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Hui, L, Hess, S orcid.org/0000-0002-3650-2518, Daly, A orcid.org/0000-0001-5319-2745 et al. (1 more author) (2017) Measuring the impact of alcohol multi-buy promotions on consumers' purchase behaviour. *Journal of Choice Modelling*, 24. pp. 75-95. ISSN 1755-5345

<https://doi.org/10.1016/j.jocm.2016.05.001>

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Measuring the impact of alcohol multi-buy promotions on consumers' purchase behaviour

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The objective of this study was to understand the impact of alcohol multi-buy promotions on individual's purchasing behaviour. Our study deployed a Stated Preference survey to measure consumers' potential responses towards price changes and the introduction of promotions, as well as the resulting effects on demand. A series of econometric models were developed, ranging from simple selection models to advanced multiple discrete-continuous extreme value (MDCEV) models, to capture the discrete and continuous feature of alcohol purchasing choice behaviour. The model results were compared and then extrapolated to a series of policy scenario tests, to enable the evaluation of factors that underpin consumers' alcohol purchasing behaviour. This research contributes to evidence on the role of multi-buy promotions on alcohol purchasing behaviour, as well as adding to recent developments in the choice modelling literature by providing a comparison of results across a range of different model structures suitable for the analysis of data such as used here.

Keywords: alcohol consumption; discrete continuous; MDCEV

1. Introduction

Excessive alcohol consumption is a major cause of ill-health and mortality and is also associated with economic and social harm. The Department of Health in the UK has estimated that the harmful use of alcohol costs the National Health Service (NHS) approximately £3.5 billion per year and 7% of all hospital admissions were alcohol related¹ in 2009 - 2010. The Government Alcohol Strategy report (2012)² stated that the cost of alcohol related harm is estimated to be £21 billion annually.

Alcohol pricing is considered by some to be a potential means of influencing levels of alcohol consumption (Anderson et al., 2009; Purshouse et al., 2010). However, alcohol pricing is a sensitive policy issue, with those in favour of price regulation arguing that it has the potential to reduce harms from overconsumption of alcohol, and those against emphasising the need to limit the impact on those who drink alcohol in moderation.

In this study, we examine the impact of one aspect of pricing - multi-buy promotions - on consumers' purchasing of alcohol for consumption off the premises where the purchase was made. By multi-buy promotions, we refer specifically to promotions where there is a link between the number of products purchased and the price of the product, for example 'two for the price of one', 'three for the price of two' or the purchase of more than one item for a fixed price discount. The study was carried out under considerable time pressure between September 2012 and January 2013 in order to inform the impacts of proposed policy to ban alcohol multi-buy promotions.

¹ Nakamura, et. al (2014)

² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224075/alcohol-strategy.pdf

We contribute to the empirical literature on better understanding alcohol purchase behaviour under multi-buy promotion in three ways. First, we deploy a novel data collection approach to measure consumers' stated alcohol purchases under different market changes which are not easily observed in the real market. Second, a series of econometric techniques ranging from the Tobit and Heckman models to advanced MDCEV models are developed to explain the discrete – continuous nature of alcohol purchasing behaviour. This is, to the best of our knowledge, the first time that MDCEV models have been used for interpreting consumers' alcohol purchase behaviour. Third, the results are then used in a series of policy scenario tests, which help to gauge the potential impact of removing alcohol multi-buy promotions.

The remainder of the paper is organised as follows. Section 2 briefly describes the design of the stated preference survey and the data collection more widely. Section 3 summarises key literature regarding econometric models that predict discrete-continuous choices with a special emphasis on the comparison of these models. Section 4 discusses the estimation of the econometric models. Section 5 presents a series of policy scenario tests, followed by Section 6 which concludes the paper with the discussion of the policy implications and future work.

2. Data Description

2.1 Stated Preference Survey Design

Given the limitations of available retail measurement data (lack of detail on consumers, and limited information on promotions), an online survey was designed to collect self-reported information on existing patterns of alcohol consumption and purchasing. This included a stated preference component to examine potential responses to alcohol promotions under different market situations, including multi-buy promotions. Stated choice techniques have been widely used in marketing, environmental science, transport demand analysis and the health sector (Louviere, et al., 2000). Within the survey, each respondent was presented with a number of hypothetical scenarios, with different alcohol prices and with/without the multi-buy promotions for six types of alcohol, and asked to indicate which types of alcohol they would purchase and the volumes of each they would purchase.

For realism, respondents were asked to consider purchases that they made themselves (for themselves and their households where relevant). To avoid excessive incidence of zero expenditure, we asked respondents to consider their likely purchases over the following four week period. This was also important in the context where we wanted to explore the impact of multi-buy offers on purchasing, which puts an emphasis on cross-product substitution, requiring respondents to imagine a situation in which they were making a number of purchases (and ideally multiple purchases).

Three types of alcohol were included in the choice scenarios: wine, beer / cider and spirits, using generic brands, with wine and beer quality reflected through different price ranges. Three types of multi-buy promotion were tested for each alcohol type, as outlined in Table 1.

Table 1 Alcohol alternatives and promotions included in the survey

Alcohol type	Quality differentiation	Promotion type
Wine (750 ml/bottle)	1. Wine A – (less than £5) 2. Wine B – (£5 – 10)	1. 3 for a fixed price discount (70/80/90% of the fixed price)

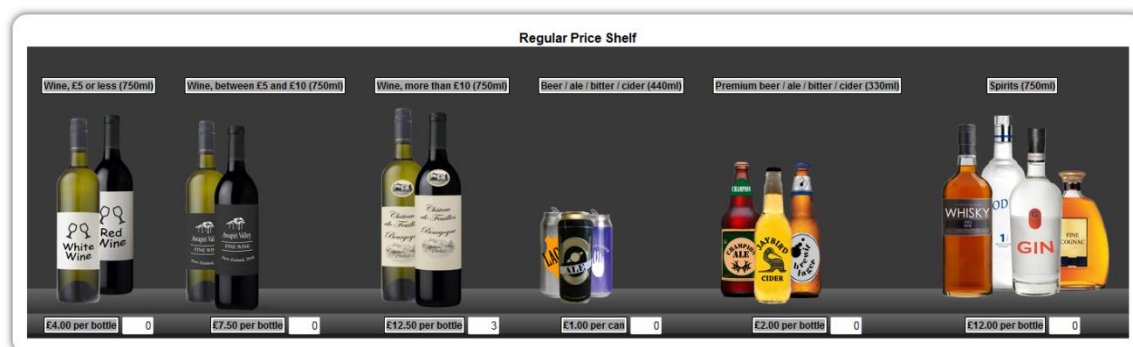
	3. Wine C – (more than £10)	2. 3 for 2 3. 2 for 1
Beer	1. Beer A – (440ml /can, around £1/can) 2. Beer B – (330ml /bottle, around £2/bottle)	1. 12 for a fixed price discount (70/80/90% of the fixed price) 2. 12 for 8 3. 8 for 6
Spirits (750ml/bottle)		1. 2 for a fixed price discount (70/80/90% of the fixed price) 2. 3 for 2

Although the primary aim of the research was to model the specific impact of alcohol multi-buy promotions on purchasing behaviour, it was also important for validation of the model to estimate an accurate price sensitivity. With this in mind, we included some choices with price differences only (and no promotions) and some choices with promotions. Respondents were therefore asked to participate in two sets of scenarios, with 12 choice tasks in total. The first four choice scenarios involved choices between non-promotion items, with alternatives varying in price only, while the second set of eight choice scenarios included non-promotion items and promotion items for some alcohol types. All choice tasks included the non-promotion versions of each of the six products (three types of wine, two types of beer and spirits). In the scenarios with promotions, one promotion on wine and one promotion on beer were included in each choice task, where these always applied to just one product within a category (so e.g. no joint promotions for wine A and wine B). In half of the scenarios, a promotion on spirits was included (with one of two types), while in the others, spirits were not on promotion.

The first choice task reflected a scenario where all alcohol types were present, at baseline prices, with no promotions. This scenario formed the baseline for analysis of changes as a result of the introduction of pricing changes and promotions.

The presentation of the choices drew on the visual presentation of two supermarket shelves. On one shelf were the six types of non-promotion alcohol products. Respondents were asked to indicate how many bottles or cans of each alcohol type they would purchase at that price. The total price for all choices they made was shown on the screen which is updated immediately after any adjustments to the choices made. Figure 1 illustrates an example choice scenario without promotions.

