Heterogeneity in Alcohol Consumption: the Case of Beer, Wine and Spirits in Australia*

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Abstract

This paper examines Australian individuals' participation in beer, wine and spirits consumption using a trivariate probit model and unit-record data from nationally representative surveys during 1991-2001. The effects of socioeconomic and demographic factors on an individual's decisions of alcohol participation are estimated. The trivariate probit formulation allows for potential correlation across three alcoholic drinks via unobserved personal characteristics. All three beverages are shown to have negative own-price elasticities, to be substitutes in participation and to be related to rather different population groups. An alarming proportion of young Australians are found to be drinking spirits regularly due to the increasing popularity of pre-mixed drinks.

***JEL Classification**:* C3, D1, I1

***Keywords*:** alcohol consumption, beer, wine, and spirits, discrete choice modelling, trivariate probit model

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1. Introduction

Alcohol consumption and its related government policies have long been the centre of discussion in many countries. There have been reports linking regular consumption of small quantity of alcohol to positive health benefits. Moderate drinking has also been related to beneficial socialising and networking effects, as well as better labour market outcomes. However, much has also been reported on the adverse social, economic and health impacts associated with alcohol abuse. Indeed, significant amount of public resource has been allocated by governments worldwide on alcohol related educational campaigns and rehabilitation programs.

According to data in 1999/2000, Australia is ranked 19th in the world in terms of per capita alcohol consumption, with 7.8 litres of pure alcohol consumed per person per year which is behind major European countries but ahead of the US, Canada and New Zealand (World Drink Trends, 2002). When breaking down to specific alcohol types, Australians ranked even higher for beer consumption but much lower in terms of spirits. An average Australian consumed 95 litres of beer (9th in the world), 19.7 litres of wine (18th in the world) and 1.3 litres of pure alcohol from spirits (34th in the world). Australian governments has spent significant amount of public funds in dealing with the negative health and social consequences of alcohol intake, in particular chronic heavy drinking. According to an estimate by Collins and Lapsley (2002), the social cost of alcohol in Australia in 1998/99 was in the order of $7.6 billion. In Australia, alcohol is second only to tobacco as the major cause of drug related mortality (AIHW, 2002).

Alcohol is consumed in heterogenous product forms. While there are abundant empirical economic studies investigating alcohol consumption and its response to price changes, most papers have considered alcohol as a homogenous product and many have used aggregated level data. Anecdotal evidence would suggest that consumers of beer, wine and spirits relate to rather different socioeconomic and demographic groups and exhibit rather different consumer behaviours. Any government economic policies or educational campaigns would need to be informed of such differences. Understanding the relationships between the consumption of different alcohol types and such factors as age profile, gender, geographic location, family type, ethnic group and employment status via micro level data is invaluable for policies to be effectively targeted. In addition, an individual's decisions on consumption of various alcoholic types are related via observed and unobserved individual characteristics. Any univariate approach would ignore potential cross-commodity correlations for the same individual via unobserved characteristics such as individual tastes.

Economic studies on specific alcoholic types have been carried out using a variety of datasets. In a study undertaken by Grossman *et al.* (1998) using US data, the authors demonstrated that an increase in the prices of beer and spirits which can be achieved by raising alcoholic taxes can effectively reduce drinking. Edwards *et al.* (1994) carried out a survey of studies conducted on alcohol across 18 countries. They found that the estimated elasticities for beer, wine and spirits differed widely over time and, across places, data sets and estimation methods. In almost every case, the own-price elasticities were found to be negative, an indication that alcoholic beverages is similar to any other normal good. From an extensive survey of the economic literature on the demand for alcoholic beverages, Leung and Phelps (1993) concluded that the price elasticities of demand for beer, wine and distilled spirits are –0.3, –1.0 and –1.5, respectively. It thus appears that while wine and spirits consumption is very responsive to price changes, the demand for beer is relatively insensitive. In an earlier survey undertaken by Ornstein (1985), the author concluded that based on studies using aggregated data, the demand for beer was substantially price inelastic while the price elasticity of spirits was close to one. However, he could not find reliable results for wine.

