667	19	205	17
South East	854	319	32	178	72	287	776	29	214	29
South West	857	266	58	185	59	278	722	40	258	25
Wales	1,011	196	74	148	64	330	544	65	223	25
Scotland	708	196	28	306	52	304	550	33	396	26
Northern Ireland	769	189	29	282	114	251	478	25	248	28
Overall	934	256	35	199	73	309	615	34	243	24

Table 30 Mean Volumes Across Socio-Economic Groups

	On-Trade					Off-Trade				
	Beer	Wine	Cider	Spirit	RTD	Beer	Wine	Cider	Spirit	RTD
Higher Skilled	2804	198	83	108	96	2187	2243	244	188	84
Lower Skilled	2950	61	114	93	163	2331	795	335	171	119
Medium Skilled	3032	125	120	123	153	2343	1508	305	195	101
Not Classified	1321	50	35	36	33	947	737	174	191	27
Student	3450	112	283	440	526	1340	775	295	129	67
Unemployed	1255	29	48	54	99	1359	437	325	94	75
Overall	2376	96	86	88	109	1816	1188	258	187	76

Table 31 Mean Expenditure Across Socio-Economic Groups

	On-Trade					Off-Trade				
	Beer	Wine	Cider	Spirit	RTD	Beer	Wine	Cider	Spirit	RTD
Higher Skilled	1193	618	36	261	68	408	1312	35	259	28
Lower Skilled	1119	133	43	204	107	375	341	44	215	36
Medium Skilled	1229	335	51	278	104	400	780	41	256	32
Not Classified	472	119	14	80	20	158	366	22	244	9
Student	1378	319	115	863	301	235	415	41	179	23
Unemployed	416	60	17	118	59	216	231	43	111	25
Overall	934	256	35	199	73	309	615	34	243	24

Table 32 Socio-economic Groupings

Not classified
- Not recorded
- Occupations not started
- Not classifiable for other reason

Student
- Full-time students

Higher skilled
- Employers in large organisations
- Higher managerial
- Higher professional (traditional) - employees
- Higher professional (new) - employees
- Higher professional (traditional) – self-employed
- Higher professional (new) – self-employed

Medium skilled
- Lower professional & higher technical (traditional) - employees
- Lower professional & higher technical (new) - employees
- Lower professional & higher technical (traditional) – self-employed
- Lower professional & higher technical (new) – self-employed
- Lower managerial
- Higher supervisory
- Intermediate clerical and administrative
- Intermediate sales and service
- Intermediate technical and auxilary
- Intermediate engineering
- Employers (small organisations, non-professional)
- Employers (small - agricultural)
- Own account workers (non-professional)
- Own account workers (agriculture)
- Lower supervisory
- Lower technical craft
- Lower technical process operative

Lower skilled
- Semi-routine sales
- Semi-routine service
- Semi-routine technical
- Semi-routine operative
- Semi-routine agricultural
- Semi-routine clerical
- Semi-routine childcare
- Routine sales and service
- Routine production
- Routine technical
- Routine operative
- Routine agricultural

Unemployed
- Never worked
- Long-term unemployed

Figure 8 Histogram of Drink Prevalence

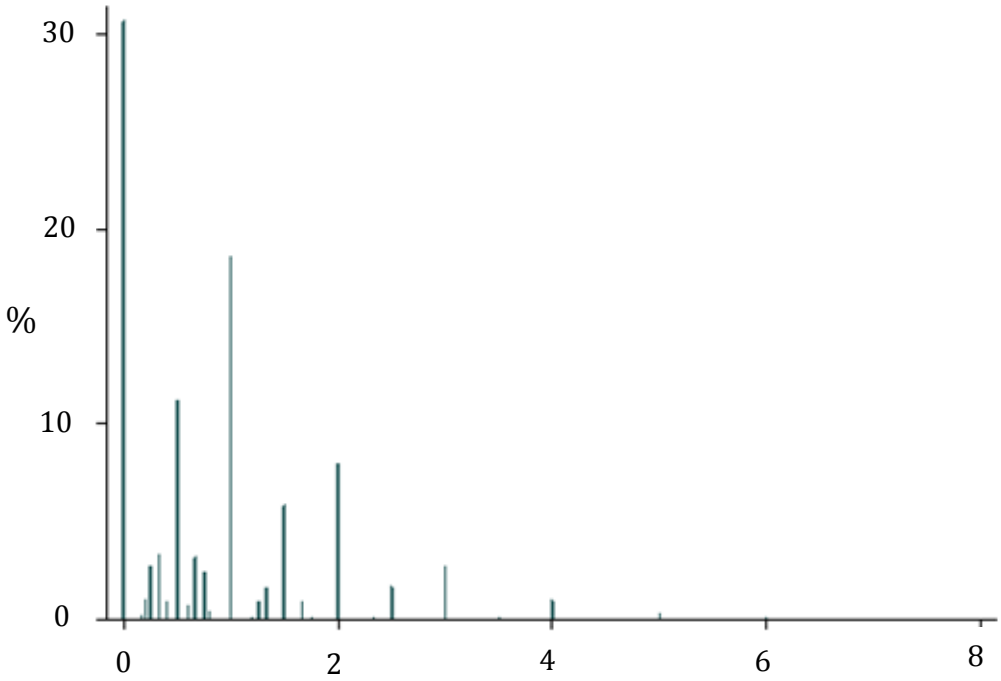


Table 33 Model Selection: On-trade Beer

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	-7107.567***	-7163.630***	-0.059***	-0.055***	*P(beer on)*	-10776.16***	-10114.97***	-0.063***	-0.053***
	-305.022	*-310.775*	*-0.004*	*-0.004*		*-1028.231*	*-1045.570*	*-0.011*	*-0.011*
lnP(wine on)	-624.838***	-596.181***	-0.004*	-0.003*	*P(wine on)*	-154.910***	-126.783**	-0.002***	-0.001**
	-151.994	*-153.951*	*-0.002*	*-0.002*		*-46.502*	*-47.633*	*0.000*	*0.000*
lnP(cider on)	912.871*	1108.487**	0.012*	0.016**	*P(cider on)*	2689.758**	3126.736**	0.031**	0.036**
	-417.987	*-428.162*	*-0.005*	*-0.005*		*-949.865*	*-952.082*	*-0.012*	*-0.012*
lnP(spirits on)	-1302.025***	-1409.270***	-0.010***	-0.013***	*P(spirits on)*	-50.946	-69.579	0.000	-0.001
	-151.803	*-154.089*	*-0.002*	*-0.002*		*-43.941*	*-48.547*	*0.000*	*0.000*
lnP(RTDs on)	-324.046	-124.945	-0.004	-0.002	*P(RTDs on)*	-127.575	-19.750	-0.003	-0.003
	-373.155	*-378.891*	*-0.005*	*-0.005*		*-520.012*	*-513.874*	*-0.006*	*-0.006*
lnP(beer off)	-1308.196***	-1306.735***	-0.014***	-0.013***	*P(beer off)*	-7054.549***	-6365.421***	-0.081***	-0.073***
	-264.731	*-269.287*	*-0.003*	*-0.003*		*-1250.815*	*-1260.040*	*-0.015*	*-0.015*
lnP(wine off)	-507.822*	-477.732*	-0.002	-0.002	*P(wine off)*	-2180.485***	-1853.669***	-0.023***	-0.017***
	-205.840	*-209.521*	*-0.002*	*-0.002*		*-309.171*	*-309.759*	*-0.003*	*-0.003*
lnP(cider off)	37.219	134.832	-0.003	0.000	*P(cider off)*	-1303.590	-1112.293	-0.033	-0.029
	-255.490	*-256.648*	*-0.003*	*-0.003*		*-1428.408*	*-1438.941*	*-0.018*	*-0.018*
lnP(spirit off)	-147.828	-171.908	0.004	0.004	*P(spirit off)*	-501.751**	-487.647*	-0.004	-0.003
	-291.243	*-296.904*	*-0.004*	*-0.004*		*-193.412*	*-194.421*	*-0.002*	*-0.002*
lnP(RTD off)	-38.013	-10.613	0.001	0.000	*P(RTD off)*	-1262.832	-1481.114*	-0.008	-0.011
	-254.807	*-258.299*	*-0.003*	*-0.003*		*-729.546*	*-737.064*	*-0.010*	*-0.009*
lnincome	3577.461***		0.024***		*income*	7.004***		0.000***	
	-141.084		*-0.001*			*-0.198*		*0.000*	
lnexp_notalc		2412.234***		-0.006***	*exp_notalc*		5.016***		0.000*
		-102.763		*-0.002*			*-0.253*		*0.000*
sigma	8957.339***	9109.922***	0.118***	0.116***	*sigma*	9016.079***	9176.475***	0.118***	0.117***
	-188.572	*-190.745*	*-0.002*	*-0.002*		*-188.399*	*-190.941*	*-0.002*	*-0.002*
log-likelihood	-180000	-181000	2048	1835	*log-likelihood*	-182000	-182000	1961	1724