Figure 1 Example choice scenario without multi-buy promotions

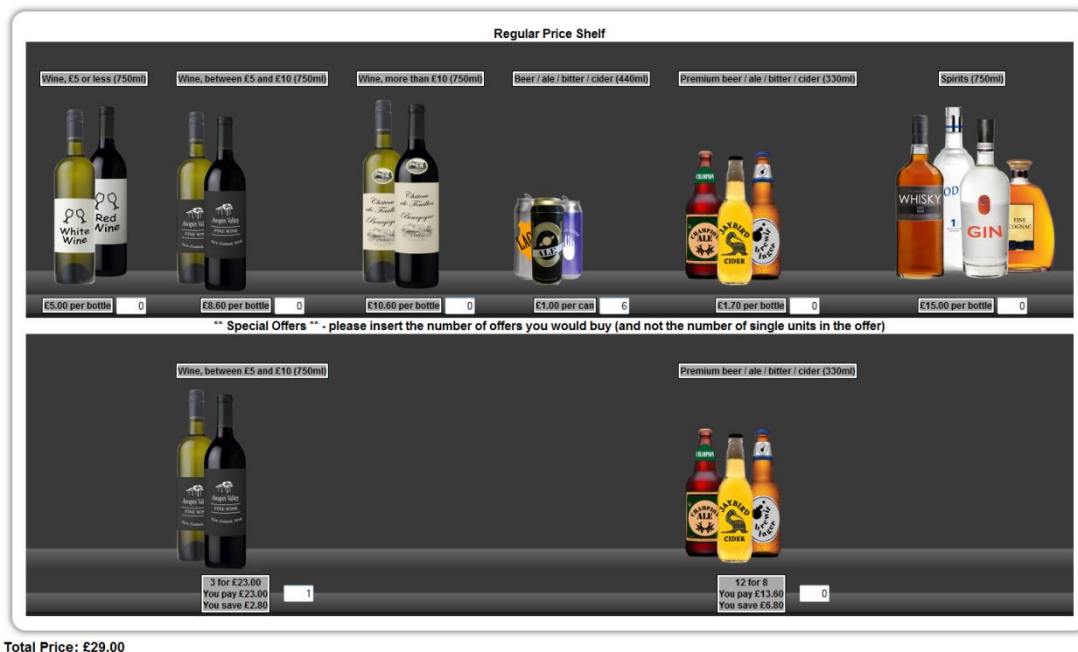


Total Price: £37.50

A second shelf containing promotion items was introduced in the second set of scenarios. Each promotion was described by the type of promotion, the total cost and the amount saved for each offer. Respondents were asked to indicate the number of 'offers' they would purchase. Figure 2 illustrates an example choice scenario involving promotions. The order in which the shelves were presented, i.e. with either the promotions presented on the top shelf or the bottom shelf, was randomly varied between individuals.

In addition to the stated choice tasks, respondents were asked about their level of alcohol consumption, as well as other general background information (age, gender, ethnicity, marital status, education, religion) and household information (size of household, drinking habits and purchasing habits of others in the household where known, household income, socio-economic classification). After the choice tasks, respondents were asked about their attitudes to multi-buy discounts, their alcohol consumption habits and preferences, and their attitude to alcohol more generally. For further details on the design of the survey and stated preference scenarios, see Rohr et al. (2013).

Figure 2: Example choice scenario with multi-buy promotions



2.2 Data collection field work and sample description

To understand preferences by different types of drinkers, it was necessary to have observations across a range of alcohol consumption levels. The categorisation of consumption levels followed the Quantity – Frequency approach (Goddard, 2007) adopted by the General Lifestyle survey (ONS, 2010), defining four consumption levels: Moderate A (low moderate), Moderate B (high moderate), Hazardous and Harmful consumption levels. Consumption levels are determined by self-reported average weekly alcohol consumption.

300 respondents were targeted for each alcohol consumption level, leading to a two-stage recruitment methodology, whereby a screener survey was undertaken with a large online panel of respondents representing the age, gender, socio-economic group and regional distributions of the national population to identify potential respondents in each consumption segment. Respondents

were then drawn from each consumption segment to participate in the main survey. The main survey was undertaken between 22 November and 4 December 2012. 1,265 completed surveys were obtained, reflecting an overall response rate of 47.7 percent, after which data cleaning removed 42 individuals (3.3% of the whole sample).

2.3 Preliminary data analysis

Prior to the choice scenarios, individuals were asked to report the amount that they had spent on alcohol purchases off-trade (i.e. in supermarkets, at off-licences, abroad and through internet and other locations). This information is used to assess their consumption levels and as reliability check of their stated expenditure in the choice tasks. At an aggregate level, the comparison in Table 2 shows that the stated expenditure levels in the choice tasks are very similar to the reported expenditure in the supermarkets (albeit with a higher standard deviation), but are lower than the total spending in all locations. Moreover, it shows that the expenditure increases with the level of drinking which is within expectation.

Table 2 Comparison of average spending on alcohol products in the previous four weeks compared to the stated expenditure levels in the Stated Preference scenarios

Segment	Average reported spend in previous four weeks in supermarkets		Average reported spend in previous four weeks in supermarkets, off-licences, abroad, internet and other locations		Average stated expenditure in choice tasks	
	Mean (£)	SD (£)	Mean (£)	SD (£)	Mean (£)	SD (£)
Consumption segment						
Moderate A	13.17	18.17	16.14	22.23	14.51	26.39
Moderate B	25.49	25.16	38.82	45.65	22.83	32.64
Hazardous	45.28	46.23	65.56	78.70	43.37	83.27
Harmful	68.70	80.77	102.10	149.83	67.47	114.93
Gender						
Male	37.81	50.78	54.83	74.71	38.36	91.72
Female	38.03	55.96	55.52	109.85	35.46	58.47
Age						
18–24	24.04	45.29	43.72	161.67	27.61	62.82
25–34	36.90	72.23	57.34	97.82	37.29	66.99
35–44	44.53	40.34	60.41	75.56	41.89	105.84
45–54	49.94	66.36	67.00	95.01	42.71	65.53
55–64	49.94	48.84	57.09	70.22	40.76	72.09
65plus	31.91	36.63	47.10	57.41	31.55	76.94
Socio-economic group						
ABC1	41.78	59.48	62.72	113.30	40.85	91.39
C2DE	33.53	45.22	46.59	64.35	32.42	55.67
All	37.92	53.44	55.17	93.97	36.90	76.89

* Measures of socio-economic group were collected as screening questions. ABC1 refers to those employed in managerial, professional, administrative, supervisory or clerical roles, or students; C2DE refers to those performing unskilled, semi-skilled or skilled manual work or those not in permanent employment.

In terms of purchasing patterns from the data, we see that people purchased multiple types of alcohol products, specifically in 10.7% of the choice tasks respondents buy either two or three different types of wine, and in 8.9% of tasks, they buy both types of beer. These rates vary across our four segments, and, for harmful drinkers, the rates are 15.9% and 13.1%, respectively. Out of those tasks where respondents buy any wine (73% of tasks), respondents buy two or three types in 14.7% of those tasks, where for beer, the corresponding rate is 16.6% (of the 53.8% of tasks where respondents buy any beer). This clearly shows that respondents buy multiple products from the same overall alcohol family at the same time. Overall, respondents buy at least one product in 76.8%

of tasks, and in 41.6% of tasks (i.e. more than half of those where a purchase is made), they buy more than one product.

The situation of course becomes slightly more complex in the presence of promotions. If there is a promotion, say on wine A, then the a priori expectation might be that a consumer should buy all his/her wine A products under the promotion. That argument would of course apply in the case of a promotion where you can buy a single bottle at a reduced price. A respondent would then buy all his/her bottles at that price. However, such a promotion type was not included in our survey, which was specifically concerned with multi-buy promotions. Let us then consider for example the case where, for wine A, there is a promotion where you can buy 3 bottles and receive a 20% discount on the price of each bottle. A respondent might however for example want to buy 4 bottles, and would then buy one bottle at full price, and the remaining 3 with the 20% discount. In fact, the only case where the presence of a promotion should in theory rule out a respondent also buying the product at full price is the 2 for 1 promotion on wine.

Our data also supports the notion that respondents do indeed combine full price and promotion purchases for the same product. In 4.8% of choice tasks that involve promotion items, the respondent is observed to buy bottles of the same product both at full price and at the promotion price. This varies across product types and quality. For wine, this occurs for 5.4% in the case of wine A (i.e. the lowest price category), and drops to 0.6% for wine C (i.e. the highest price category). For beer, we see a similar pattern (3.2% for beer A and 1.5% for beer B). This is in line with expectations and the notion that premium products might be less for immediate consumption than lower price ones.

For just over a third of those cases (i.e. of the 4.8%), we see respondents buying enough bottles at full price for them to have saved money by instead buying some of those bottles at the discount price. Two possible interpretations arise here. Firstly, respondents may of course make mistakes (as shoppers clearly do at times) by not completely understanding the promotion or misjudging the savings they would get by shifting some of their full price items to promotion items. Secondly, there is the possibility that some respondents assumed that the promotion items may not be of the same quality as the full price items for wine category A – this is realistic as we did not explicitly say what vintage or winemaker a given bottle related to.

3. Econometric models

The stated preference scenarios collected respondents' choices of both the type of alcohol they would purchase (a discrete choice) and the amount that they would purchase (a continuous value). When zero purchases are present, standard econometric models using ordinary least squares (OLS) based on all the positive observations would generate biased parameter estimates (Amemiya, 1984). In addition, excluding zero observations would cause a loss of efficiency.

3.1. Tobit models

Previous work in this area has largely been based on the Tobit model (Tobin, 1958), often referred to as a censored regression model, and widely used to estimate demand relationships with limited dependent variables, especially with the context in which quantity lies in a specific range, often that

is non-negative. A rich literature documents the overview and application of Tobit models (Amemiya, 1984; Breen, 1996; Long, 1997).

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

$$y_i^* = X_i\beta + \varepsilon_i, \text{ where } \varepsilon_i \text{ is assumed to be normally distributed } N(0, 1) \quad [1]$$

X_i is a vector of independent variables and β is a vector of the coefficients to be estimated. The latent variable y_i^* has a normal homoskedastic distribution with linear conditional mean, and y_i has a continuous distribution with a threshold, so that below the threshold, y_i is either, in one version of the Tobit model, not observed at all (truncated model) or, in the alternative version which is applicable here, set to some arbitrary value (censored model). When the data is censored at 0, the observed dependent variable is

$$y_i = y_i^* \text{ if } y_i^* > 0 \quad [2]$$

$$y_i = 0 \text{ if } y_i^* \leq 0 \quad [3]$$

The Tobit model is restrictive because it assumes that the same set of variables, with the same coefficients, determine both the probability of a non-zero purchase and the volume of alcohol purchased. Several empirical evidence have emphasised the importance of a generalisation beyond the Tobit model in the analysis of alcohol consumption (Blaylock and Blisard, 1993; Yen and Jensen, 1996), hypothesising that participation and consumption processes stem from two separate individual choices. In addition, the Tobit model is restricted to binary choice, whereas we are interested in respondents' alcohol purchase of multiple products under multiple promotions.