Clements *et al.* (1997) estimated demand functions for a few European countries, as well as Australia, Canada and New Zealand. Using aggregated data covering about 30 years, they found that the average own-price elasticities of demand are –0.35 for beer, –0.68 for wine and –0.98 for spirits. Clements and Johnson (1983) were the first economists who used Australian data to analyse the demand for beer, wine and spirits. In a more recent study, Clements and Daryal (1999) estimated the own-price elasticities of beer, wine and spirits to be –0.2, –0.4 and –0.6 respectively. Using Australian aggregated level data, Chang *et al.* (2001) estimated the demand for wine, beer and spirits, which they found to be price inelastic. They also found that beer and wine to be luxury goods. However, none of these studies have investigated the effects of demographic variables on the demand for different types of alcoholic beverages. There have been some other alcohol-related economic studies in Australia (Cameron and Williams, 2001; Zhao and Harris, 2003) which have estimated demand equations for alcohol using micro level data. However, none of these studies have estimated demand functions for beer, wine and spirits separately.

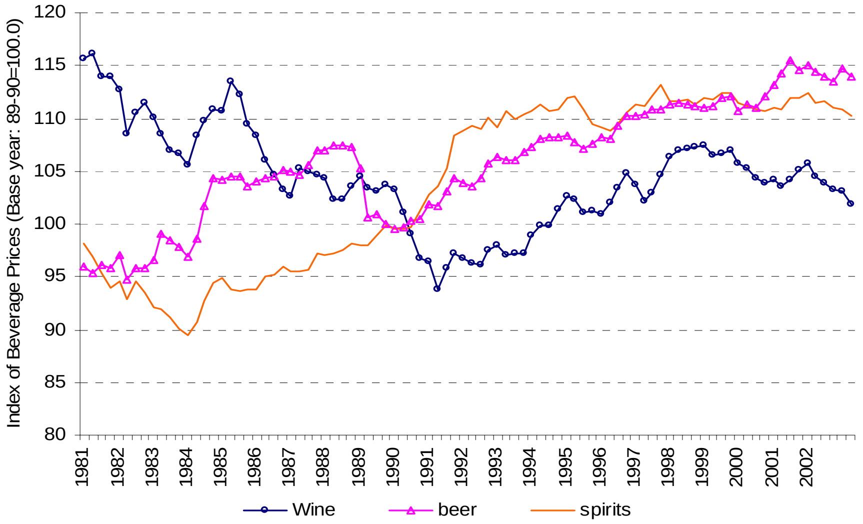
In this paper, we investigate the factors that influence the participation in alcohol consumption in Australia by specifying separate demand functions for beer, wine and spirits. To our knowledge, this will be the first study in Australia that will use unit-record data for such an analysis. We use a trivariate probit model to also allow for correlations among the error terms across the three participation equations. It is expected that an individual's decisions cross the three beverages are correlated due to unobserved characteristics. This also allows us to estimate joint and conditional probabilities across alcoholic types unavailable from univariate models. Prediction of such probabilities indeed provides valuable cross-commodity information to policymakers.

2. Data, and Alcohol Consumption in Australia

The data used in this study are drawn from five National Drug Strategy Household Surveys (NDSHS, 2001) carried out between 1991 and 2001. The NDSHS is a comprehensive survey representing the non-institutionalised population of Australia aged 14 and above. While the 1991 survey covered about 3,000 individuals, almost 27,000 people provided information in the 2001 survey on their drug use patterns, attitudes and behaviours. Individuals were personally interviewed about their general attitude to both licit and illicit drugs while more sensitive questions about personal drug usage were answered by means of self-completion drop-and-collect method. Altogether, around 45,000 individuals are involved. The 1998 and 2001 surveys also provide more disaggregated information on alcoholic types such as pre-mixed beverages which have become popular only in recent years. For the purpose of this study, the range of alcoholic drinks from the five surveys has been grouped into three categories of beer, wine and spirits. Details on the definition of the dependent and explanatory variables used in this study (Table A.1), as well as their sample characteristics (Table A.2), are given in the Appendix.