*p<0.05 **p<0.01 ***p<0.001

Table 34 Model Selection: Off-trade Beer

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	-899.536	-1021.155*	-0.008**	-0.007**	*P(beer on)*	-2755.654*	-2252.592	-0.021**	-0.018*
	-462.586	*-464.624*	*-0.003*	*-0.003*		*-1148.012*	*-1166.584*	*-0.007*	*-0.007*
lnP(wine on)	1417.991***	1421.352***	0.009***	0.010***	*P(wine on)*	70.009	81.163	0.000	0.001
	-217.823	*-219.124*	*-0.001*	*-0.001*		*-57.804*	*-59.801*	*0.000*	*0.000*
lnP(cider on)	1886.517**	1966.990***	0.011**	0.012**	*P(cider on)*	4257.909**	4588.478***	0.024**	0.026**
	-594.650	*-595.624*	*-0.004*	*-0.004*		*-1308.338*	*-1310.420*	*-0.008*	*-0.008*
lnP(spirits on)	274.134	245.858	0.003**	0.002	*P(spirits on)*	-126.564**	-140.700**	-0.001*	-0.001**
	-191.099	*-191.101*	*-0.001*	*-0.001*		*-46.412*	*-49.721*	*0.000*	*0.000*
lnP(RTDs on)	-476.530	-315.670	-0.002	-0.001	*P(RTDs on)*	-305.305	-218.879	-0.002	-0.002
	-534.299	*-529.036*	*-0.003*	*-0.003*		*-1101.768*	*-1071.382*	*-0.005*	*-0.005*
lnP(beer off)	-12340.66***	-12349.83***	-0.046***	-0.045***	*P(beer off)*	-28639.73***	-28046.3***	-0.057***	-0.054***
	-463.636	*-465.377*	*-0.003*	*-0.003*		*-3427.555*	*-3405.397*	*-0.013*	*-0.013*
lnP(wine off)	-2572.524***	-2541.920***	-0.016***	-0.016***	*P(wine off)*	-4694.352***	-4474.459***	-0.028***	-0.026***
	-303.597	*-305.538*	*-0.002*	*-0.002*		*-575.492*	*-584.582*	*-0.003*	*-0.003*
lnP(cider off)	158.068	165.647	0.001	0.002	*P(cider off)*	-497.550	-399.147	-0.003	-0.002
	-366.587	*-366.593*	*-0.002*	*-0.002*		*-2047.643*	*-2053.505*	*-0.012*	*-0.012*
lnP(spirit off)	-1756.928***	-1747.586***	-0.009***	-0.009***	*P(spirit off)*	-1063.904***	-1055.010***	-0.006**	-0.005**
	-447.232	*-447.182*	*-0.003*	*-0.003*		*-317.320*	*-318.577*	*-0.002*	*-0.002*
lnP(RTD off)	52.950	63.657	0.002	0.001	*P(RTD off)*	-509.813	-745.389	0.002	0.001
	-373.165	*-372.929*	*-0.002*	*-0.002*		*-1127.724*	*-1124.442*	*-0.007*	*-0.007*
lnincome	3104.158***		0.009***		*income*	5.811***		0.000***	
	-170.247		*-0.001*			*-0.269*		*0.000*	
lnexp_notalc		2656.351***		0.000	*exp_notalc*		4.842***		0.000
		-140.468		*-0.001*			*-0.336*		*0.000*
sigma	11772.061***	11813.148***	0.074***	0.074***	*sigma*	12229.927***	12294.502***	0.075***	0.075***
	-273.585	*-273.211*	*-0.002*	*-0.002*		*-280.355*	*-280.856*	*-0.002*	*-0.002*
log-likelihood	-117000	-117000	1463	1393	*log-likelihood*	-118000	-118000	1187	1124

*p<0.05 **p<0.01 ***p<0.001

Table 35 Model Selection: On-trade Wine

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	235.172***	200.522***	0.013***	0.012***	*P(beer on)*	345.244***	389.099***	0.020***	0.024***
	-35.745	*-34.053*	*-0.002*	*-0.002*		*-69.032*	*-69.734*	*-0.004*	*-0.004*
lnP(wine on)	-522.866***	-523.044***	-0.011***	-0.011***	*P(wine on)*	-41.747***	-42.800***	0.003***	0.003***
	-26.510	*-26.248*	*-0.001*	*-0.001*		*-4.593*	*-4.675*	*0.000*	*0.000*
lnP(cider on)	34.337	25.712	0.002	0.002	*P(cider on)*	63.646	75.535	0.004	0.005
	-42.439	*-42.094*	*-0.003*	*-0.003*		*-92.694*	*-94.804*	*-0.005*	*-0.006*
lnP(spirits on)	-5.610	-0.325	-0.001	-0.001	*P(spirits on)*	0.863	-0.516	0.000	0.000
	-16.088	*-15.970*	*-0.001*	*-0.001*		*-2.980*	*-2.907*	*0.000*	*0.000*
lnP(RTDs on)	114.179**	146.152***	0.006*	0.008**	*P(RTDs on)*	131.617**	159.647**	0.006*	0.007*
	-38.187	*-37.857*	*-0.002*	*-0.002*		*-50.444*	*-52.610*	*-0.003*	*-0.003*
lnP(beer off)	77.321**	67.708**	0.005***	0.005**	*P(beer off)*	-113.879	-56.295	-0.006	-0.002
	-26.204	*-26.091*	*-0.002*	*-0.002*		*-111.596*	*-113.599*	*-0.006*	*-0.007*
lnP(wine off)	62.057*	50.243	0.003	0.002	*P(wine off)*	-2.550	9.467	-0.003	-0.001
	-27.244	*-26.063*	*-0.001*	*-0.001*		*-37.697*	*-37.097*	*-0.002*	*-0.002*
lnP(cider off)	145.406***	136.237***	0.007***	0.007***	*P(cider off)*	519.078***	514.164***	0.024**	0.025**
	-27.415	*-27.108*	*-0.002*	*-0.002*		*-136.134*	*-134.499*	*-0.008*	*-0.008*
lnP(spirit off)	54.487	50.245	0.004*	0.004*	*P(spirit off)*	-11.355	-15.319	-0.001	-0.001
	-28.994	*-28.970*	*-0.002*	*-0.002*		*-20.156*	*-20.687*	*-0.001*	*-0.001*
lnP(RTD off)	39.849	51.621	0.002	0.002	*P(RTD off)*	20.961	10.575	0.000	-0.001
	-28.038	*-28.658*	*-0.002*	*-0.002*		*-74.757*	*-73.858*	*-0.004*	*-0.004*
lnincome	440.082***		0.022***		*income*	0.794***		0.000***	
	-26.242		*-0.001*			*-0.040*		*0.000*	
lnexp_notalc		476.720***		0.020***	*exp_notalc*		0.808***		0.000***
		-27.324		*-0.001*			*-0.057*		*0.000*
sigma	785.794***	780.293***	0.049***	0.050***	*sigma*	814.278***	820.713***	0.048***	0.049***
	-20.199	*-20.057*	*-0.001*	*-0.001*		*-20.495*	*-20.512*	*-0.001*	*-0.001*
log-likelihood	-71600	-71400	4780	4681	*log-likelihood*	-72800	-73000	4815	4465

*p<0.05 **p<0.01 ***p<0.001

Table 36 Model Selection: Off-trade Wine

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	767.732***	626.107***	0.008**	0.008**	*P(beer on)*	520.530	806.185*	0.002	0.007
	-179.624	*-179.102*	*-0.003*	*-0.003*		*-389.387*	*-410.195*	*-0.005*	*-0.005*
lnP(wine on)	229.476*	228.437*	0.003*	0.004**	*P(wine on)*	30.793	32.568	0.000	0.000
	-96.595	*-97.136*	*-0.001*	*-0.001*		*-25.494*	*-27.853*	*0.000*	*0.000*
lnP(cider on)	541.401*	544.706*	0.006	0.008*	*P(cider on)*	688.477	862.511	0.004	0.007
	-231.665	*-232.008*	*-0.003*	*-0.003*		*-502.468*	*-514.289*	*-0.007*	*-0.007*
lnP(spirits on)	377.116***	382.113***	0.007***	0.006***	*P(spirits on)*	-23.014	-32.689*	0.000	0.000
	-79.265	*-79.146*	*-0.001*	*-0.001*		*-14.214*	*-15.373*	*0.000*	*0.000*
lnP(RTDs on)	534.320**	638.446**	0.008*	0.009**	*P(RTDs on)*	268.562	351.416	0.004	0.004
	-202.720	*-203.331*	*-0.003*	*-0.003*		*-281.788*	*-288.778*	*-0.004*	*-0.004*
lnP(beer off)	-46.889	-75.484	0.001	0.001	*P(beer off)*	-397.197	-119.998	0.000	0.005
	-153.228	*-155.391*	*-0.002*	*-0.002*		*-709.541*	*-716.850*	*-0.010*	*-0.010*
lnP(wine off)	-3534.424***	-3527.985***	-0.025***	-0.025***	*P(wine off)*	-2656.995***	-2537.816***	0.005	0.008**
	-135.626	*-135.885*	*-0.002*	*-0.002*		*-213.335*	*-214.590*	*-0.003*	*-0.003*
lnP(cider off)	674.351***	649.560***	0.009***	0.010***	*P(cider off)*	2636.926***	2639.612***	0.036**	0.038***
	-143.085	*-144.102*	*-0.002*	*-0.002*		*-776.021*	*-783.271*	*-0.011*	*-0.011*
lnP(spirit off)	52.353	41.613	0.002	0.002	*P(spirit off)*	-55.791	-61.593	-0.001	0.000
	-181.208	*-183.085*	*-0.003*	*-0.003*		*-117.888*	*-121.666*	*-0.002*	*-0.002*
lnP(RTD off)	-153.840	-121.649	-0.002	-0.002	*P(RTD off)*	-745.570	-847.604*	-0.008	-0.010
	-134.748	*-136.741*	*-0.002*	*-0.002*		*-382.179*	*-387.754*	*-0.006*	*-0.006*
lnincome	2134.053***		0.020***		*income*	4.034***		0.000***	
	-80.876		*-0.001*			*-0.120*		*0.000*	
lnexp_notalc		2051.933***		0.010***	*exp_notalc*		3.787***		0.000***
		-63.834		*-0.001*			*-0.189*		*0.000*
sigma	5074.900***	5097.479***	0.075***	0.076***	*sigma*	5105.717***	5175.891***	0.075***	0.075***
	-108.874	*-109.237*	*-0.002*	*-0.002*		*-107.952*	*-109.220*	*-0.002*	*-0.002*
log-likelihood	-149000	-149000	5996	5723	*log-likelihood*	-151000	-151000	5839	5565