3.2. Heckman models

The Heckman model (Heckman, 1976, 1979) is more general for the analysis of self-selected data, and is formed by a probit model for participation and an OLS model for consumption.

The first part of the model predicts participation as a function of the sign of z

$$z = X_i'\beta' + \varepsilon', \text{ where } \varepsilon' \text{ is normally distributed } N(0, 1) \quad [4]$$

which is a binary probit model; the consumption Equation [1] applies when z is positive. The data vectors X and X' may overlap, and particularly ε and ε' may be correlated, but the pair of models give more scope for accurate specification than the simpler Tobit specification.

Heckman (Heckman, 1979) sets out a consistent estimation procedure for models of this form. This consists of estimating the probit model in the usual way, but then adding an additional term to the linear regression:

$$y_i^* = X_i\beta + \rho\sigma\lambda + \varepsilon_i, \text{ where } \varepsilon_i \text{ is normally distributed} \quad [5]$$

where σ is the standard deviation of ε , ρ denotes the correlation between ε and ε' , and λ is the inverse Mills ratio:

$$\lambda = \frac{\phi\left(\frac{X_i'\beta'}{\sigma'}\right)}{\Phi\left(\frac{X_i'\beta'}{\sigma'}\right)} \quad [6]$$

where σ' is the standard deviation of ε' and ϕ and Φ are respectively the frequency and cumulative functions of the standard Normal distribution. The coefficient $(\rho\sigma)$ is estimated in the regression model along with β . The term $(\rho\sigma\lambda)$ is simply the expected value of $(Y - X\beta)$ when z is known to be positive. Thus, with this correction, the expectation of ε in Equation [5] is zero.

The likelihood function for the Heckman model is:

$$L = \prod_0 [1 - \Phi(X_i'\beta')] \prod_+ \Phi\left[\frac{X_i'\beta' + \frac{\rho}{\sigma'}(y - X_i\beta)}{\sqrt{1 - \rho^2}}\right] \frac{1}{\sigma} \phi\left[\frac{y - X_i\beta}{\sigma}\right] \quad [7]$$

Heckman demonstrates that this is a generalisation of the Tobit model and that the estimator is consistent. The probability that consumers will be purchasers of a specific type of alcohol is predicted by a binary model, then for those who decided to purchase, the volume purchased is predicted by a linear model. This is different from the Tobit model in which the same function is used to predict both the decision to purchase and the quantity purchased. Indeed, in the Heckman model, it is necessary that the functions be different to allow full statistical identification of the model (Puhari, 2000).

3.3. Limitations of Tobit and Heckman models

The main issues regarding Tobit models, such as the restriction to binary choices and the consequent limitation on the treatment of promotions, also apply to Heckman models. Furthermore, despite Heckman models offering greater freedom in modelling behaviour, they also present a specific problem in forecasting in that it is not guaranteed that the linear model [1] will give a positive outcome (Daly, 2013). While Tobit and Heckman models correct conventional regressions by incorporating the fact that purchases must be zero or positive (i.e. not negative), they represent substitution and competition between products only at an aggregate level. That is, in our case, the choice by respondents for a particular alcohol type can be represented in these models by the price and promotions of other types, but does not take account of the specific choices of the individual over several alcohol types. Finally, the models do not give any representation of "satiation", i.e., that the additional benefit gained per unit purchased may decline as the amount purchased increase, and also omit any consideration that the total amount spent may restrict the spending behaviour of consumers.

To overcome the limitations of Tobin and Heckman models, a series of recent studies provide more advanced models in both microeconomic and econometric aspects (Dubin and McFadden, 1984; Train, 1986; De Jong 1991; Bolduc, 2001). Accent and RAND Europe (2002) provide a thorough review of these models. The advantages of these models are reflected in that they not only bring the model within the bounds of economic theory, but contain the possibility of introducing a more complex choice model framework than the binary probit models used in the earlier work. Through a good formulation of the demand function in the regression model, for instance including the exact cost term, the models are more consistent with economic theory (accounting for satiation and diminishing marginal utility by introducing curvature in the utility function). The application of strict economic theory indicates how the choice and purchase models relate and may suggest suitable forms for testing.

In both Dubin and McFadden's and in Train's work, the choice and usage models are estimated sequentially and there is therefore no mechanism by which consistency between the indirect utility and the purchase equation can be maintained. De Jong's work takes a different approach which allows simultaneous estimation, but this leads to quite complicated functions, which would be even more complicated in the present study where multiple alternatives are considered, and, as pointed out by Bolduc et al. (2001), this can lead to the propagation of specification error from one model to the other.

3.4. Family of multiple discrete-continuous extreme value models

The MDCEV model (Bhat, 2005, 2008) goes further in representing competition between products at the disaggregate level. Consumers are modelled as making a simultaneous choice of a number of different products and, for each of product chosen, how many units to purchase. They are assumed to maximise a direct utility function $U(\mathbf{x})$, where \mathbf{x} is a vector of non-negative quantities of consumption for each of the goods, such that $\mathbf{x} = (x_1, \dots, x_K)$. The consumption activities of a consumer are subject to a budget constraint, such that the consumer maximises $U(\mathbf{x})$ subject to $\mathbf{x}\mathbf{p} = E$, where E is the budget, and where \mathbf{p} is the vector of prices for the different goods. In most applications, \mathbf{x} includes an outside good to represent expenditure on all other items, say good number 1, which is assumed to have unit price (so that $p_1 = 1$). The chief advantages of this framework in the context of the present study are that it is better able to capture the substitution effects between the different products through the operation of the budget constraint and that a satiation effect can be modelled for each product.

At the heart of the model used in the present application is a non-linear utility form that allows the marginal utility, i.e. the additional benefit of an additional unit purchased, of each additional unit of a given good to decrease with increasing consumption of that good. Using the formulation introduced by Bhat and Pinjari (2013), with good 1 being the outside good (of K goods), we have that:

$$U(x) = \frac{1}{\alpha_1} \psi_1 x_1^{\alpha_1} + \sum_{k=2}^K \frac{\gamma_k}{\alpha_k} \psi_k \left(\left(\frac{x_k}{\gamma_k} + 1 \right)^{\alpha_k} - 1 \right) \quad [8]$$

This model relies on three distinct parameters for each good, namely ψ_k , γ_k , and α_k . The specific role of these parameters is as follows.

- ψ_k is the marginal utility of good k at the point of zero consumption, also referred to as the baseline marginal utility. A higher baseline utility makes non-zero consumption of a good more likely. The baseline utility is parametrised by interactions between estimated parameters and (non-price) attributes of the good and characteristics of the decision maker. To ensure positive baseline marginal utilities, we define $\psi(z_k) = e^{\beta' z_k}$. With the addition of a multiplicative random element, we obtain $\psi(z_k, \varepsilon_k) = e^{\beta' z_k + \varepsilon_k}$, where ε_k is an extreme-value error term, and where z_k contains the attributes of product k and those of the consumer, while β is an estimated vector of parameters, including a product-specific constant, and where, for normalisation, we set the deterministic part of the log baseline utility for one good to zero, say the outside good.
- The key role of γ_k is to allow for zero consumption for good k , i.e. it is a translation parameter, although Bhat and Pinjari (2013) also suggest a role for γ_k as a satiation parameter. There is no translation parameter for the outside good (as it is always consumed), and we have a constraint that $\gamma_k > 0$ for $k > 1$.

- α_k has a more explicit role as a satiation parameter as it reduces the marginal utility of good k with increasing consumption, where lower α_k means faster satiation, and where $\alpha_k \geq 0$, and where it can be assumed that $\alpha_k \leq 1$ as values larger than 1 would imply increasing utility with increasing consumption, i.e. no satiation.

As outlined by Bhat and Pinjari (2013), joint estimation of α_k and γ_k is numerically problematic due to the similar (satiation) roles that the parameters have, and some normalisation is generally required. In the present application, we have made use of the alpha-gamma profile (cf. Bhat and Pinjari, 2013), which sets $\alpha_k = \alpha_1, \forall k \geq 1$, i.e. using a generic α parameter and estimating $\gamma_k, k > 1$. A key advantage of this profile is the availability of the forecasting procedure outlined in Pinjari and Bhat (2011), which is too complex to be reproduced here in detail.

The probability of a given consumption vector $(x_1^*, x_2^*, \dots, x_M^*, 0, \dots, 0)$, where M of the K goods are consumed, is given by:

$$P(x_1^*, x_2^*, \dots, x_M^*, 0, \dots, 0) = \frac{1}{p_1} \frac{1}{\sigma^{M-1}} \left(\prod_{m=1}^M f_m \right) \left(\sum_{m=1}^M \frac{p_m}{f_m} \right) \left(\frac{\prod_{m=1}^M e^{v_i/\sigma}}{\left(\sum_{k=1}^K e^{v_k/\sigma} \right)^M} \right) (M-1)! \quad [9]$$

where σ is an estimated scale parameter and where $f_m = \left(\frac{1-\alpha_m}{x_m^* + \gamma_m} \right)$.

The MDCEV model explicitly reflects that an individual can choose several of the specific products, i.e. offers of wine, beer or spirits in our case. Thus this model can better represent how the introduction of promotions impacts on the purchasing of other alcohol products and total alcohol purchases. Moreover, the MDCEV framework uses all the available information to estimate the choice of different types of alcohol type simultaneously, so that the statistical inefficiencies of separate estimation, e.g. in Tobit or Heckman models, are avoided. Furthermore, the MDCEV models are able to represent better the particular choice of purchasing products on promotion, which are represented as separate choice alternatives in the model, i.e. they can have alternative-specific effects reflecting the impact of the promotion. This is not possible in the Tobit or Heckman models.