Data on the respective prices of beer, wine and spirits correspond to the Consumer Price Index (CPI) for each of these sub-categories (ABS, 2003a). The three price series are then deflated using the all-items CPI for individuals' respective states of residence (ABS, 2003b). The CPI series are all obtained from the Australian Bureau of Statistics. Figure 1 shows the trend in the real prices of the three alcoholic beverages.

Figure 1: Inflation-adjusted Alcoholic Beverage Prices, 1980:Q3 – 2002:Q4



Source: NDSHS (2001)

The 2001 NDSHS data indicate that 57 per cent of males and 39 per cent of females aged 14 and over drink alcohol at least once a week. Of the 1.2 million teenagers who consumed alcohol in 2001, approximately 6,500 were daily drinkers, 460,700 were weekly drinkers and a further

730,000 drank less than weekly. According to definition by the health Authorities, about one-third of the Australians interviewed put themselves at risk of alcohol-related harm in the short term on at least one drinking occasion. Adults in the age group 20-29 years were found most likely to consume alcohol at levels considered hazardous or harmful to health in the long run.

Table 1 shows the proportions of individuals in the surveyed samples who consumed each of the three kinds of alcoholic drinks over the years 1991 through 2001. The proportion of individuals who consumed wine increased gradually from 27.7 per cent in 1991 to 51.5 per cent in 2001, representing a rise of around 24 per cent over the decade. The proportion of beer consumers fluctuated between 32 per cent and 46 per cent across the years. In 2001, 43.9 per cent of the respondents were found to be drinking beer. The proportion of individuals who consumed spirits dropped from 17.6 per cent in 1991 to 14.4 per cent in 1993. It picked up considerably in the subsequent years to reach 42.9 per cent in 1998 and remained around that level in 2001.

Table 1: Participation in Alcoholic Drinks

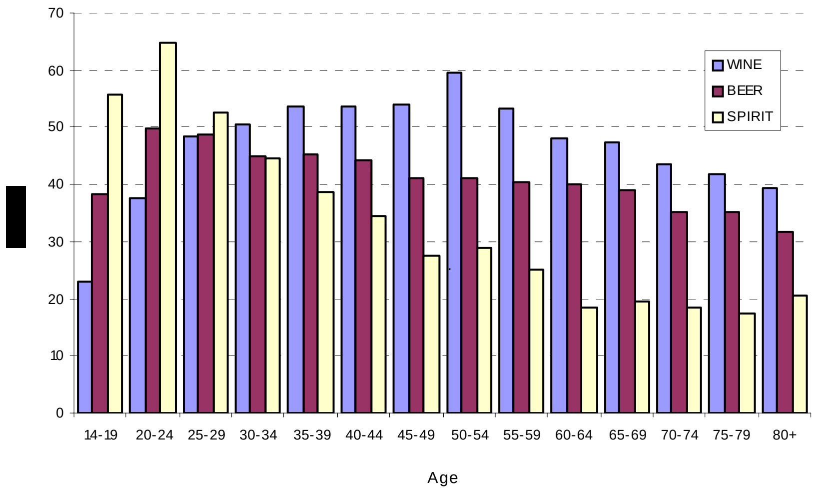
	1991	1993	1995	1998	2001	Combined
Wine	789	955	1485	4924	13543	21696
%	*(27.7)*	*(29.3)*	*(40.0)*	*(49.9)*	*(51.5)*	*(47.2)*
Beer	996	1040	1552	4556	11533	19677
%	*(34.9)*	*(31.9)*	*(41.9)*	*(46.2)*	*(43.9)*	*(42.8)*
Spirits	502	471	1099	4234	11192	17498
%	*(17.6)*	*(14.4)*	*(29.6)*	*(42.9)*	*(42.6)*	*(38.1)*
Of which:						
Pre-mixed Spirits	-	-	-	1226	3681	4907
%				*(12.4)*	*(14.0)*	*(13.6)*
Bottled Spirits	-	-	-	3661	9278	12939
%				*(37.1)*	*(35.3)*	*(35.8)*
Pre-mixed bottles	-	-	-	1017	3556	4573
%				*(10.3)*	*(13.5)*	*(12.6)*
Other alcoholic drinks	97	77	161	1123	1440	2898
%	*(3.4)*	*(2.4)*	*(4.3)*	*(11.4)*	*(5.5)*	*(6.3)*

- : not available. Source: NDSHS (2001).