*p<0.05 **p<0.01 ***p<0.001

Table 37 Model Selection: On-trade Spirits

regressors	Model 1a	Model 2a	Model 3a	Model 4a	regressors	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	58.420	30.512	0.001	0.001	P(beer on)	80.617	139.526	0.005	0.009
	-50.746	-51.003	-0.003	-0.003		-141.717	-148.862	-0.008	-0.008
lnP(wine on)	42.927	39.093	0.003*	0.003*	P(wine on)	12.797*	11.211	0.001*	0.001*
	-22.525	-22.215	-0.001	-0.001		-5.680	-6.075	0.000	0.000
lnP(cider on)	92.700	92.439	0.007	0.007	P(cider on)	410.175*	427.514**	0.024**	0.025**
	-64.595	-64.057	-0.004	-0.004		-160.286	-158.172	-0.009	-0.009
lnP(spirits on)	-857.147***	-854.105***	-0.034***	-0.035***	P(spirits on)	-44.370***	-45.182***	0.000	0.000
	-32.355	-32.220	-0.002	-0.002		-11.158	-11.441	0.000	0.000
lnP(RTDs on)	-68.673	-42.313	-0.002	-0.001	P(RTDs on)	-78.349	-61.498	-0.003	-0.002
	-60.638	-60.101	-0.003	-0.003		-90.508	-86.349	-0.005	-0.005
lnP(beer off)	-3.008	-3.354	0.002	0.002	P(beer off)	-539.401**	-482.175*	-0.025*	-0.022*
	-41.061	-40.739	-0.002	-0.002		-204.540	-205.593	-0.011	-0.011
lnP(wine off)	-74.160*	-75.683**	-0.003	-0.003	P(wine off)	-295.181***	-277.756***	-0.015***	-0.014***
	-29.405	-28.906	-0.002	-0.002		-52.719	-53.922	-0.003	-0.003
lnP(cider off)	-1.358	-2.577	0.001	0.001	P(cider off)	-227.794	-219.103	-0.010	-0.009
	-39.682	-39.381	-0.002	-0.002		-210.688	-209.162	-0.012	-0.012
lnP(spirit off)	-84.121	-92.731*	-0.004	-0.004	P(spirit off)	-66.327*	-70.169*	-0.003	-0.003
	-44.506	-44.258	-0.003	-0.003		-32.462	-32.748	-0.002	-0.002
lnP(RTD off)	68.191	74.569*	0.005*	0.005*	P(RTD off)	-22.455	-34.794	0.002	0.002
	-36.937	-36.680	-0.002	-0.002		-114.290	-112.953	-0.007	-0.007
lnincome	378.628***		0.016***		income	0.773***		0.000***	
	-23.730		-0.001			-0.035		0.000	
lnexp_notalc		416.176***		0.014***	exp_notalc		0.780***		0.000***
		-18.641		-0.001			-0.045		0.000
sigma	1053.298***	1051.848***	0.063***	0.064***	sigma	1163.432***	1169.380***	0.065***	0.065***
	-29.043	-29.049	-0.002	-0.002		-31.010	-31.001	-0.002	-0.002
log-likelihood	-57900	-57800	990	926	log-likelihood	-59500	-59600	394	287

*p<0.05 **p<0.01 ***p<0.001

Table 38 Model Selection: Off-trade Spirits

regressors	Model 1a	Model 2a	Model 3a	Model 4a	regressors	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	-164.968	-199.907	-0.008	-0.007	P(beer on)	-783.169**	-750.673**	-0.035**	-0.032*
	-102.227	-103.283	-0.005	-0.005		-268.748	-277.123	-0.012	-0.013
lnP(wine on)	407.993***	406.868***	0.020***	0.020***	P(wine on)	46.407***	41.072**	0.002**	0.002***
	-50.741	-50.804	-0.002	-0.002		-13.733	-12.873	-0.001	-0.001
lnP(cider on)	219.348	224.619	0.009	0.011	P(cider on)	597.013	609.665	0.024	0.026
	-145.184	-144.949	-0.007	-0.007		-316.872	-315.877	-0.015	-0.015
lnP(spirits on)	83.258	74.963	0.005*	0.004	P(spirits on)	-7.318	-9.700	0.000	0.000
	-44.898	-44.848	-0.002	-0.002		-8.621	-8.754	0.000	0.000
lnP(RTDs on)	-58.196	-14.246	-0.002	0.000	P(RTDs on)	-35.727	6.609	-0.002	-0.001
	-125.247	-124.104	-0.006	-0.006		-181.646	-177.925	-0.008	-0.008
lnP(beer off)	-406.903***	-416.041***	-0.019***	-0.019***	P(beer off)	-1770.104***	-1760.695***	-0.086***	-0.085***
	-88.263	-88.516	-0.004	-0.004		-480.168	-483.883	-0.022	-0.022
lnP(wine off)	-144.298*	-131.548	-0.005	-0.004	P(wine off)	-285.880*	-269.601*	-0.012*	-0.010
	-73.617	-73.547	-0.003	-0.003		-127.989	-124.843	-0.005	-0.005
lnP(cider off)	114.795	104.044	0.003	0.003	P(cider off)	293.815	275.297	-0.001	-0.001
	-86.760	-87.223	-0.004	-0.004		-462.819	-461.487	-0.022	-0.022
lnP(spirit off)	-1655.903***	-1650.569***	-0.051***	-0.050***	P(spirit off)	-371.750***	-372.881***	0.003	0.003
	-114.628	-114.499	-0.005	-0.005		-77.040	-76.426	-0.003	-0.003
lnP(RTD off)	-22.642	-10.031	-0.001	-0.001	P(RTD off)	-226.038	-236.859	-0.009	-0.010
	-83.378	-83.052	-0.004	-0.004		-236.088	-234.423	-0.011	-0.011
lnincome	597.313***		0.018***		income	0.999***		0.000***	
	-42.266		-0.002			-0.074		0.000	
lnexp_notalc		511.153***		0.005***	exp_notalc		1.063***		0.000***
		-34.161		-0.002			-0.079		0.000
sigma	2392.858***	2400.765***	0.118***	0.118***	sigma	2434.491***	2436.940***	0.118***	0.118***
	-66.752	-66.776	-0.003	-0.003		-66.881	-66.886	-0.003	-0.003
log-likelihood	-58300	-58400	-4042	-4113	log-likelihood	-59100	-59100	-4200	-4234

*p<0.05 **p<0.01 ***p<0.001

Table 39 Model Selection: On-trade Cider

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	-942.504**	-1074.647**	-0.011*	-0.012**	*P(beer on)*	-2508.789**	-2465.676**	-0.028*	-0.027*
	-346.051	*-346.089*	*-0.004*	*-0.004*		*-913.815*	*-928.422*	*-0.012*	*-0.012*
lnP(wine on)	-156.396	-164.695	-0.002	-0.002	*P(wine on)*	-59.368	-58.419	-0.001	-0.001
	-151.974	*-150.800*	*-0.002*	*-0.002*		*-40.964*	*-41.463*	*-0.001*	*-0.001*
lnP(cider on)	-2424.185***	-2347.823***	-0.022**	-0.021**	*P(cider on)*	-601.170	-376.369	0.017	0.020
	-531.742	*-533.203*	*-0.007*	*-0.007*		*-1182.646*	*-1202.837*	*-0.015*	*-0.015*
lnP(spirits on)	-601.638***	-577.592***	-0.008***	-0.008***	*P(spirits on)*	-35.596	-41.546	-0.001	-0.001
	-160.647	*-159.512*	*-0.002*	*-0.002*		*-38.544*	*-39.110*	*-0.001*	*-0.001*
lnP(RTDs on)	-482.436	-355.117	-0.006	-0.005	*P(RTDs on)*	-497.091	-358.256	-0.005	-0.004
	-423.105	*-421.771*	*-0.005*	*-0.005*		*-675.441*	*-659.780*	*-0.009*	*-0.009*
lnP(beer off)	173.565	154.062	0.002	0.002	*P(beer off)*	-1552.694	-1338.214	-0.020	-0.017
	-247.370	*-251.524*	*-0.003*	*-0.003*		*-1109.250*	*-1126.685*	*-0.015*	*-0.015*
lnP(wine off)	-285.517	-277.174	-0.003	-0.003	*P(wine off)*	-630.396	-527.748	-0.007	-0.006
	-210.206	*-211.544*	*-0.003*	*-0.003*		*-363.312*	*-367.013*	*-0.005*	*-0.005*
lnP(cider off)	-750.093**	-726.886**	-0.009*	-0.009*	*P(cider off)*	-3298.139*	-3063.266*	-0.042*	-0.039
	-281.968	*-281.816*	*-0.004*	*-0.004*		*-1585.471*	*-1558.479*	*-0.021*	*-0.021*
lnP(spirit off)	-211.413	-200.209	-0.003	-0.003	*P(spirit off)*	-342.522	-330.721	-0.005	-0.005
	-287.672	*-285.538*	*-0.004*	*-0.004*		*-207.439*	*-205.345*	*-0.003*	*-0.003*
lnP(RTD off)	-49.595	-55.413	-0.001	-0.001	*P(RTD off)*	-621.493	-772.017	-0.008	-0.010
	-253.443	*-253.885*	*-0.003*	*-0.003*		*-730.755*	*-729.405*	*-0.010*	*-0.010*
lnincome	1563.855***		0.017***		*income*	2.753***		0.000***	
	-164.631		*-0.002*			*-0.229*		*0.000*	
lnexp_notalc		1479.327***		0.014***	*exp_notalc*		2.397***		0.000***
		-125.676		*-0.001*			*-0.207*		*0.000*
sigma	5185.017***	5208.401***	0.069***	0.070***	*sigma*	5190.568***	5222.164***	0.069***	0.069***
	-215.894	*-217.519*	*-0.003*	*-0.003*		*-213.598*	*-214.387*	*-0.003*	*-0.003*
log-likelihood	-20900	-20900	-1534	-1555	*log-likelihood*	-21100	-21200	-1553	-1590