For this study we tested multinomial model structures only, where all products (whether they are the same type of alcohol or not, and whether they are promotion items or not) are represented as separate alternatives, equally competitive with each other. A key property of multinomial models is that the unexplained model error across alternatives in the model is independently and identically distributed (IID). This is a clearly a simplification, when in reality, complex correlation patterns may be at play. Recent developments in the literature have developed the model structure further, introducing correlations between alternatives, either through an underlying GEV-style nesting structure or through a probit-style model, leading to the MDCNEV (Pinjari and Bhat, 2010) and MDCGEV (Pinjari, 2011) or the MDC-probit models (cf. Bhat et al., 2013). The use of these models was not possible in the present study given the time constraints, but remains an important avenue for future work.

Another recent development is the MDCEV-MNL variant of the model (see Bhat et al., 2009 or Eluru et al., 2010), a model that in essence makes some of the products mutually exclusive. This approach is however not suitable for our data, given the earlier discussion about respondents buying multiple products within the same category (e.g. wine) as well as combining full price and promotion purchases for the same product.

4. Model Estimation

In all the models, the dependent variable was the volume of alcohol purchased, reflected by the number of units, using average alcohol by volume (ABV) conversions (as in the methodology employed for the General Lifestyle Survey). This follows on from initial tests using expenditure as the dependent variable, which yielded worse fit to the data, as did a log formulation of the explanatory variables. We found that the pattern of model estimations from Moderate A and Moderate B alcohol consumption levels were not significantly different from each other and nor were the Hazardous and Harmful segments. Therefore, the two pairs of groups were combined in the models.

The impact of a promotion is reflected by both the price reduction (modelled through a price sensitivity term) and a “psychological” impact of the promotion (measured by constants detecting the impact of the different promotion types). Therefore, in predicting demand for a specific alcohol type, the model incorporates the price and promotion characteristics of the specific alcohol type as well as the price and promotion characteristics of competitor products (referred to as cross-price and cross-promotion terms).

Because Tobit and Heckman models are restricted to reflecting binary choices, for these models we adopt a similar approach to that used by Collis et al. (2010), whereby purchasing behaviour for a specific type of alcohol is modelled separately. A general representation of competition is reflected by including prices and promotions on other alcohol types. Furthermore, the Tobit and Heckman models do not explicitly predict the likelihood of choosing multi-buy promotions; rather they predict the impact of multi-buy promotions at an aggregate level. This poses some issues when estimating the impact of promotions on monetary expenditure as we cannot disentangle alcohol purchases under non-promotion prices from purchases under promotion prices.

In the interest of space, we focus on the preferred Heckman and MDCEV models in the current paper. The development and results of the Tobit models are available in Rohr et al. (2013), although we include the forecasts from these models later on in the paper.

The models also seek to identify variation in purchase behaviour of consumers by their socio-demographic and economic characteristics, where they are significant, with further details of the variables tested in Table 3.

Table 3 Explanatory variables tested in the model development

Price and promotion variables	Socio-demographic / economic variables
own price (per unit)	Age
competitor prices (per unit)	Gender
own category promotions, if promotion	Region
own price, if promotion (per unit)	household income
amount saved, if promotion (per unit)	socio-economic classification
competition promotions, if promotions	Religion
competition prices, if promotions (per unit)	education level
competition amount saved, if promotions (per unit)	marital status
promotion shelf location (top or bottom)	Ethnicity
	number of adults/children in the household
	share of the household purchases that the individual makes

4.1 Heckman Models

In this study, the Heckman model was estimated using a maximum likelihood approach to obtain simultaneous estimation of the choice and consumption models, ensuring efficient estimates. Given

the very large number of parameters (running to 6 pages), the full estimation results are shown in the report which is available online (Rohr et al., 2013), and we instead focus on a summary of the results showing signs and significance levels, where estimations are split by moderate (mod.) and hazardous and harmful (h&h) consumption, with Table 4 looking at the selection model, and Table 5 at the regression model. The convention used is that +++ refers to a positive estimate significant at the 99% level, with ++ used for the 95% level and + for the 90% level, and a corresponding notation for negative estimates.

Table 4: Summary results for Heckman selection model

	wine A		wine B		wine C		beer A		beer B		spirits	
	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h
Heckman correction term	+++	+++	+++	+++	+++	+	+++	+++	+++		+++	+++
Constant	---	+++			---	---		+++	---	---	---	---
Own price	---	---	---	---	---	---	---	---	---	---	---	---
Own promotion 1	+	++	+++	+++	+++	+++	+++	+++	+++	++	+++	+++
Own promotion 2	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Own promotion 3	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++		
Cross effect price beer B							+++					
Cross effect price of wine B	+++	+++										
Cross effect promotion 1 beer A									---	---	---	---
Cross effect promotion 1 beer B							---	---			---	---
Cross effect promotion 1 spirits									---	---		
Cross effect promotion 1 wine A			---	---								
Cross effect promotion 1 wine B	---	---			---	---						
Cross effect promotion 1 wine C	---	---	---	---								
Cross effect promotion 2 beer A									---	---	---	---
Cross effect promotion 2 beer B							---	---			---	---
Cross effect promotion 2 spirits			+						-			
Cross effect promotion 2 wine A			---	---								
Cross effect promotion 2 wine B	---	---				---						
Cross effect promotion 2 wine C	---	---	---	---								
Cross effect promotion 3 beer A									---	---	---	---
Cross effect promotion 3 beer B							---	---			---	---
Cross effect promotion 3 wine A			---	---								
Cross effect promotion 3 wine B	---	---				-						
Cross effect promotion 3 wine C	---	---	---	---								
Female	+++	+++	+++	+++		---	---	---	---	+++	+++	+++
Age 18 - 24 (base 25-44)		---	---					++	+++	+++	+++	+++
Age 45 - 54 (base 25-44)							---	---				
Age 55 - 64 (base 25-44)	+++	++			+++		---	---	-		+	
Age 65 + (base 25-44)	++				++	---	---	---	---		+	+++
Age above 45 (base 25-44)										---		
Household income £20-40k p.a. (base < £20k)	+++		+++	+++	+++	+++			+++	+++		+++
Household income £40-60k p.a. (base < £20k)			+++	+++		+++			++	+++	---	++
Household income >£60k p.a. (base < £20k)	-	---	+++	+++	+++	+++		---	+++	+++		
Household income not known (base < £20k)			+++	+++	+++			---				
Low Skilled	---		---	---	---	---	---					+++

East (base London & South East)				---	---	---				-		
North (base London & South East)	---	+++	---						+++	---		+++
Scotland (base London & South East)	---				+++	---	---	+++			+++	+++
West (base London & South East)	---		---	---	---				+++		-	++
2 or more adults in household	---		---	---	---		+++			++		
GCSE or less (base A levels)			---			---		+++	---		++	
No high education (base A levels)				---	+++			++	---			-
Other Education (base A levels)			--					+++	+++	+++	+	
Further education (base A levels)		+++	+		+++	+++	---	+++	--	+++	+++	
Respondent's share of alcohol buying for household	+++	+++	+++	+++	+++	+++	++	+++	+++	++	+++	+++
Asian or Asian British (base White)			-		-			---				
Black or Black British (base White)		---	+++		+++				+++			
Mixed race (base White)			---					---	---			
Promotions on upper shelf	+++	---	+++		++		+++		+	---	--	---
Household with children	+++		--		++			++				
Student				-					++	---	--	
Unemployed		+++						++	--			

Table 5: Summary of results for Heckman regression model

	wine A		wine B		wine C		beer A		beer B		spirits	
	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h	mod.	h&h
Constant	+++	+++	+++	+++	++			+++	++		+++	+++
Own price			--	--		--						--
Own promotion 1	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Own promotion 2	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Own promotion 3	+++	+++	+++	+++	+	+++	+++	+++	+++	+++		
Female				+	---		---	---	++			
Age 18 - 24 (base 25-44)		---			++							+++
Age 45 - 54 (base 25-44)		+++	+++	+++					-		+++	
Age 55 - 64 (base 25-44)		+++	++	+++	++			++				
Age 65 + (base 25-44)		+++						+++	+++		+++	+++
Age above 45 (base 25-44)	+++											
Household income £20-40k p.a. (base < £20k)	++	--			+++							++
Household income £20-60k p.a. (base < £20k)			+						+++			
Household income £40-60k p.a. (base < £20k)	+++	+++		+++	+		---					+++
Household income >£40k p.a. (base < £20k)						+++						
Household income >£60k p.a. (base < £20k)	+++		+++				++					
Household income not known (base < £20k)			++	-								
Low Skilled	-	--		-	++	-			--			-
East (base London & South East)				+++			--	---				---
North (base London & South East)			+++					---	+++	--		
Scotland (base London & South East)			++				---	--			+	
West (base London & South East)	---	+++										---
2 or more adults in household	---	---	---		---			+++		+++		+++
GCSE or less (base A levels)					++							++
No high education (base A levels)		--					+++	--	--	+++		

Other Education (base A levels)	---				--				+++
Further education (base A levels)				+	+++		-	-	++
Respondent's share of alcohol buying for household	+++	+++		+		+++		--	
Asian or Asian British (base White)				-					---
Black or Black British (base White)		++	++	+++				--	---
Mixed race (base White)									---
Promotions on upper shelf	+++	++		++					++
Student									+++
Unemployed		--							++

The level of detail of the models is again too high to discuss every single estimate. We see that price and promotions have significant impacts on the selection model (decision to purchase), but matter less in the quantity model. Cross price and cross promotions have significant impacts on the decision to buy alcohol, but are hardly significant in the quantity model.