This substantial rise in spirits consumption can be attributed to the increased popularity of pre-mixed alcoholic or ready-to-drink (RTD) beverages. These drinks have been tailored to teenage tastes with the alcohol masked by sweet flavourings and have eventually gained significant popularity among the younger generation. Another inducement for these RTDs also known as flavoured alcoholic beverages (FAB) has been the tax differentials that seem to greatly favour them to the traditional alcoholic drinks. Thus, the lower prices coupled with the marketing of these products have largely contributed towards an increased consumption of spirits over the years. A more disaggregated picture of spirits consumption which is available since the 1998 survey shows that the proportion of individuals who consumed pre-mixed spirits (e.g. UDL) went up from 12.4 per cent in 1998 to 14 per cent in 2001 while the share of individuals who consumed bottled spirits (e.g. scotch, brandy, vodka) declined from 37.1 per cent to 35.3 per cent during the same period. Those consuming pre-mixed bottles (e.g. sub-zero, Bacardi Breezer) also recorded a rise from 10.3 per cent in 1998 to 13.5 per cent in 2001.

Figure 2 illustrates the percentages of individuals within each age group who consume beer, wine and spirits using the NDSHS data over the five surveys collectedly. Clearly, beer and spirits are more popular than wine among teenagers and young adults. In fact, spirits consumption is distinctly more appealing to teenagers and young adults. Given these age differentials, aggregating the alcoholic beverages may have misleading consequences and may result into inappropriate policy recommendations.

Figure 2: Participation of Beer, Wine and Spirits – By Age Groups



Source: NDSHS (2001).

Table 2 highlights some sample statistics that provide insights on how the consumption of beer, wine and spirits relates to various socioeconomic and demographic variables[1]. These figures represent proportions of individuals who consume the respective alcoholic beverages in each population group. It appears that males are more likely to consume beer but less likely to consume wine and spirits than females. Higher proportions of married, divorced and widowed individuals consume wine than single individuals but lower proportions drink beer and spirits. In terms of main activity, relative to those individuals who are retired or stay at home (OTHERACT), all those who work have more chances of consuming beer, wine and spirits while all those who study or are unemployed have less chances of drinking wine but higher chances of consuming beer and spirits. It is interesting to see how educational attainment is related to the consumption of wine. It appears that the more highly educated individuals are, the

[1] Unfortunately the surveys prior to 1995 do not contain information on individuals' incomes, so we do not provide any estimates for the income effects.

more likely they are to consume wine. However, no such distinct relationship is observed for beer and spirits. The participation proportion among aboriginals or Torres Strait Islanders (ATSI) is lower than those of non-aboriginals for wine or spirits, but similar for beer. Also, it appears from the sample proportions that individuals residing in capital cities are more likely to consume wine and spirits but less likely to consume beer than those living in non-capital areas.

Table 2: Participation Rates by Population Groups - Sample Statistics

	WINE	BEER	SPIRITS
MALE	39.3	66.7	35.1
FEMALE	53.7	23.3	40.5
MARRIED	52.4	43.1	33.1
SINGLE	36.3	47.0	52.8
DIVORCED	50.8	39.3	35.8
WIDOWED	42.4	24.9	19.0
WORK	52.9	49.5	41.9
STUDY	31.8	39.6	48.7
UNEMPL	32.5	52.1	44.4
OTHERACT	45.4	31.8	27.3
DEGREE	70.8	44.6	36.0
DIPLOMA	48.4	50.2	39.4
YR12	47.7	44.1	48.3
YR10	41.6	37.2	39.5
LESSYR10	29.1	36.0	28.4
ATSI	37.9	42.1	31.9
NON-ATSI	48.2	42.9	38.8
CAPITAL	50.2	42.3	38.5
NON-CAPITAL	39.9	44.0	36.9

Source: NDSHS (2001)

Based on the sample data, the estimated joint and marginal probabilities of consuming the three alcoholic drinks are given in Table 3. Around 47 per cent of the surveyed individuals consume wine while slightly lower proportions of 42.8 per cent and 38.1 per cent consume beer and spirits respectively. A further 18.8 per cent have reported to consume none of these three alcoholic drinks. A decomposition of the marginal probabilities reveals the following: out of the total respondents 17.7 per cent drink wine only, 16 per cent drink beer only and a further 11.4 per cent consume spirits only. It appears that 9.5 per cent consume wine jointly with beer and 9.3 per cent drink it jointly with spirits. A further 6.6 per cent consume spirits and beer jointly while 10.8 per cent of the total respondents jointly drink all three alcoholic drinks.