**p<0.05 **p<0.01 ***p<0.001*

Table 40 Model Selection: Off-trade Cider

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	192.897	119.102	0.002	0.002	*P(beer on)*	-284.905	-127.361	-0.001	0.000
	-664.099	*-667.645*	*-0.004*	*-0.004*		*-1524.220*	*-1548.913*	*-0.009*	*-0.009*
lnP(wine on)	1262.741***	1258.151***	0.008***	0.008***	*P(wine on)*	122.021	121.101	0.001	0.001
	-315.013	*-316.362*	*-0.002*	*-0.002*		*-79.927*	*-80.728*	*0.000*	*0.000*
lnP(cider on)	-193.665	-122.504	-0.002	-0.001	*P(cider on)*	-438.001	-336.619	-0.005	-0.004
	-971.843	*-970.866*	*-0.006*	*-0.006*		*-2083.743*	*-2086.819*	*-0.013*	*-0.013*
lnP(spirits on)	728.087**	706.582**	0.005**	0.004**	*P(spirits on)*	-16.362	-20.722	0.000	0.000
	-273.512	*-274.158*	*-0.002*	*-0.002*		*-49.744*	*-50.662*	*0.000*	*0.000*
lnP(RTDs on)	-912.853	-833.184	-0.005	-0.004	*P(RTDs on)*	-2082.821	-1991.900	-0.011	-0.011
	-744.151	*-741.456*	*-0.005*	*-0.005*		*-1206.240*	*-1199.758*	*-0.007*	*-0.007*
lnP(beer off)	-2207.661***	-2161.105***	-0.012***	-0.012***	*P(beer off)*	-9619.911**	-9294.783**	-0.050*	-0.049*
	-574.935	*-577.008*	*-0.004*	*-0.004*		*-3357.885*	*-3377.622*	*-0.020*	*-0.020*
lnP(wine off)	-4244.744***	-4228.904***	-0.026***	-0.026***	*P(wine off)*	-6574.140***	-6514.470***	-0.039***	-0.039***
	-460.195	*-460.114*	*-0.003*	*-0.003*		*-1265.857*	*-1267.138*	*-0.007*	*-0.007*
lnP(cider off)	-7929.484***	-7929.078***	-0.038***	-0.037***	*P(cider off)*	-14269.03**	-14317.49**	-0.038	-0.038
	-750.605	*-748.108*	*-0.005*	*-0.005*		*-5326.449*	*-5323.173*	*-0.025*	*-0.025*
lnP(spirit off)	-1824.261**	-1839.235**	-0.010**	-0.010**	*P(spirit off)*	-1286.820*	-1301.355*	-0.008*	-0.008*
	-609.854	*-610.041*	*-0.004*	*-0.004*		*-538.042*	*-526.305*	*-0.003*	*-0.003*
lnP(RTD off)	-486.992	-484.252	-0.002	-0.002	*P(RTD off)*	-3623.253*	-3698.825*	-0.016	-0.017
	-516.974	*-517.501*	*-0.003*	*-0.003*		*-1546.075*	*-1544.560*	*-0.010*	*-0.010*
lnincome	1530.166***		0.005***		*income*	2.505***		0.000***	
	-206.430		*-0.001*			*-0.373*		*0.000*	
lnexp_notalc		1123.482***		0.000	*exp_notalc*		2.240***		0.000*
		-201.060		*-0.001*			*-0.408*		*0.000*
sigma	11438.496***	11455.539***	0.071***	0.070***	*sigma*	11801.986***	11813.962***	0.072***	0.072***
	-423.443	*-422.804*	*-0.003*	*-0.003*		*-432.491*	*-432.519*	*-0.003*	*-0.003*
log-likelihood	-27700	-27700	-2029	-2040	*log-likelihood*	-28000	-28000	-2155	-2160

**p<0.05 **p<0.01 ***p<0.001*

Table 41 Model Selection: On-trade RTD

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	351.978	207.673	0.006	0.004	*P(beer on)*	791.705	894.251	0.015	0.017
	-260.109	*-255.579*	*-0.004*	*-0.004*		*-534.659*	*-544.672*	*-0.008*	*-0.009*
lnP(wine on)	0.940	-23.335	0.000	0.000	*P(wine on)*	-47.109	-60.159*	-0.001*	-0.001*
	-109.682	*-106.827*	*-0.002*	*-0.002*		*-28.528*	*-30.080*	*0.000*	*0.000*
lnP(cider on)	301.979	307.728	0.008	0.008	*P(cider on)*	1589.309*	1708.483*	0.032**	0.033**
	-331.335	*-326.599*	*-0.005*	*-0.005*		*-740.083*	*-736.264*	*-0.012*	*-0.012*
lnP(spirits on)	-1171.160***	-1133.059***	-0.018***	-0.018***	*P(spirits on)*	-60.524	-62.855	-0.001	-0.001
	-125.190	*-124.392*	*-0.002*	*-0.002*		*-41.508*	*-42.885*	*-0.001*	*-0.001*
lnP(RTDs on)	-2393.916***	-2298.129***	-0.024***	-0.023***	*P(RTDs on)*	-859.926	-773.782	0.004	0.005
	-329.132	*-323.328*	*-0.005*	*-0.005*		*-569.455*	*-542.811*	*-0.007*	*-0.007*
lnP(beer off)	-322.038	-367.667*	-0.004	-0.004	*P(beer off)*	-3121.758***	-2951.556**	-0.043**	-0.041**
	-184.830	*-184.339*	*-0.003*	*-0.003*		*-942.667*	*-953.280*	*-0.014*	*-0.014*
lnP(wine off)	-746.544***	-764.873***	-0.012***	-0.012***	*P(wine off)*	-1722.488***	-1785.787***	-0.027***	-0.028***
	-150.227	*-146.457*	*-0.002*	*-0.002*		*-414.955*	*-396.775*	*-0.006*	*-0.006*
lnP(cider off)	121.866	91.887	0.002	0.002	*P(cider off)*	328.764	275.904	0.005	0.005
	-186.116	*-184.566*	*-0.003*	*-0.003*		*-814.699*	*-808.950*	*-0.013*	*-0.013*
lnP(spirit off)	-246.708	-272.475	-0.003	-0.003	*P(spirit off)*	-145.676	-155.030	-0.002	-0.002
	-246.982	*-242.829*	*-0.004*	*-0.004*		*-158.340*	*-157.359*	*-0.002*	*-0.002*
lnP(RTD off)	-44.442	-49.346	-0.001	-0.001	*P(RTD off)*	-305.877	-365.021	-0.005	-0.006
	-193.729	*-196.443*	*-0.003*	*-0.003*		*-571.467*	*-571.826*	*-0.009*	*-0.009*
lnincome	1437.253***		0.018***		*income*	2.473***		0.000***	
	-106.708		*-0.001*			*-0.159*		*0.000*	
lnexp_notalc		1703.027***		0.022***	*exp_notalc*		2.616***		0.000***
		-102.809		*-0.001*			*-0.184*		*0.000*
sigma	4136.839***	4109.935***	0.067***	0.068***	*sigma*	4187.719***	4201.805***	0.067***	0.067***
	-139.941	*-139.537*	*-0.002*	*-0.002*		*-140.155*	*-140.127*	*-0.002*	*-0.002*
log-likelihood	-28400	-28300	-1670	-1624	*log-likelihood*	-28600	-28700	-1767	-1790