The differential income effects for selection and the quantity models for Wine A purchasing illustrate the strength of the incorporation of different behavioural formulations. Here we observe that respondents from higher incomes are *less likely* to purchase cheap Wine A products, but for those who do make the decision to purchase these products, higher income levels are associated with *higher levels* of purchasing. Generally, we were able to identify more socio-economic variation in the selection (purchasing) model, particularly incorporating significant ethnicity terms, which were not able to be identified in the Tobit models, where the terms are constrained to be the same to explain both purchasing and quantity purchased. In the majority of the Heckman models, the respondent's share of alcohol purchasing for the household was positively linked with alcohol purchasing. The region terms had varying impacts across the models, which was not surprising given the small sample sizes. The term testing the impact of the shelf ordering in the choice scenarios was significant for some of the alcohol products, for some of the segments, but the sign was inconsistent across these and thus we concluded that shelf order should not be included.

4.2 MDCEV models

In the specification of the MDCEV model for the present application, we made use of 24 products, where product 1 is the outside good, goods 2 to 4 are the three types of wine (as full price items), goods 5 and 6 are the two types of beer (as full price items) and good 7 is spirits (as full price item). These are then followed by the different promotion items, where different types of promotion for a given good are treated as separate products, so that we have three promotion items for each wine and beer type, with two promotion products for spirits. The treatment of promotions as separate goods allows both their different marginal price and their specific attraction as promotions to be modelled. However, in any single presentation, at most one promotion for each alcohol type was shown, so that respondents could choose several from 6 to 9 offers (with a minimum of 8 in the promotion scenarios). The MDCEV structure implicitly includes the own and competitor prices and promotions within the structure, as the model incorporates competition between all alcohol types directly and simultaneously.

As described above, the MDCEV model framework assumes the presence of a budget constraint. The assumptions made in relation to money budgets are one of the most challenging aspects of working with MDCEV models in our experience. Typically, this has been treated either as a time budget

(Bernardo et al. 2015, Bhat 2005, Sener and Bhat 2012), a money budget (Yu et al. 2011, Yu & Zhang 2015) or even separate time and money budgets (Castro et al. 2012). Authors are increasingly recognising the difficulty with the definition of money budgets, where a simple hard constraint such as 24 hours a day for a time budget does not apply. Indeed, individuals may for example have different mental accounts for different products. The situation is further complicated in the case of work using stated preference data (such as here) where arguments can be made that the expenditure observed for a given respondent may well be below their budget constraint (if the scenarios presented were not varied enough) or may be above the real world budget constraint (by being based on hypothetical choices). Recent work by Augustin et al. (2015), has put forward the idea of using regression approaches to estimate a latent budget for vehicle miles travelled, while Dumont et al. (2013) proposed a latent budget approach for money budgets.

For the budget assumption, a number of different specifications were tested. The most meaningful results were obtained by assuming that the budget for a given consumer was the maximum expenditure observed for that consumer across any of the twelve choice tasks, plus £1, ensuring that in each task, at least one unit of the outside good is chosen. We acknowledge that this is a major assumption, and further work investigating approaches such as in Augustin et al. (2015) or Dumont et al. (2013) is an interesting area for additional work. The maximum expenditure across all tasks for a given individual combines data from both sets of scenarios, thus including those tasks where promotions were presented. This should help improve the model's suitability for predicting expenditure in the presence of promotions. Of course, the increase in expenditure observed in the presence of promotions may differ depending on the extent of the promotions presented, and our budget assumptions clearly relate only to what was presented in the SP tasks. As such, the model may potentially lead to an underestimation of the impact of promotions when more (or stronger) promotions than those presented in the tasks for that respondents are considered in a forecast.

The results for the MDCEV models are split across two tables, with the *structural* parameters and product specific constants shown in Table 6, and the socio-demographic effects in Table 7. In both models, we observed that α tended to zero, essentially implying a log transform on consumption, i.e. a very strong satiation effect. The product specific constants also generally imply a higher baseline utility for a product under promotion than at full price, showing the market impact of promotion. The socio-demographic effects are mostly similar to those identified in the Heckman models, although subtle differences arise, e.g. for age impacts on Wine B, the impact of the low-skilled term for Spirits, and the impact of the Age45+ term for spirits.

As in the other models, the impacts of region terms were inconsistent in these models. The term testing for the impact of the shelf ordering in the choice scenarios was generally insignificant and inconsistent in sign across products and segments. These variables were therefore omitted from the final models.

5. Forecast and policy scenario test

5.1 Forecasting framework

To understand consumers' likely responses to alcohol policy interventions and their behaviour in a changing market, the Tobit, Heckman and MDCEV models were next used in a forecast framework.

For this, the sample observations were re-weighted to achieve a nationally representative distribution of population characteristics and consumption level.

The forecast models are applied to the first record of the SP survey for each respondent in the main survey, weighted to reflect population and consumption patterns, remembering that this first record reflected the baseline in terms of all alcohol types at their baseline prices without promotions.

The Tobit forecast follows a procedure described in Carson and Sun (2007), using a Microsoft Excel spreadsheet model. In the Heckman model, an instrumental variable (inverse Mills ratio) is calculated and applied in estimation as a correction term, to maintain consistency. In forecasting, this term is also used and it generally ensures that the majority of forecasts are non-negative. However, there remains a possibility that some negative consumption is predicted (Daly, 2013). In the present study, we have observed very few cases of predicted negative consumption. To retain consistency, this small number of negative forecasts is retained in the forecast, despite their lack of reality. If negative forecasts were suppressed, the overall total would be biased upwards. For the MDCEV model, the forecast follows the detailed approach described in Pinjari & Bhat (2011).

Scenario tests were run to provide a set of bespoke alcohol policy intervention analysis for the impact of the price change and promotion compared to the “Do nothing” scenario:

- A 10% increase in price to compute the price elasticity for each type of alcohol product (six categories) separately;
- Introducing alcohol multi-buy promotions;
- Removing a package of alcohol multi-buy promotions.

Table 6 MDCEV results (technical parameters)

	Moderate		Hazardous & harmful		Moderate		Hazardous & harmful		
	Final LL	54,789.85	87,159.06		estimate	t-ratio	estimate	t-ratio	
					wine A	-4.555	-41.72	-4.89	-48.02
					wine A promotion 1	-4.033	-27.3	-4.113	-28.41
					wine A promotion 2	-4.116	-24.54	-4.278	-23.7
					wine A promotion 3	-4.003	-23.85	-4.244	-25.41
					wine B	-4.907	-23.44	-5.987	-28.14
					wine B promotion 1	-4.258	-19.33	-4.837	-21.29
					wine B promotion 2	-3.449	-15.19	-4.003	-17.43
					wine B promotion 3	-4.079	-17.5	-4.866	-20.81
					wine C	-7.558	-15.02	-6.803	-18.47
					wine C promotion 1	-6.331	-12.02	-5.114	-12.52
					wine C promotion 2	-5.416	-10.63	-4.439	-10.99
					wine C promotion 3	-6.499	-11.84	-5.002	-12.04
					beer A	-3.386	-18.3	-4.919	-27.15
					beer A promotion 1	-3.144	-15.67	-4.129	-21.06
					beer A promotion 2	-3.086	-14.38	-4.44	-21.34
					beer A promotion 3	-2.899	-13.51	-4.542	-21.34
					beer B	-4.255	-18.87	-5.449	-23.21
					beer B promotion 1	-4.883	-18.63	-6.093	-22.17
					beer B promotion 2	-4.232	-16.09	-5.131	-19.07
					beer B promotion 3	-4.108	-15.59	-5.254	-18.85
					spirits	-6.233	-28.7	-5.927	-32.1
					spirits promotion 1	-6.014	-25.83	-5.438	-27.04
					spirits promotion 2	-5.778	-24.87	-5.293	-26.52
γ	α_0	tends to zero	tends to zero						
	σ	1.085	92.08	1.243	109.2				
	wine A	20.25	21.15	26.41	24.6				
	wine B	22.47	13.76	23.2	16.44				
	wine C	18.34	7.341	15.88	9.699				
	beer A	13.01	18.42	13.47	22.68				
	beer B	6.224	16.36	4.791	18.03				
	spirits	57.31	15.93	36.6	22.82				
	wine A promotion 1	51.39	6.698	43.94	8.031				
	wine A promotion 2	26.73	6.207	27.86	6.11				
	wine A promotion 3	35.92	5.375	45.24	5.867				
	wine B promotion 1	69.08	6.375	49.02	9.038				
	wine B promotion 2	24.39	7.561	23.61	8.885				
	wine B promotion 3	60.07	4.988	47.16	6.96				
	wine C promotion 1	92.47	2.738	84.54	3.405				
	wine C promotion 2	34.48	3.813	37.14	4.236				
	wine C promotion 3	88.28	1.853	58.41	3.221				
	beer A promotion 1	46.73	8.104	36.53	11.01				
	beer A promotion 2	44.62	5.594	34.21	7.515				
	beer A promotion 3	26.61	5.973	32.08	6.856				
beer B promotion 1	74.28	2.85	45.72	4.63					
beer B promotion 2	44.18	3.712	28.2	5.658					
beer B promotion 3	24.81	4.315	18.77	5.282					
spirits promotion 1	241.2	5.756	120.7	10.05					
spirits promotion 2	134.5	6.522	77.17	10.2					

δ (product specific constants)

Table 7: MDCEV results (socio-demographics)