Table 4 shows the conditional probabilities of participation, which also gives us an indication of the degree of interrelationship that exists between the consumption of wine, beer and spirits. For instance, while 47.2 per cent of the respondents from the general population drink wine, among the spirits drinking sub-population the probability of wine consumption is increased to 52.7 per cent. Nearly 46 per cent of spirits drinkers also drink beer, as compared to a 42.8 per cent probability of beer consumption among the general population.

Table 3: Joint and Marginal Participation Probabilities

	Joint Probab	Marginal (Wine)	Marginal (Beer)	Marginal (Spirits)
Wine only	17.7	17.7	-	-
Beer only	16.0	-	16.0	-
Spirits only	11.4	-	-	11.4
Wine and Beer only	9.5	9.5	9.5	-
Wine and Spirits only	9.3	9.3	-	9.3
Beer and Spirits only	6.6	-	6.6	6.6
Wine and Beer and Spirits	10.8	10.8	10.8	10.8
None	18.8	-	-	-
Total	100.0	47.2	42.8	38.1

Table 4: Conditional Participation Probabilities

	P(.)	$P(.\|Y_W = 1$	$P(.\|Y_B = 1$	$P(.\|Y_S = 1$
Wine	47.2	1	47.2	52.7
Beer	42.8	42.8	1	45.7
Spirits	38.1	42.5	40.6	1

3. A Trivariate Probit Model for Beer, Wine and Spirits

Assume that $\boldsymbol{(Y_B^*, Y_W^*, Y_S^*)'}$ is a vector of latent variables, with Y_j^* being proportional to the unobserved level of demand for alcoholic beverage *j* ($\boldsymbol{Y_j^*} \subseteq [-\infty, \infty]$, $\boldsymbol{j = B, W, S}$). The latent demand variables are linearly related to set of observed characteristics X_j as follows:

$$Y_j^* = \mathrm{X}'_j \beta_j + \varepsilon_j \qquad (j = W, B, S)\,, \qquad (1)$$

where β_j is a vector of parameters to be estimated and ε_j is a stochastic component that represents unobserved characteristics. The latent variable $\boldsymbol{Y_j^*}$ is related to the observed binary variable Y_j via:

$$Y_j = \begin{cases} 1 & \text{if } Y_j^* > 0 \\ 0 & \text{if } Y_j^* \le 0 \end{cases} \qquad (2)$$

where $\boldsymbol{Y_j = 1}$ if the individual consumes alcohol *j* and $\boldsymbol{Y_j = 0}$ otherwise.

Assume that the error terms in the three latent equations in (1) jointly follow a trivariate normal distribution; that is, $(\varepsilon_B, \varepsilon_W, \varepsilon_S)' \sim MVN(\underline{0}, \Sigma)$, where the variance-covariance matrix Σ is given by

$$\Sigma = \begin{pmatrix} 1 & \rho_{BW} & \rho_{BS} \\ \rho_{BW} & 1 & \rho_{WS} \\ \rho_{BS} & \rho_{WS} & 1 \end{pmatrix}, \qquad (3)$$

and ρ_{ij} is the correlation coefficient of ε_i and ε_j $(i, j = B, W, S;\ i \neq j)$. Under this assumption, equations (1) to (3) define a multivariate probit (MVP) model that jointly models the participation decisions for the three alcoholic drinks. The potentially non-zero off-diagonal elements in Σ allows for correlations across the three error terms in the three latent equations, which represent unobserved characteristics for the same individual. This allows for the knowledge on an individual's participation in one alcohol beverage to be used to predict his/her probability of participation in another alcoholic drink. Unit variances are assumed for the error terms for identification purpose. Note that, when $\rho_{ij} \equiv 0$, the MVP model defined above becomes three univariate probit (UVP) models where the three equations are estimated independently.