*p<0.05 **p<0.01 ***p<0.001

Table 42 Model Selection: Off-trade RTD

regressors	Model 1a	Model 2a	Model 3a	Model 4a	*regressors*	Model 1b	Model 2b	Model 3b	Model 4b
lnP(beer on)	228.269	103.308	0.003	0.002	*P(beer on)*	444.946	399.903	0.006	0.006
	-314.583	*-306.758*	*-0.003*	*-0.003*		*-657.781*	*-667.707*	*-0.006*	*-0.006*
lnP(wine on)	593.309***	553.801***	0.006***	0.006***	*P(wine on)*	18.455	0.211	0.000	0.000
	-140.062	*-134.987*	*-0.001*	*-0.001*		*-34.152*	*-34.880*	*0.000*	*0.000*
lnP(cider on)	358.534	293.716	0.003	0.003	*P(cider on)*	850.831	810.371	0.008	0.008
	-423.897	*-412.932*	*-0.004*	*-0.004*		*-933.447*	*-928.720*	*-0.009*	*-0.009*
lnP(spirits on)	-114.138	-55.557	-0.001	0.000	*P(spirits on)*	-18.142	-17.640	0.000	0.000
	-143.179	*-139.696*	*-0.001*	*-0.001*		*-29.422*	*-29.369*	*0.000*	*0.000*
lnP(RTDs on)	-416.337	-372.590	-0.005	-0.004	*P(RTDs on)*	-133.062	-81.029	-0.002	-0.001
	-393.560	*-387.385*	*-0.004*	*-0.004*		*-597.526*	*-581.346*	*-0.006*	*-0.006*
lnP(beer off)	-646.438*	-684.968*	-0.005*	-0.006*	*P(beer off)*	-2782.703	-2921.973	-0.023	-0.024
	-278.344	*-274.884*	*-0.003*	*-0.003*		*-1482.173*	*-1491.364*	*-0.014*	*-0.014*
lnP(wine off)	-1412.474***	-1413.691***	-0.014***	-0.014***	*P(wine off)*	-2492.678***	-2559.403***	-0.024***	-0.024***
	-212.902	*-208.408*	*-0.002*	*-0.002*		*-514.519*	*-512.611*	*-0.005*	*-0.005*
lnP(cider off)	-100.978	-153.841	-0.001	-0.001	*P(cider off)*	250.225	254.437	0.005	0.005
	-275.819	*-278.273*	*-0.003*	*-0.003*		*-1350.082*	*-1344.808*	*-0.013*	*-0.013*
lnP(spirit off)	-988.951***	-972.496***	-0.009**	-0.009**	*P(spirit off)*	-422.674	-428.182	-0.004	-0.004
	-296.766	*-291.736*	*-0.003*	*-0.003*		*-238.182*	*-234.725*	*-0.002*	*-0.002*
lnP(RTD off)	-2580.740***	-2610.165***	-0.017***	-0.017***	*P(RTD off)*	-1856.659	-1896.493	0.001	0.001
	-330.095	*-331.397*	*-0.003*	*-0.003*		*-1016.680*	*-1012.235*	*-0.009*	*-0.009*
lnincome	713.637***		0.005***		*income*	1.175***		0.000***	
	-122.430		*-0.001*			*-0.178*		*0.000*	
lnexp_notalc		1267.807***		0.009***	*exp_notalc*		1.981***		0.000***
		-104.504		*-0.001*			*-0.187*		*0.000*
sigma	4859.288***	4805.725***	0.048***	0.048***	*sigma*	4988.196***	4968.301***	0.048***	0.048***
	-186.578	*-185.573*	*-0.002*	*-0.002*		*-190.371*	*-189.891*	*-0.002*	*-0.002*
log-likelihood	-18400	-18300	-1373	-1343	*log-likelihood*	-18600	-18500	-1439	-1425