	Moderate		Hazardous & harmful			Moderate		Hazardous & harmful			
	estimate	t-ratio	estimate	t-ratio		estimate	t-ratio	estimate	t-ratio		
wine A					beer A						
	Female	0.2928	4.92	0.4702	8.09		Female	-0.5682	-8.79	-0.5371	-8.69
	Age 18-24 (base 25-44)	-0.0815	-0.82	-0.4984	-4.60		Age 18-24 (base 25-44)	-0.0413	-0.42	0.3160	3.10
	Age over 45 (base 25-44)	-0.1073	-1.62	0.1742	2.90		Age over 45 (base 25-44)	-1.0280	-14.73	-0.6883	-10.68
	Household income £40-60k p.a. (base under £40k)	-0.2216	-2.51				Household income over £60k p.a.			-0.2584	-2.41
	Household income over £60k p.a. (base under £40k)	-0.4754	-4.02				Household income not known			-0.6578	-6.38
	Household income not known	-0.3237	-3.70				Low Skilled	-0.3356	-3.99	0.3074	3.83
	Low Skilled	-0.1801	-2.35	0.2069	2.69		East (base London & SE)	-0.5596	-5.23	0.1947	1.89
	East (base London & SE)	-0.1967	-2.08	0.3733	3.85		North (base London & SE)	-0.1379	-1.58	-0.0023	-0.03
	North (base London & SE)	-0.2844	-3.45	0.0918	1.20		Scotland (base London & SE)	-0.1579	-1.38	-0.5184	-3.91
	Scotland (base London & SE)	-0.3786	-3.51	-0.0253	-0.21		West (base London & SE)	-0.0507	-0.58	-0.1391	-1.56
	West (base London & SE)	-0.2641	-3.18	-0.0533	-0.63		Higher education	-0.2590	-2.96	0.1850	2.23
	2 or more adults in household	0.3958	6.70	-0.0104	-0.18		Low education (GCSE or less)	0.2249	2.46	0.3926	4.63
	Respondent's share of alcohol buying for household	0.0004	1.12	-0.0005	-1.21		Respondent's share of alcohol buying for household	0.0001	0.20	0.0012	3.11
	Promotions on upper shelf	-0.1699	-1.42	-0.0371	-0.32		Promotions on upper shelf	-0.3197	-3.12	-0.2810	-3.03
	Female	0.2793	3.89	0.3125	4.48		Female	-0.4410	-5.80	0.0692	0.89
	Age 18-24 (base over 25)	-0.1932	-1.72	-0.0713	-0.57		Age 18-24 (base 25-44)	0.5897	5.32	0.9532	8.02
	Household income £20-60k p.a. (base under £20 k p.a.)	0.2876	3.51	0.6652	7.40		Age over 45 (base 25-44)	-0.7185	-8.55	-1.1060	-12.99
	Household income over £60k p.a. (base under £20k)	0.1695	1.19	1.3450	10.67		Household income £20-60k p.a. (base under £20 k p.a.)	0.4275	4.94	0.5890	6.04
	Household income not known	0.2355	2.07	0.5647	4.67		Household income over £60k p.a. (base under £20k)	0.8680	6.05	0.8686	5.91
	Low Skilled	-0.4056	-3.75	-0.0760	-0.69		Household income not known	0.2692	2.20	0.1433	1.02
	East (base London & SE)	-0.6849	-5.70	0.1584	1.36		East (base London & SE)	-0.0701	-0.52	0.0046	0.04
	North (base London & SE)	-0.3233	-3.35	-0.1626	-1.79		North (base London & SE)	0.3389	3.03	-0.5635	-5.56
	Scotland (base London & SE)	-0.0021	-0.02	-0.1325	-0.96		Scotland (base London & SE)	0.6593	4.94	-0.1870	-1.24
	West (base London & SE)	-0.5047	-4.99	-0.2503	-2.46		West (base London & SE)	0.5760	5.32	-0.2840	-2.58
	2 or more adults in household	0.1085	1.11	0.1024	1.13		Higher education	-0.1304	-1.31	0.3605	3.53
wine B						beer B					

wine C

Low education (GCSE or less)	-0.4472	-4.07	-0.4168	-4.17
Respondent's share of alcohol buying for household	0.0002	0.44	-0.0006	-1.36
Promotions on upper shelf	-0.1763	-1.75	-0.1112	-1.21
Female	-0.1211	-0.93	-0.2848	-2.35
Age 18-24 (base 25-44)	-0.2140	-0.78	0.3668	1.75
Age over 45 (base 25-44)	0.1426	0.93	-0.6136	-4.77
Household income £20-60k p.a. (base under £20 k p.a.)	0.5935	3.26		
Household income over £60k p.a. (base under £20k)	1.2370	4.87		
Household income not known (base under £20k p.a.)	0.7799	3.55		
Household income under £20k p.a. (base over £20k p.a.)			0.8782	5.63
Low skilled	-0.5823	-2.46	-0.6736	-3.04
East (base London & SE)	-0.7123	-2.91	-0.0802	-0.40
North (base London & SE)	-0.0252	-0.15	-0.3669	-2.41
Scotland (base London & SE)	0.8010	4.13	-1.1110	-4.16
West (base London & SE)	-0.7566	-3.67	-0.6473	-3.65
Higher education	0.8408	3.70	0.3672	2.24
Low education (GCSE or less)	0.2366	0.96	-0.6838	-3.54
2 or more adults in household	-0.2573	-1.92	0.0722	0.50
Respondent's share of alcohol buying for household	-0.0002	-0.30		
Promotions on upper shelf	0.0118	0.06	-0.4518	-2.39

spirits

Low education (GCSE or less)	-0.1332	-1.23	0.0554	0.49
2 or more adults in household	0.1318	1.73	0.1550	1.76
Respondent's share of alcohol buying for household	0.0010	2.31	0.0005	0.97
Promotions on upper shelf	-0.3086	-2.09	0.2278	1.64
Female	0.2032	3.10	0.2243	3.70
Age 18-24 (base 25-44)	0.5143	4.87	0.5363	5.02
Age over 45 (base 25-44)	-0.0426	-0.56	0.1287	1.98
Household income over £20k p.a.			0.3343	5.33
Low Skilled	0.2561	3.14	0.1940	2.32
East (base London & SE)	-0.1675	-1.57	0.2798	2.66
North (base London & SE)	-0.0982	-1.09	0.3001	3.72
Scotland (base London & SE)	0.3586	3.31	0.4073	3.38
West (base London & SE)	-0.1596	-1.73	-0.0501	-0.55
Higher education	0.5082	5.26	0.0243	0.31
Low education (GCSE or less)	0.3873	3.77	0.0024	0.03
2 or more adults in household	-0.1041	-1.64	-0.2968	-4.64
Respondent's share of alcohol buying for household	0.0010	2.62	0.0014	3.75
Promotions on upper shelf	-0.1206	-1.13	-0.0174	-0.19

5.2 Price elasticity

We use the models to predict the impact of a 10% pricing increase (compared to the baseline scenario) on the volume of alcohol units purchased for each alcohol type by level of consumption. We then computed the impact on expenditure.

Table 8 summarises the own-price elasticities for each specific alcohol type, derived from the Tobit, Heckman and MDCEV models. The elasticities are calculated using the ratio between the log price change and log purchase volume change. It is further assumed that prices for other alcohol types would not change.

Generally, elasticities are relatively consistent between the Tobit and Heckman models, however, higher price elasticities, particularly for cheaper alcohol products, are observed in the MDCEV models. Across all models as expected, the elasticities for purchasing units are higher (more strongly negative³) than for expenditure. Alcohol price increases lead to reductions in the volume of units purchased. However, as the amount paid for each unit increases, the impact of price reduction on the total expenditure is relatively smaller than the impact on units. Therefore the elasticities for purchasing units would be expected to be numerically larger than the elasticity for expenditure.

Moreover, some of the expenditure elasticities from the Tobit and Heckman models are positive, which are not observed in the MDCEV models. Wine A and wine B are at the lower end of price (inferior good) within the same type of alcohol and are found relatively inelastic to price changes compared to the other types of alcohol (normal good) in this study. Volland (2012) found that beer is an inferior good in Germany and is price inelastic. Gallet and List (1998) found similar results, but corresponded to a minority of results (e.g., Nelson, 2003). This may also be attributed to incomplete representation of the competition of alcohol types in these models.

In the MDCEV models, the own-price elasticities on units purchased for less expensive Wine A and Beer A products are higher (more negative), because of the better representation of competition in these models.

For most products, we tend to find that the price elasticities for moderate drinkers are higher than for hazardous and harmful drinkers (although the differences are less in the Tobit and Heckman models). These findings are consistent with findings from others, e.g. Fogerty (2004). However, because hazardous and harmful drinkers purchase much higher volumes of alcohol, the absolute impact on these groups will be greater compared to less heavy drinkers.

³ When a single alcohol type is considered, the expenditure elasticity is exactly 1 more than the units elasticity.