Given the trivariate probit defined in Equations (1) to (3), mathematical expressions for univariate marginal probabilities, as well as bivariate and trivariate joint and conditional probabilities, can be derived using cumulative distribution functions (*c.d.f.*) of univariate, bivariate and trivariate normal distributions[2]. For example, for $i, j, k = B,\ W,$ or S (in each equation, $i \neq j, i \neq k; j \neq k$),

$$P(Y_j = 1 \mid X_j) = \Phi_1(X_j'\beta_j),$$

$$P(Y_i = 1, Y_j = 0, Y_k = 0 \mid X_i, X_j, X_k) = \Phi_3(X_i'\beta_i, -X_j'\beta_j, -X_k'\beta_k; -\rho_{ij}, -\rho_{ik}, \rho_{jk}),$$

$$P(Y_i = 1 \mid Y_j = 1; X_i, X_j) = \frac{\Phi_2(X_i'\beta_i, X_j'\beta_j; \rho_{ij})}{\Phi_1(X_j'\beta_j)}, \text{ and}$$

$$P(Y_i = 1 \mid Y_j = 0, Y_k = 0; X_i, X_j, X_k) = \frac{\Phi_3(X_i'\beta_i, -X_j'\beta_j, -X_k'\beta_k;\ -\rho_{ij}, -\rho_{ik}, \rho_{jk})}{\Phi_2(-X_j'\beta_j, -X_k'\beta_k; \rho_{jk})},$$

where $\Phi_3(z_1, z_2, z_3; \gamma_{12}, \gamma_{13}, \gamma_{23})$ denotes the cumulative distribution function of standard trivariate normal distribution with γ_{st} as the correlation coefficient between two of the three univariate random elements Z_s and Z_t $(s, t = 1,2,3; s \neq t)$, and Φ_1 and Φ_2 relate to univariate and bivariate *c.d.f.*'s respectively and are defined similarly.

[2] See Ramful and Zhao (2006) for details.

Given an *i.i.d.* sample of *N* individuals and conditional on observed personal heterogeneity, the parameters β_j $(\boldsymbol{j = B, W, S})$ and correlation coefficients ρ_{ij} $(\boldsymbol{i, j = B, W, S; i \neq j})$ of the MVP model can be estimated using conditional maximum likelihood.

4. Results

Table 5 presents the estimated coefficients for the MVP model and the resulted marginal effects of explanatory factors on the probability of participation. Standard errors of all estimates are presented in the brackets. Note that the marginal effects (MEs) reported in the table correspond to those of univariate marginal probabilities, and they are evaluated at the sample means of all explanatory variables[3]. The ME for a continuous explanatory variable relates to the actual change in the unconditional probability of participation for a particular alcoholic beverage in response to a unit change in the explanatory variable, while for a dummy variable it represents the change in the probability when the dummy variable changes from 0 to 1.

We note first that the three estimated correlation coefficients in Table 5 are small in values but statistically highly significant. These correlation coefficients measure the relationship among the decisions of the three drinks for the same individual after the effects of observable factors in the explanatory variables have been accounted for. They embody correlation via unobservable personal characteristics such as tastes towards the three alcoholic beverages. The results suggest that there is definitely a small degree of correlation across the three drinks. The results are consistent with our *a priori* expectation that these three alcoholic beverages are quite heterogenous in characteristics such that the decision to consume any one of them is only slightly associated with the decision to consume the other two drinks, controlling for observable factors. The lowest correlation is estimated in the case of beer and spirits (0.058) while correlation coefficients of 0.111 and 0.169 are observed for wine-beer and wine-spirits. In a similar study that investigates the demand for cocaine, heroin and marijuana, Ramful and Zhao (2005) found that the error terms from the three participation equations induced fairly high correlation ranging between 0.6 and 0.8.