*p<0.05 **p<0.01 ***p<0.001

Figure 9 Residuals: On-trade Beer

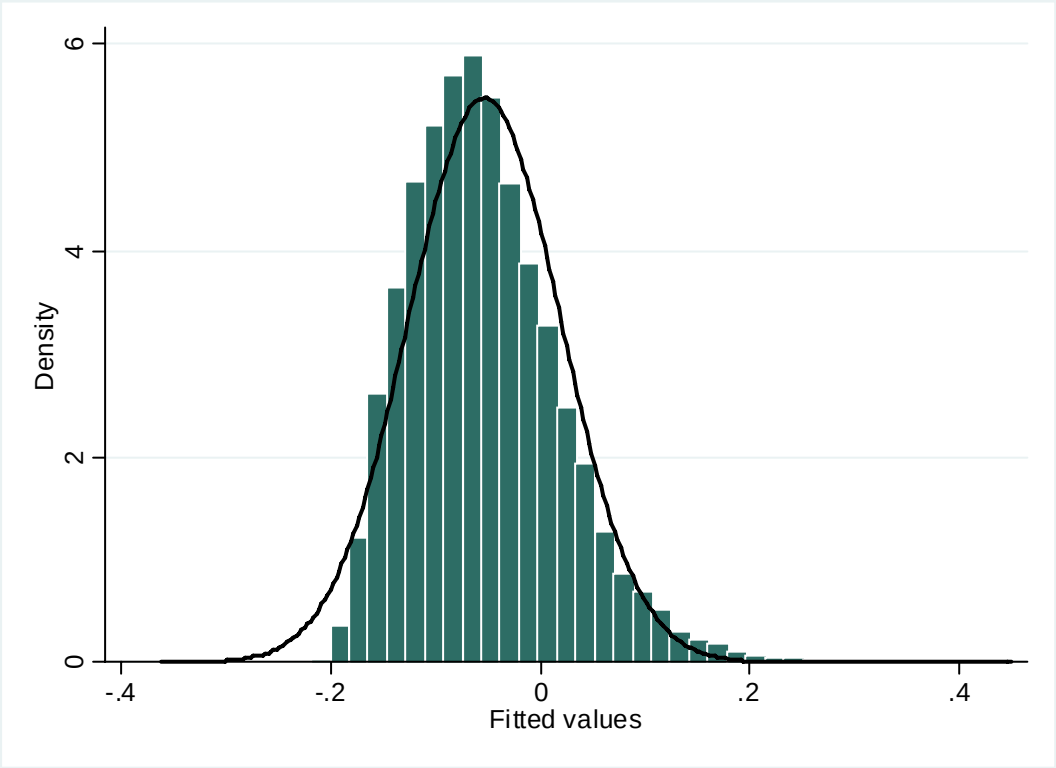


Figure 10 Residuals: Off-trade Beer

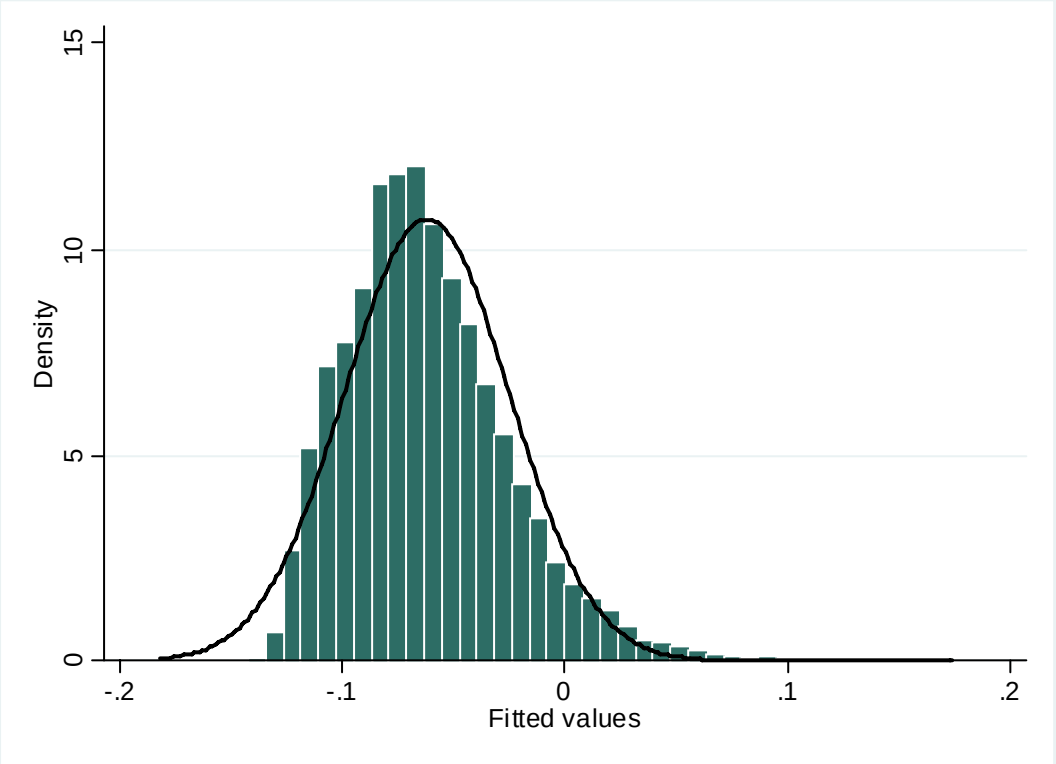


Figure 11 Residuals: On-trade Wine

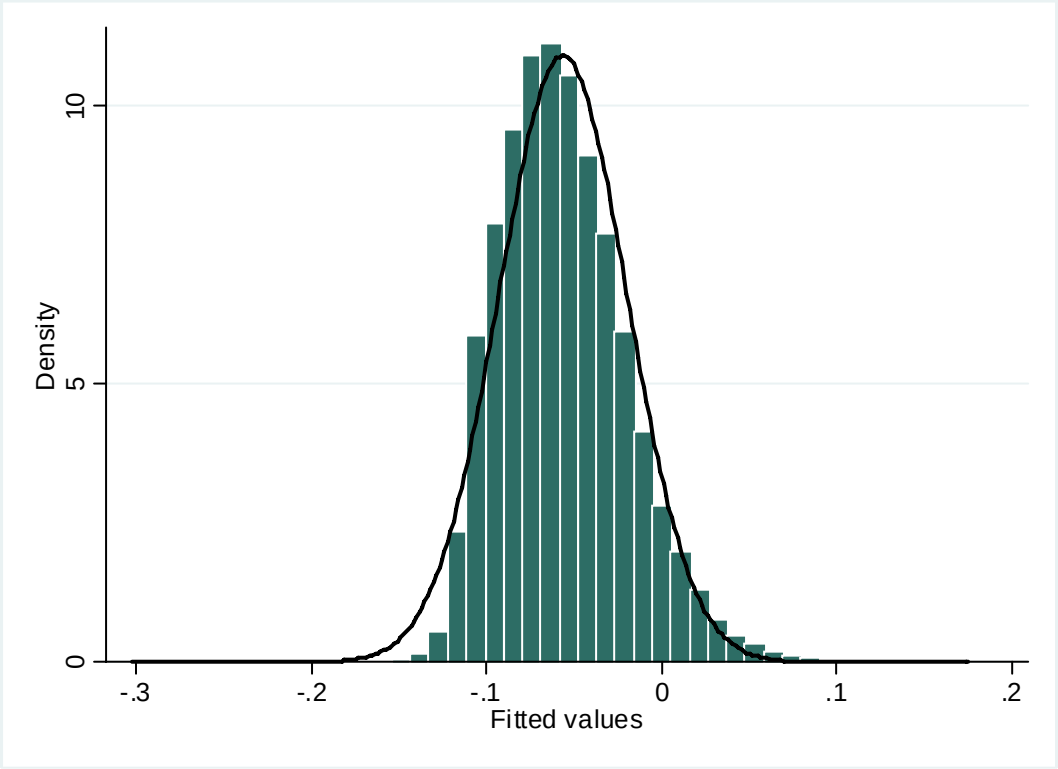


Figure 12 Residuals: Off-trade Wine

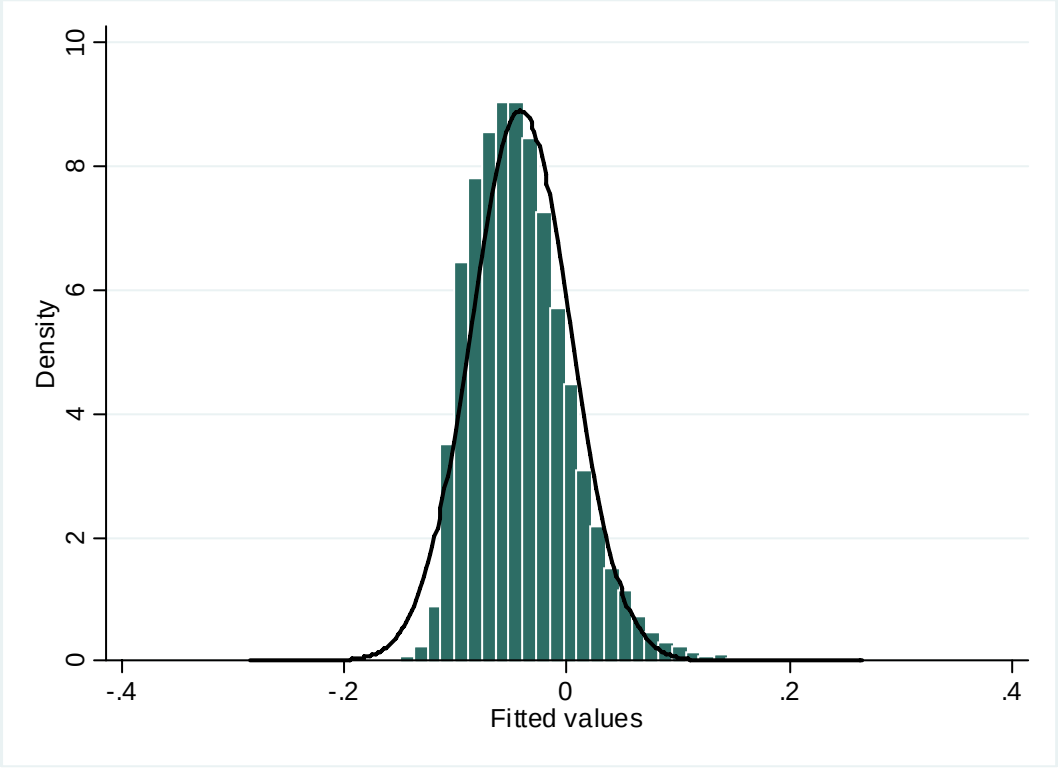


Figure 13 Residuals: On-trade Spirits

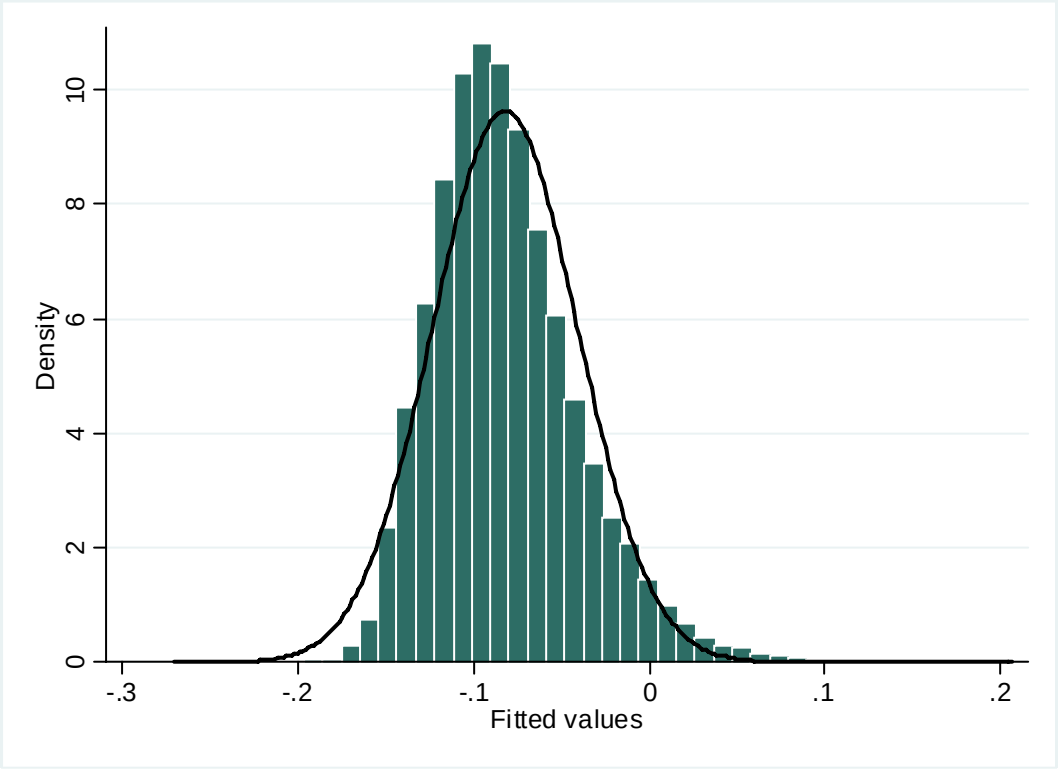


Figure 14 Residuals: Off-trade Spirits

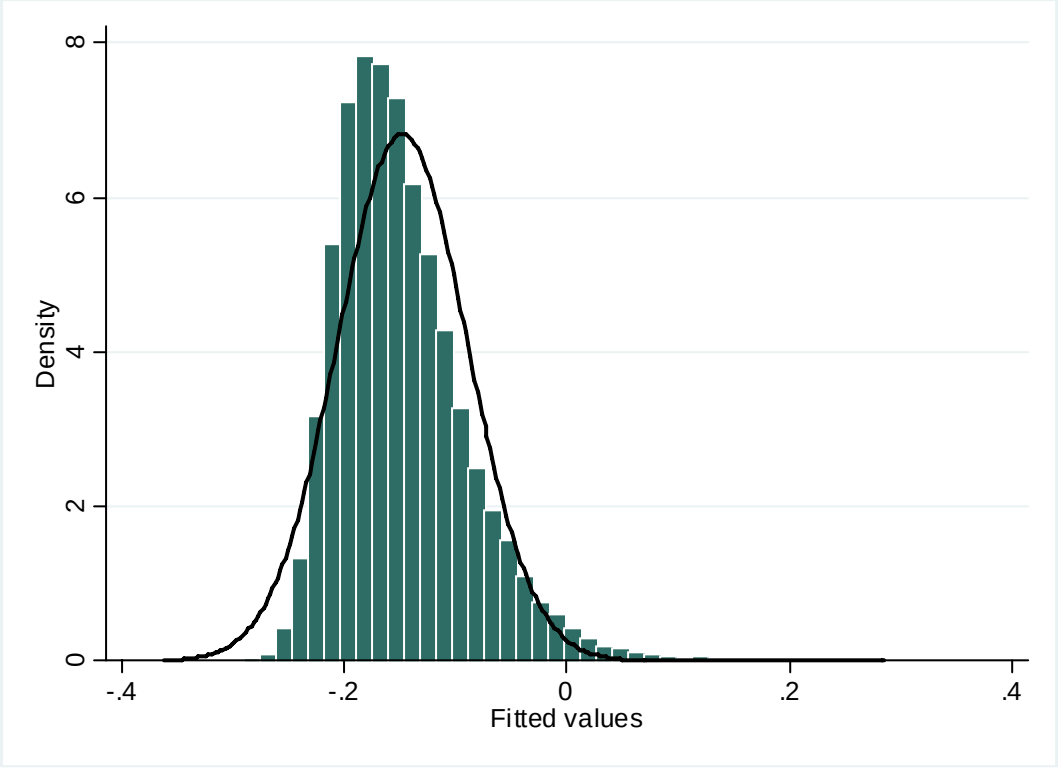


Figure 15 Residuals: On-trade Cider

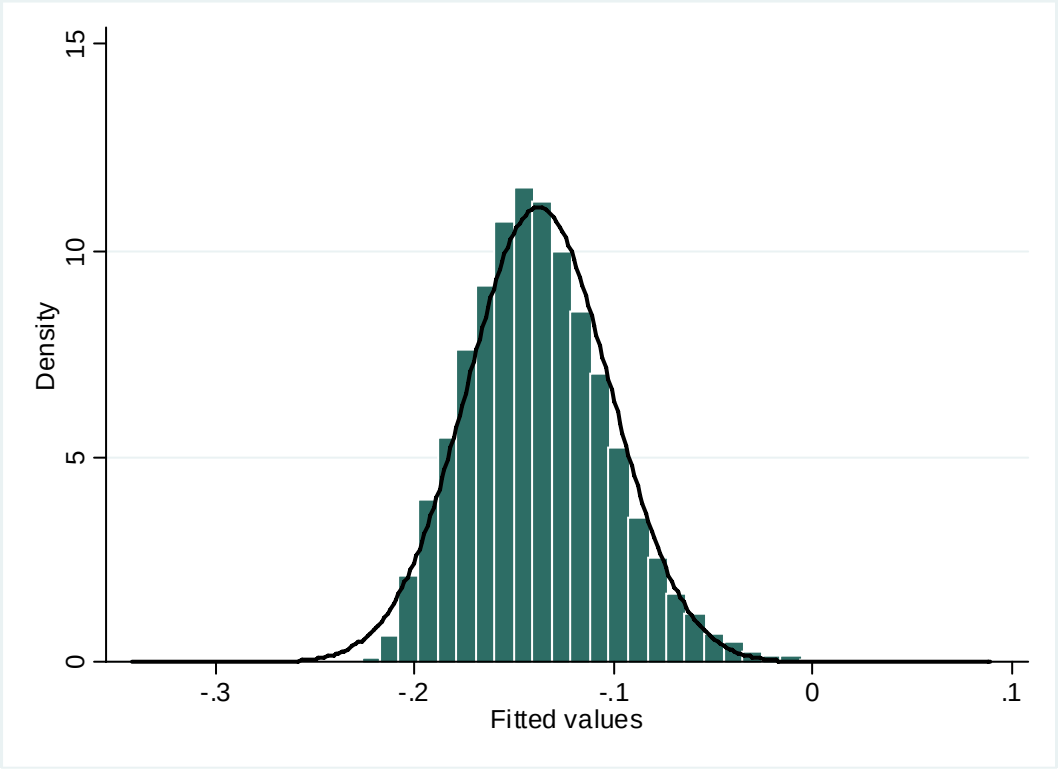


Figure 16 Residuals: Off-trade Cider

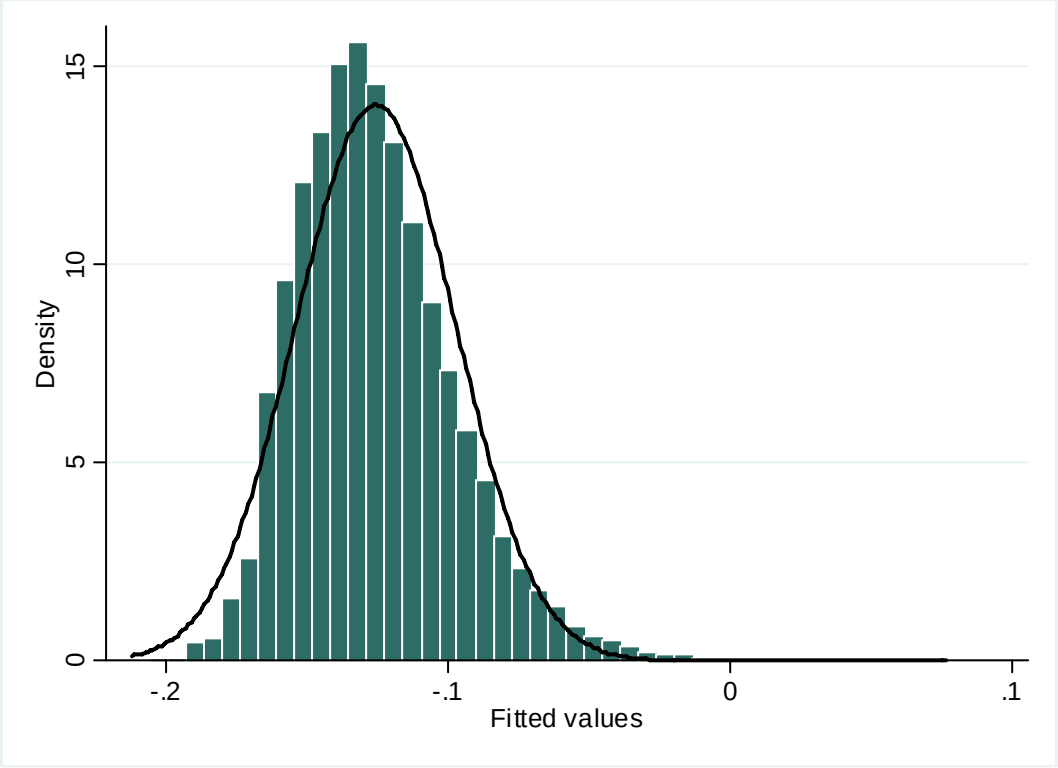


Figure 17 Residuals: On-trade RTD

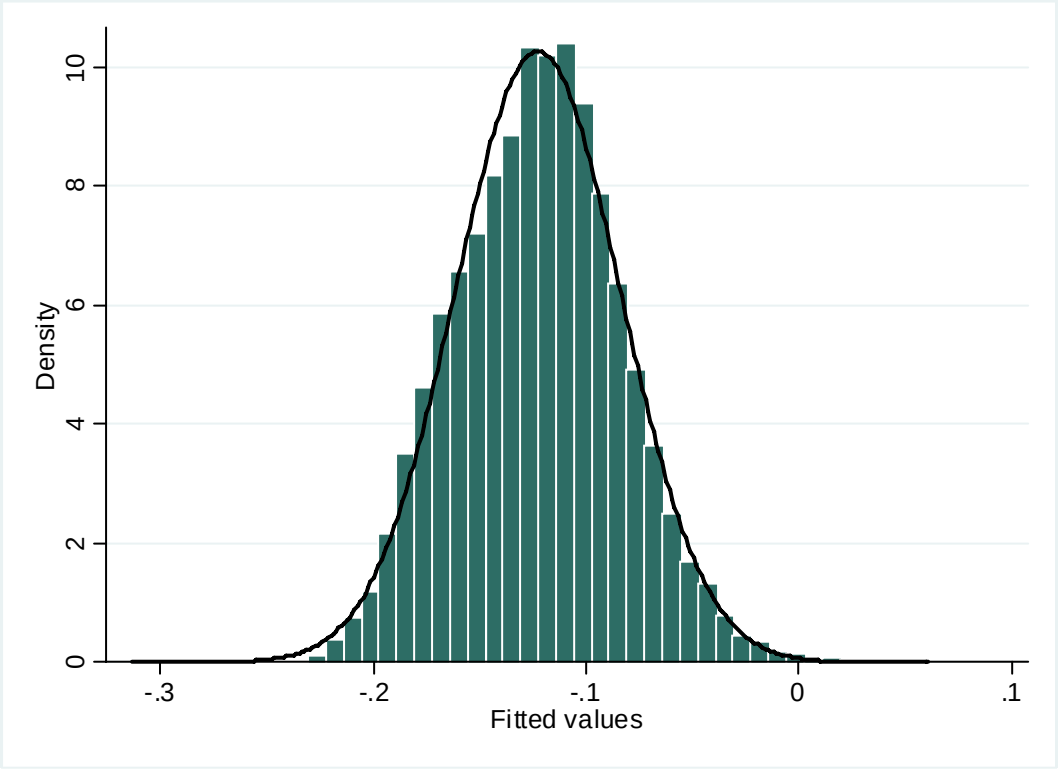


Figure 18 Residuals: Off-trade RTD

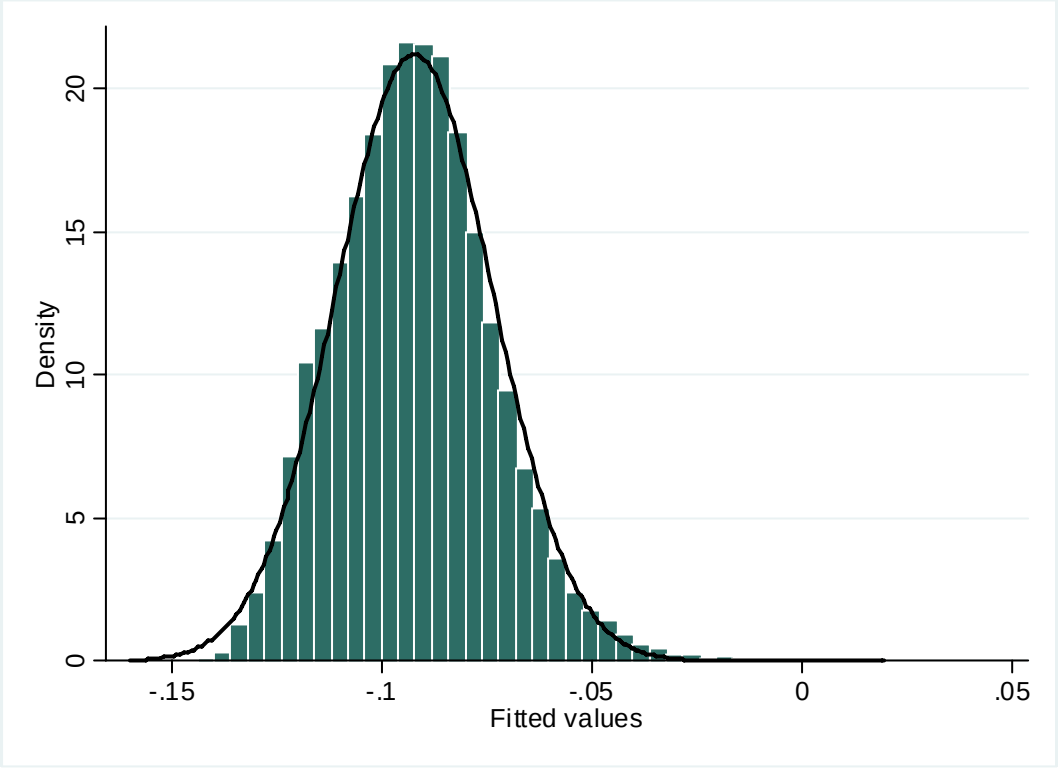


Table 43(i) Informal Evaluation of Tobit

	(beer on)		(wine on)		(cider on)		(spirit on)		(RTD on)	
regressors	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit
lnP(beer on)	-0.500	-0.890	0.265	0.336	-0.159	-0.170	0.016	0.016	0.090	0.073
lnP(wine on)	-0.034	-0.051	-0.224	-0.754	-0.029	-0.027	0.048	0.066	0.000	0.006
lnP(cider on)	0.102	0.144	0.041	0.126	-0.319	-0.452	0.111	0.145	0.119	0.128
lnP(spirits on)	-0.085	-0.186	-0.020	-0.023	-0.116	-0.135	-0.540	-0.742	-0.269	-0.317
lnP(RTDs on)	-0.034	0.024	0.122	0.129	-0.087	-0.101	-0.032	0.019	-0.358	-0.604
lnP(beer off)	-0.119	-0.119	0.102	0.180	0.029	0.043	0.032	0.034	-0.060	-0.062
lnP(wine off)	-0.017	-0.002	0.061	0.066	-0.043	-0.066	-0.048	-0.048	-0.179	-0.201
lnP(cider off)	-0.025	0.006	0.143	0.199	-0.130	-0.126	0.016	0.028	0.030	0.061
lnP(spirit off)	0.034	0.088	0.082	0.115	-0.043	-0.032	-0.063	-0.036	-0.045	-0.036
lnP(RTD off)	0.008	-0.024	0.041	0.025	-0.014	-0.016	0.079	0.063	-0.015	-0.056
lnincome	0.203	0.466	0.449	0.611	0.246	0.310	0.254	0.364	0.269	0.342

	(beer off)		(wine off)		(cider off)		(spirit off)		(RTD off)	
regressors	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit
lnP(beer on)	-0.108	-0.098	0.107	0.219	0.028	0.007	-0.068	-0.069	0.063	0.054
lnP(wine on)	0.122	0.149	0.040	0.077	0.113	0.108	0.169	0.183	0.125	0.117
lnP(cider on)	0.149	0.161	0.080	0.188	-0.028	0.012	0.076	0.093	0.063	0.078
lnP(spirits on)	0.041	0.034	0.093	0.091	0.070	0.066	0.042	0.039	-0.021	-0.020
lnP(RTDs on)	-0.027	-0.051	0.107	0.129	-0.070	-0.077	-0.017	-0.019	-0.104	-0.138