Table 8 Own-price elasticities from the models (10% price increase)

	Units			Expenditure		
	Total	Moderate	H&H	Total	Moderate	H&H
Tobit models						
Wine A	-0.33	-0.37	-0.29	+0.67	+0.63	+0.71
Wine B	-1.76	-1.76	-1.76	-0.76	-0.76	-0.76
Wine C	-1.57	-1.57	-1.56	-0.57	-0.57	-0.56
Beer A	-0.61	-0.57	-0.66	+0.39	+0.43	+0.34
Beer B	-1.07	-1.18	-0.87	-0.07	-0.18	+0.13
Spirits	-1.34	-1.52	-1.14	-0.34	-0.53	-0.14
All wine	-0.19	-0.15	-0.24	+0.43	+0.44	+0.41
All beer	-0.58	-0.64	-0.50	+0.38	+0.30	+0.50
Heckman Models						
Wine A	-0.37	-0.45	-0.30	+0.63	+0.55	+0.70
Wine B	-2.00	-2.04	-1.95	-1.00	-1.04	-0.95
Wine C	-1.77	-1.63	-1.95	-0.77	-0.63	-0.95
Beer A	-0.45	-0.32	-0.59	+0.55	+0.68	+0.41
Beer B	-1.05	-1.11	-0.91	-0.05	-0.11	+0.09
Spirits	-1.45	-1.45	-1.47	-0.45	-0.45	-0.47
All wine	-0.47	-0.51	-0.42	+0.19	+0.13	+0.26
All beer	-0.48	-0.40	-0.56	+0.46	+0.46	+0.46
MDCEV						
Wine A	-1.30	-1.41	-1.23	-0.30	-0.41	-0.23
Wine B	-1.60	-1.69	-1.50	-0.60	-0.69	-0.50
Wine C	-2.19	-2.19	-1.78	-1.19	-1.19	-0.78
Beer A	-1.36	-1.48	-1.26	-0.36	-0.48	-0.26
Beer B	-1.51	-1.57	-1.39	-0.51	-0.57	-0.39
Spirits	-1.44	-1.58	-1.33	-0.44	-0.58	-0.33
All wine	-1.30	-1.39	-1.22	-0.33	-0.43	-0.25
All beer	-1.35	-1.45	-1.26	-0.37	-0.47	-0.28

Collis et al. (2010) report the following elasticities from a review of existing UK alcohol studies:

- Beer, median = -0.40, mean = -0.56
- Wine, median = -0.86, mean = -0.90
- Spirits, median = -0.72, mean = -0.75

It is difficult to make direct comparisons with the model outputs from this study, as it is not clear to what extent these published values reflect units purchased or expenditure (Collis et al. (2010) refer to the impact of price on alcohol consumption more generally⁴). Furthermore, in their summary they do not state to what extent these reflect on-trade or off-trade purchases (or both). However, we note generally that the mean values reported by Collis et al. (2010) fall between the units and expenditure elasticities from the MDCEV models developed in this study.

We also note that, for all categories in the MDCEV model and some categories for Tobit and Heckman, the increase in cost not only leads to reduced consumption (units) but also reduced expenditure. Suppose price changes by $p\%$ and consequently purchasing (units) changes by $-q\%$. The price elasticity of purchasing is then approximately $-q/p$. However, expenditure changes by

⁴The linkage between purchasing and consumption is not well reported in the literature. Purshouse et al. (2010) in their work estimating the effect of alcohol pricing policies equated purchasing and consumption. In an earlier paper this assumption was tested by comparing beverage preferences between subgroups in each survey. This comparison showed a good match overall, although they found that older females purchased a greater proportion of beer and spirits (in the EFS) than they consumed (measured in the GLF), probably because they were purchasing for the household, rather than only for themselves (Meier et al., 2009).

approximately $(p-q)\%$, so the price elasticity of expenditure is $1-q/p$, i.e. 1 more than the elasticity of purchasing. This is clearly visible in Table 8 for all individual products, across models. Clearly, the situation is different when looking at changing the price on more than one product at the same time (final two rows for each model in Table 8), as a fixed p across products gives us different values of q for the different products, making the total q some intermediate value.

There is also no behavioural reason why q/p should be more or less than 1. Particularly in a market with a lot of competition, consumers are prone to switching easily. As a result, expenditure elasticity could be positive or negative. If q/p was less than 1, a producer could simply increase prices to generate more revenue for less product. The MDCEV model is more elastic (bigger q) so we more often get negative expenditure elasticity.

In fact, all elasticities we have seen published in literature are negative, although unfortunately it is not always clear whether what are reported are in units or expenditure (e.g. Collis et al, 2010). It is clearly possible that an increase in alcohol prices will lead respondents to reduce their consumption so much that they in fact spend less money. This is what we see in the MDCEV model results – which tend to be more negative in terms of own-price elasticities for units (than the corresponding Tobit and Heckman ones), particularly for cheaper alternatives (we note that it is the own-price elasticities that are published here and not the elasticity for total expenditure). The reverse clearly also applies where, with reduced prices, respondents not only buy more alcohol for the same amount of money, but actually spend more money. Indeed, it is entirely realistic to expect consumers to “stock up” on alcohol when it is cheap, and to not spend much on it when it is expensive. The situation may of course be different if the change in price is a long term change rather than a short term fluctuation.

5.3 Introducing promotions

In our example looking at the impact of introducing a promotion, we assume that the prices of all other alcohol products are equal to the non-discounted prices, and that non-promotion items are also available. For example for the tests with promotions on Wine A products, these same products are also available at non-discounted prices. The Tobit and Heckman models do not differentiate the purchase between promotion and non-promotion items, so we computed the ratio of expenditure between promotion and non-promotion items in the choice exercises where both were present. Based on the findings on expenditure from the survey, an average price assuming that 86 percent of the expenditure came from the promotion items and 14 percent from non-promotion items was calculated and then used when computing expenditure from these models. In the MDCEV models, the expenditure calculation accurately reflects the predicted purchase pattern predicted in the model, differentiating between promotion and non-promotion items.

We report the impacts both on the specific alcohol type (e.g. the impact of a ‘3 for 2’ promotion on the purchasing of Wine A products), the alcohol category (e.g. the impact of a ‘3 for 2’ promotion on Wine A products on all wine products) and across all alcohol products. For spirits, the former two are obviously equal to each other. In the Tobit and Heckman models, the impacts across categories and across all alcohol products are obtained by summing the impacts across the different models. They are calculated directly from the MDCEV models.

The reported figures reflect both the impact of the price reduction (measured through the price term) and the psychological impact of the promotion itself (measured as a constant in the model)

with results shown as a proportional change on demand, i.e. the change in demand divided by the demand from the baseline scenario. The results shown in Table 9 look at the overall market, i.e. after combining the different categories of drinkers.

For the Tobit models, in general, we see that the introduction of a promotion always leads to a predicted increase in the purchasing of alcohol units for that product. For example, with the introduction of a '3 for 2' promotion on Wine A products, the models predict a 0.88 increase (88 percent increase) in the units of Wine A products purchased overall compared to the baseline situation with no promotions. This leads to a 35 percent increase in expenditure on Wine A products overall – the proportional increase in expenditure is less than the increase in units purchased because some of the purchases are made at a reduced price (because of the promotion). Again we emphasise that the expenditure calculations from the Tobit models are imprecise, because the model does not explicitly predict the proportion of the market that would purchase promotions.

The relative impact on expenditure for the alcohol category, e.g. wine, is much smaller – because of cross-switching effects. For example, with a promotion on Wine A products, people who tend to purchase Wine B products may purchase fewer of these and instead purchase Wine A products, so we see an increase in Wine A products, but the increase across all wine purchases is not as large. So, we see that the '3 for 2' promotion on Wine A leads to a 35 percent increase in the purchasing of *units* of wine products overall, but a 17 percent reduction in *expenditure* on wine products overall. The impact across all alcohol purchases is still smaller – where the '3 for 2' Wine A promotion leads to a 15 percent increase in purchasing units of all alcohol but an 8 percent reduction in expenditure. Again, we note concerns regarding the reliability of the expenditure calculations from the Tobit models.

We observe much higher predicted increases for promotions introduced in the Wine C (expensive wine) market, particularly with regard to increases in Wine C units purchased relative to the baseline scenario (a 954 percent increase). But we note that Wine C purchases account for only around 2 percent of units in the baseline scenario. Therefore, with promotions that make Wine C nearly as attractive as Wine B (around 16 percent of the market in the baseline scenario), we see a large percentage change, but for a small market, so the overall impact is not large. In fact the impact on total wine units and all alcohol units is negligible (due to cross-trading), although the impact on total wine expenditure is larger (because some respondents will be trading up to purchase more expensive wine).

In general, the impacts in the Heckman models are higher than those predicted from the Tobit models, except for Spirits (which are quite similar), which is consistent with the higher price elasticities for the Heckman models. However, we note that many of the price terms were not as significant in the Heckman models, which is likely a result of having to estimate models for the two separate processes (selection and quantity). So, whilst having separate functions is desirable theoretically, in practice more data would be needed to provide more reliable estimates in the Heckman models.

Consistent with the price elasticity impacts, we find that the direct impacts (for example the impact of a promotion on a Wine A product on Wine A purchases) measured from the MDCEV models are generally higher than those measured from the Tobit and Heckman models, particularly for wine

products, but not for beer and spirits. This may be because the MDCEV models better represent the impacts of competition, but IID assumptions are also a concern (see earlier discussion).

However, the benefit of the MDCEV models is that they better reflect the impacts of pricing and promotions on other products and on total alcohol purchased. So, from the promotion impacts of the MDCEV model we see the following trends:

- The introduction of a promotion always leads to increased purchasing of alcohol for that specific type of product (both in terms of units purchased and expenditure).
- This increase is partly compensated by a reduction in purchasing of units for other types of alcohol, which are measured directly in the model.
 - So, for example, the introduction of a '3 for 2' promotion on medium-priced wine (Wine B-type products) leads to a 630 percent increase in purchasing of Wine B units, but a smaller increase (72 percent) in all wine products, because of the likelihood of switching between wine products.
- Moreover, the MDCEV models predict the impact on all alcohol purchases, taking account of cross-product trading.
 - So, the '3 for 2' promotion on Wine B products will lead to a 20 percent increase in all alcohol units, because of consumer trade-offs between beer and spirits and wine, and a 23 percent increase in expenditure across all alcohol products.

More generally, in the MDCEV models applying individual promotions on less expensive wine and less expensive beer lead to increased purchasing of alcohol units, while promotions on expensive wine and beer lead to more purchases of these items at the expense of cheaper counterparts and therefore a smaller increase (or even a small reduction) in total units purchased. For spirits, promotions lead to increased purchases of units, because of the higher number of units per bottle.