Price Effects

Next we look at the effects of prices on participation probabilities. The price coefficients in Table 5 show that demands for all three alcoholic drinks respond negatively to own prices. The marginal effects of own and cross prices are summarised in Table 6. For wine, we find that a 1 per cent increase in wine price decreases its probability of consumption by 0.0088, or 0.88 percentage points. As for cross price effects, we find that while the effect of beer price is statistically insignificant, that of spirits price is positive and statistically significant such that the participation probability of wine increases by 0.61 percentage points in response to a 1 per cent increase in the price of spirits. This suggests that wine and spirits are economic substitutes.

[3] Alternatively, we can compute the average MEs over all individuals in the sample. The differences between the two approaches in the results are trivial.

Table 5: Multivariate Probit Results

	Wine				Beer				Spirits			
	Coefficient		**ME**		**Coefficient**		**ME**		**Coefficient**		**ME**	
CONSTANT	-5.774	(1.313)**	-2.294	(0.681)**	-9.185	(1.339)**	-3.581	(0.945)**	-1.500	(1.318)	-0.563	(0.426)
PRW	-2.201	(0.262)**	-0.875	(0.235)**	0.462	(0.267)*	0.180	(0.093)*	0.649	(0.266)**	0.244	(0.109)**
PRB	0.283	(0.268)	0.113	(0.091)	-1.040	(0.269)**	-0.406	(0.130)**	0.036	(0.265)	0.014	(0.082)
PRS	1.541	(0.228)**	0.612	(0.171)**	0.699	(0.229)**	0.273	(0.099)**	-0.735	(0.227)**	-0.276	(0.104)**
AGE	2.920	(0.285)**	1.160	(0.288)**	4.509	(0.289)**	1.758	(0.424)**	1.516	(0.282)**	0.569	(0.156)**
AGESQ	-0.340	(0.039)**	-0.135	(0.035)**	-0.652	(0.040)**	-0.254	(0.060)**	-0.333	(0.039)**	-0.125	(0.034)**
MALE	-0.475	(0.014)**	-0.189	(0.051)**	1.194	(0.014)**	0.465	(0.116)**	-0.159	(0.014)**	-0.060	(0.026)**
MARRIED	0.166	(0.020)**	0.066	(0.024)**	-0.091	(0.020)**	-0.036	(0.017)**	-0.217	(0.020)**	-0.081	(0.026)**
DIVORCED	0.072	(0.027)**	0.029	(0.018)	-0.111	(0.028)**	-0.043	(0.017)**	-0.127	(0.027)**	-0.048	(0.019)**
WIDOW	-0.038	(0.037)	-0.015	(0.084)	-0.064	(0.039)	-0.025	(0.082)	-0.167	(0.039)**	-0.063	(0.089)
WORK	0.212	(0.017)**	0.084	(0.025)**	0.073	(0.018)**	0.029	(0.014)*	0.051	(0.018)**	0.019	(0.014)
STUDY	0.236	(0.030)**	0.094	(0.024)**	-0.028	(0.029)	-0.011	(0.005)**	-0.232	(0.029)**	-0.087	(0.024)**
UNEMP	-0.005	(0.037)	-0.002	(0.006)	0.040	(0.036)	0.016	(0.007)**	0.026	(0.036)	0.010	(0.007)
#DEPCHIL	-0.015	(0.002)**	-0.006	(0.009)	-0.034	(0.007)**	-0.013	(0.009)	-0.046	(0.007)**	-0.017	(0.009)*
ATSI	-0.336	(0.051)**	-0.134	(0.035)**	0.009	(0.049)	0.003	(0.013)	-0.055	(0.051)	-0.021	(0.014)
DEGREE	0.909	(0.023)**	0.361	(0.090)**	0.025	(0.023)	0.010	(0.006)	0.030	(0.023)	0.011	(0.006)*
DILPLOMA	0.405	(0.021)**	0.161	(0.041)**	0.096	(0.021)**	0.038	(0.013)**	0.222	(0.021)**	0.084	(0.025)**
YR12QUAL	0.459	(0.023)**	0.182	(0.046)**	0.076	(0.023)**	0.030	(0.014)**	0.285	(0.023)**	0.107	(0.032)**
YR10QUAL	0.216	(0.022)**	0.086	(0.022)**	0.005	(0.022)	0.002	(0.005)	0.195	(0.022)**	0.073	(0.021)**
CAPITAL	0.208	(0.014)**	0.083	(0.026)**	-0.114	(0.015)**	-0.044	(0.019)**	0.001	(0.015)	0.000	(0.017)
YR93	0.196	(0.051)**	0.078	(0.021)**	0.032	(0.050)	0.012	(0.008)	-0.236	(0.052)**	-0.089	(0.025)**
YR95	0.873	(0.071)**	0.347	(0.086)**	0.289	(0.068)**	0.113	(0.028)**	0.340	(0.071)**	0.128	(0.036)**
YR98	0.950	(0.054)**	0.377	(0.094)**	0.401	(0.053)**	0.156	(0.039)**	0.476	(0.054)**	0.179	(0.050)**
YR01	0.818	(0.053)**	0.325	(0.081)**	0.404	(0.052)**	0.157	(0.039)**	0.673	(0.053)**	0.253	(0.070)**
ρ_{WB}	0.111	(0.009)**										
ρ_{WS}	0.169	(0.009)**										
ρ_{BS}	0.058	(0.009)**										