lnP(beer off)	-0.622	-0.796	0.013	0.047	-0.169	-0.189	-0.161	-0.207	-0.104	-0.124
lnP(wine off)	-0.216	-0.280	-0.333	-0.966	-0.366	-0.418	-0.042	-0.054	-0.292	-0.316
lnP(cider off)	0.014	0.019	0.120	0.152	-0.535	-0.518	0.025	0.059	-0.021	-0.006
lnP(spirit off)	-0.122	-0.153	0.027	0.050	-0.141	-0.170	-0.432	-0.710	-0.188	-0.214
lnP(RTD off)	0.027	0.001	-0.027	-0.069	-0.028	-0.057	-0.008	-0.007	-0.354	-0.433
lnincome	0.122	0.270	0.267	0.403	0.070	0.140	0.153	0.254	0.104	0.146

shaded areas not significant

Table 43(ii) Informal Evaluation of Tobit

	(beer on)		(wine on)		(cider on)		(spirit on)		(RTD on)	
regressors	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit
drink_prevalence	0.576	1.018	0.653	0.766	0.435	0.457	0.571	0.710	0.373	0.394
year 2	-0.042	-0.046	0.000	0.019	0.014	0.007	-0.048	-0.060	-0.015	-0.020
year 3	-0.085	-0.091	0.000	0.012	-0.043	-0.039	-0.079	-0.124	-0.164	-0.164
year 4	-0.085	-0.085	0.061	0.059	0.029	0.018	-0.095	-0.137	-0.194	-0.189
year 5	-0.085	-0.137	0.020	0.020	0.043	0.063	-0.063	-0.131	-0.328	-0.319
year 6	-0.127	-0.154	-0.061	-0.071	0.217	0.249	-0.159	-0.244	-0.537	-0.536
quarter 2	-0.017	-0.012	-0.020	-0.025	0.058	0.068	-0.016	-0.035	-0.045	-0.035
quarter 3	-0.110	-0.160	-0.041	-0.018	-0.087	-0.102	-0.048	-0.047	-0.104	-0.089
quarter 4	-0.008	-0.028	0.041	0.044	-0.058	-0.075	0.000	-0.001	-0.119	-0.113
north east	0.339	0.344	0.020	-0.072	0.333	0.330	-0.079	-0.106	0.254	0.188
north west	0.229	0.226	0.020	-0.082	0.072	0.091	-0.016	-0.027	0.119	0.075
yorkshire	0.322	0.371	0.000	-0.090	0.145	0.152	-0.063	-0.063	0.119	0.081
east midlands	0.237	0.322	-0.020	-0.097	0.246	0.258	-0.095	-0.104	0.060	0.034
west midlands	0.246	0.302	-0.102	-0.196	0.362	0.356	-0.095	-0.079	0.119	0.100
eastern	0.059	0.125	-0.041	-0.097	0.014	0.030	-0.127	-0.135	0.045	0.026
south east	0.085	0.134	0.000	-0.039	0.101	0.091	-0.127	-0.134	0.015	-0.016
south west	0.093	0.144	0.020	-0.090	0.420	0.440	-0.095	-0.110	0.000	-0.022
wales	0.220	0.204	-0.041	-0.134	0.435	0.424	-0.079	-0.055	0.075	0.014
scotland	-0.025	-0.053	-0.143	-0.270	0.072	0.047	0.333	0.332	-0.045	-0.079
northern ireland	0.144	0.158	0.041	0.077	0.261	0.296	0.476	0.530	0.507	0.505
higher skilled	-0.119	-0.078	0.061	0.109	-0.159	-0.157	-0.159	-0.152	-0.284	-0.295
lower skilled	0.110	0.038	-0.143	-0.167	0.058	0.051	0.079	0.072	0.194	0.178