5.4 Removing a package of promotions

The real-world market often has number of different competing promotions in force at the same time. Another scenario test was undertaken to quantify the impact of removing a 'package' of promotions. A quick review of UK supermarket websites⁵ indicated that the most prevalent offers were in the form of x for £y, and that many of the discounts were in the order of 25–50 percent. In order to test a package that reflected the observed magnitude of discounts more generally, we did a test with a base scenario simultaneously offering '3 for 2' promotions for all wine options (Wine A, Wine B and Wine C) and '8 for 6' promotions for beer and premium beer, and then looked at the impact of removing both promotions at the same time. No promotion for spirits was included in the test, as these were less common. We have assumed that non-promotion items are also available in the test at their non-promotion (baseline) price.

In the Tobit and Heckman models, the impacts across categories and across all alcohol products are obtained by summing the impacts across the different models. They are calculated directly from the MDCEV models. The resulting impacts from each model are summarised in Table 10 below. We again present the aggregate results across both consumption segments. We caution that these tests may overstate the impact of promotions, because it is not known to what extent all promotions would be presented simultaneously in the market place, and also as our models are not estimated on data that looks at both including and removing promotions.

⁵ The review was undertaken using the MySupermarket website: <http://www.mysupermarket.co.uk/> (Accessed on 4 June 2013)

Table 9: Impact of introducing promotions

	Impact on alcohol type		Impact on alcohol category		Impact on all alcohol purchases	
	Units	Expenditure	Units	Expenditure	Units	Expenditure
Tobit						
Wine A – 3 for 2	0.88	0.35	0.35	-0.17	0.15	-0.08
Wine B – 3 for 2	4.55	2.97	0.83	0.81	0.36	0.37
Wine C – 3 for 2	9.54	6.55	-0.04	0.22	-0.02	0.10
Beer A – 8 for 6	1.20	0.72	0.82	0.20	0.08	-0.03
Beer B – 8 for 6	2.00	1.35	0.17	0.39	-0.09	0.03
Spirits – 2 for 90%	3.58	3.19	3.58	3.19	1.09	0.68
Heckman						
Wine A – 3 for 2	1.31	0.65	0.71	0.07	0.34	0.04
Wine B – 3 for 2	5.55	3.69	1.04	1.06	0.50	0.54
Wine C – 3 for 2	17.01	11.90	0.24	0.59	0.11	0.31
Beer A – 8 for 6	2.80	1.99	2.10	0.94	0.31	0.16
Beer B – 8 for 6	6.69	5.04	1.06	1.83	0.13	0.39
Spirits – 2 for 90%	3.85	4.61	3.85	4.61	1.25	1.12
MDCEV						
Wine A – 3 for 2	2.59	1.60	2.10	1.04	0.83	0.32
Wine B – 3 for 2	6.30	4.06	0.72	0.79	0.20	0.23
Wine C – 3 for 2	35.4	23.5	0.16	0.39	-0.01	0.11
Beer A – 8 for 6	2.92	2.12	2.46	1.37	0.29	0.17
Beer B – 8 for 6	4.03	2.97	0.44	0.80	-0.02	0.09
Spirits – 2 for 90%	2.02	1.79	2.02	1.79	0.44	0.23

With the removal of the wine and beer promotions, the Tobit and Heckman models predict a decrease in purchasing of Wine B and Wine C products, but an increase in Wine A products. The result for Wine A products is a consequence of the strong cross-price and cross-promotion terms for Wine B and Wine C products in that model. This may also relate to the inelastic price elasticity found in that the wine A product. Moreover, because of the relatively large size of the Wine A market, the Tobit models predict an overall increase in units and expenditure for all wine products and for all alcohol products. We judge this to be a structural problem with the Tobit models, as each has been estimated with a relatively small amount of data, and cross-effects are not well estimated. Although the Heckman models also predict an increase in Wine A units, they predict a decrease in all wine and all alcohol products with the removal of the promotions. The impacts predicted on Wine B, beer and spirits look more reasonable; although the impact of the increased purchasing of spirits is different between the two models. The MDCEV models predict reductions in wine markets (the smallest reduction in Wine A, followed by Wine B and Wine C) and beer markets, and an increase in purchasing of spirits. Overall, removing this specific package of promotions leads to a predicted 48 percent reduction in purchasing of alcohol units and a 37 percent reduction in expenditure. All models predict an increase in the consumption of spirits if promotions on wine and beer are removed.

Table 10 Impacts of removing a package of promotions (3 for 2 on wine and 8 for 6 on beer)

	Impact on alcohol type		Impact on alcohol category		Impact on all alcohol purchases	
	Units	Expenditure	Units	Expenditure	Units	Expenditure
Tobit						
Wine A	2.58	4.00				
Wine B	-0.26	0.03	0.32	0.29		
Wine C	-0.73	-0.62			0.20	0.19
Beer A	-0.34	-0.16				
Beer B	-0.46	-0.31	-0.37	-0.23		
Spirits	2.35	2.35	2.35	2.35		
Heckman						
Wine A	1.37	2.31				
Wine B	-0.54	-0.36	-0.27	-0.36		
Wine C	-0.93	-0.90			-0.28	-0.36
Beer A	-0.59	-0.48	-0.65	-0.62		
Beer B	-0.78	-0.72				
Spirits	0.95	0.95	0.95	0.95		
MDCEV						
Wine A	-0.58	-0.42				
Wine B	-0.75	-0.64	-0.63	-0.53		
Wine C	-0.93	-0.89			-0.48	-0.37
Beer A	-0.61	-0.44	-0.62	-0.47		
Beer B	-0.67	-0.52				
Spirits	2.33	2.33	2.33	2.33		

6. Discussion and conclusions

The aim of this study was to measure the impact of multi-buy promotions on consumers' off-trade alcohol purchasing. Our analysis complements the existing evidence by deploying a stated preference approach to measure and to explain consumers' responses to changing price and multi-buy promotions which might not be easily observed in the real market. A range of econometric models were developed to interpret the consumers' behaviour and the impact of multi-buy promotion. The Tobit and Heckman models established a benchmark to the existing alcohol pricing studies, before an advanced MDCEV model was developed which can better replicate the competition of the multi-buy promotions among different types of alcohols and substitution of the purchase with presence of different offers.

The MDCEV models allow for better representation of the competition between alcohol products, which is not measured as well in the single-product regression models, as well as situations where multiple options are chosen – in around 42 percent of tasks, respondents made purchase choices that included more than one alcohol type within a specific choice scenario. Furthermore, the MDCEV models also explicitly consider the impact of an available maximum budget for purchases, so that competition between products is again better represented. The MDCEV models additionally represent the effect of satiation, i.e. that the marginal utility of additional purchases declines as more of a given product is purchased. Furthermore, the MDCEV models use the data more efficiently, because all observations (within a segment) contribute to the estimation of the model parameters.

For this study we tested multinomial model structures, where promotion and non-promotion items are represented as separate alternatives, equally competitive with each other and other types of alcohol. In practice, however, we find that some alternatives are more 'similar' and therefore are closer substitutes than others (not IID). We hypothesise that this is probably true for promotion and

non-promotion options of a specific type of alcohol, where we would expect higher cross-elasticities, for example between a Wine A non-promotion product and a Wine A promotion product. Correlation may also exist between the different categories of a given alcohol type, e.g. wine. The introduction of such correlation would therefore give a better representation of the stated behaviour, but while technically feasible (cf. Pinjari and Bhat, 2010; Pinjari, 2011; Bhat et al., 2013), it was beyond the scope of the present study. With the inclusion of a nesting structure (if justified by the data), the effect of the introduction of a new alternative, i.e. a promotion alternative in this study, is reduced. As a result, it is possible that our MDCEV models overstate the impact of introducing promotions. On the other hand, the Tobit and Heckman models are likely to underestimate the impact of promotions, because of the limited representation of competition in these models. For these reasons we recommend that the results from the MDCEV models be treated as maximum estimates of the impacts of promotions on alcohol purchasing.

The results from the stated preference data appear to be credible, and the resulting price elasticities seem to be, generally, of the same order of magnitude as other reported values, although it is difficult to make direct comparisons because of differences in study scope (on-trade vs. off-trade) and lack of clarity of output measures (units, monetary expenditure, consumption, etc.) in other studies. However, the models may overestimate the impact of multi-buy promotions for a number of reasons. First, the results are based on stated preference data, rather than observed purchases, where people may state larger responses to price changes. Second, because of the technical properties of the MDCEV model, specifically assumptions about cross-elasticities between products (as a result of the IID property of the models), it is likely to lead to overestimates of the impacts of promotions. The Tobit and Heckman models may be less likely to lead to overestimates of impacts, as a result of their model structure, but the predicted impacts from these models are still subject to the points raised above. Third, single-product promotion tests are likely to overestimate the impacts of these promotions on individual products, because they do not reflect real-world market conditions which may include a number of different competing promotions at the same time. Moreover, the package tests may also overstate the impact of promotions because it is not known to what extent all promotions would be presented simultaneously in the market place.

Mindful of the limitations of any empirical study, our findings represent an important contribution to the impact of multi-buy promotion on alcohol promotion as well as to policy. In terms of the former, the study adds to the evidence of evaluation of the multi-buy promotions on the consumers purchase behaviour, given the difficulty of evaluating alcohol policy interventions at a population level. The most frequent price interventions in the alcohol market has been that of imposing excise duties on alcohol beverages. However, there appear to be limits in the form of political and public acceptability regarding further extension of these measures. There is a reason to believe that countries may be seeking other, less contentious pricing policies – a characteristic that would arguably be met by the restriction of quantity discounts.

Acknowledgement

The work reported in this paper is based on a study commissioned jointly by Her Majesty's Revenue and Customs (HMRC), the UK Department of Health (DH) and the UK Home Office. The interpretation of the results as well as any mistakes, remains the responsibility of the authors. The

second author acknowledges the financial support by the European Research Council through the consolidator grant 615596-DECISIONS.

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