not classified	-0.169	-0.236	0.041	0.069	-0.159	-0.157	-0.111	-0.111	-0.373	-0.387
student	0.144	0.354	0.204	0.339	0.551	0.629	0.714	0.720	0.701	0.789
unemployed	0.000	0.050	0.020	0.145	0.145	0.195	0.095	0.116	0.373	0.330

shaded areas not significant

Table 43(iii)Informal Evaluation of Tobit

	(beer off)		(wine off)		(cider off)		(spirit off)		(RTD off)	
regressors	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit	tobit β/σ	probit
drink_prevalence	0.459	0.571	0.573	0.798	0.352	0.374	0.500	0.559	0.292	0.303
year 2	-0.027	-0.048	0.027	0.027	0.014	0.013	-0.025	-0.017	-0.063	-0.072
year 3	-0.041	-0.061	0.027	0.042	0.014	0.007	0.008	0.000	-0.104	-0.109
year 4	-0.068	-0.093	0.053	0.033	0.014	0.009	-0.025	-0.035	-0.188	-0.207
year 5	-0.068	-0.101	0.067	0.051	0.042	0.027	-0.059	-0.067	-0.313	-0.350
year 6	-0.041	-0.078	0.013	0.016	0.141	0.150	-0.059	-0.074	-0.292	-0.322
quarter 2	-0.041	-0.038	-0.013	-0.006	0.028	0.039	0.008	0.017	0.042	0.038
quarter 3	-0.054	-0.063	0.120	0.168	0.014	0.036	0.297	0.352	0.021	0.001
quarter 4	-0.122	-0.146	0.027	0.021	-0.028	-0.032	0.025	0.025	-0.167	-0.179
north east	0.149	0.068	0.027	-0.043	0.225	0.259	0.017	0.031	-0.083	-0.099
north west	0.135	0.112	0.093	0.099	0.197	0.229	0.161	0.189	0.042	0.034
yorkshire	0.162	0.122	0.027	-0.025	0.183	0.225	0.008	0.021	0.042	0.038
east midlands	0.054	0.049	0.120	0.106	0.225	0.270	0.042	0.062	0.042	0.037
west midlands	0.054	0.045	0.067	0.019	0.352	0.387	0.085	0.065	0.042	0.051
eastern	0.054	0.051	0.107	0.081	0.225	0.254	-0.034	-0.022	0.063	0.065
south east	0.014	0.016	0.107	0.085	0.183	0.206	-0.008	0.005	0.146	0.138
south west	0.000	-0.012	0.187	0.145	0.268	0.302	0.085	0.078	0.021	0.011
wales	0.095	0.077	0.080	0.050	0.408	0.447	0.034	0.051	0.083	0.080
scotland	0.108	0.090	0.040	0.038	0.254	0.273	0.364	0.373	0.063	0.049
northern ireland	0.000	-0.011	0.013	0.059	0.169	0.187	0.169	0.208	0.208	0.230
higher skilled	-0.081	-0.091	0.040	0.073	-0.113	-0.132	-0.161	-0.180	-0.167	-0.189
lower skilled	0.122	0.113	-0.173	-0.201	0.141	0.138	0.127	0.146	0.146	0.130
not classified	-0.189	-0.221	0.040	-0.012	-0.085	-0.111	0.356	0.345	-0.271	-0.295
student	-0.162	-0.024	-0.067	0.035	-0.042	-0.044	-0.034	0.068	0.083	0.143
unemployed	0.243	0.221	-0.093	-0.107	0.352	0.328	0.153	0.233	0.229	0.229

shaded areas not significant