Standard errors are given in parentheses. * indicates significance at 10% level. **indicates significance at 5% level.

From the beer equation, we find that a one per cent increase in its own price results in a decline of 0.41 percentage points in its probability of consumption. The cross price effects show that both wine and spirits are economic substitutes for beer although the marginal effect of wine price is statistically significant only at the 10% level; the probability of beer consumption increases by 0.18 percentage points from a one per cent rise in the price of wine and by 0.27 percentage points to a one per cent rise in the price of spirits. Lastly, from the spirits equation, we find that a one per cent increase in spirits price is likely to decrease its participation probability by 0.28 percentage points. From the cross price effects, we again find that spirits and wine are substitutes for one another where the participation probability of spirits increases by 0.24 percentage points to a one per cent rise in the price of wine. However, in contrast to the finding in the beer equation, the price of beer does not seem to have a significant effect on the participation probability of spirits.

Table 6: Marginal Effects and Participation Elasticities

	Wine		Beer		Spirits	
	ME	**SE**	**ME**	**SE**	**ME**	**SE**
Marginal Effects:						
PRW	**-0.875**	(0.235)**	0.180	(0.093)*	0.244	(0.109)**
PRB	0.113	(0.091)	**-0.406**	(0.130)**	0.014	(0.082)
PRS	0.612	(0.171)**	0.273	(0.099)**	**-0.276**	(0.104)**
Participation Elasticities:						
PRW	-1.853	(0.498)**	0.421	(0.217)*	0.640	(0.286)**
PRB	0.238	(0.193)	-0.948	(0.304)**	0.036	(0.215)
PRS	1.297	(0.362)**	0.637	(0.231)**	-0.725	(0.273)**

Standard errors are given in parentheses. * indicates significance at 10% level. **indicates significance at 5% level.

In the lower panel of Table 6, marginal effects are converted to participation elastcities, or the relative changes in participation parobabilities. For example, the own price elasticities of participation for wine, beer and spirits are estimated at –1.85, –0.95 and –0.73 respectively. This seems to indicate that participation in wine consumption is highly responsive to its own price. Note though the values of these price elasticities of participation cannot be directly compared to the price elasticities of demand. Note also that in the wine equation the cross price elasticity of wine and spirits is estimated at 1.3, while in the spirits equation a lower cross elasticity of 0.6 is obtained. This indicates some degree of asymmetry in substitution between wine and spirits (see Petry 2001). The cross price elasticity between beer and spirits is significant only in the beer equation and is estimated at 0.6 while wine and beer seem to have a cross price elasticity of about 0.4.

Socioeconomic and Demographic Factors

Start with the effect of age for the three drinks. The inclusion of both a linear and a quadratic term in the analysis allows for a more flexible age profile for participation. Both terms are significant for all three equations. The effects of age on consumption are illustrated in Figure 3 by the predicted participation probabilities for different ages, evaluated at the sample means of all explanatory variables. As expected, it appears that the probability of wine consumption increases with age although at a decreasing rate. An "average" person aged 40 or more has at least 50 per cent chances of participation in wine as compared to a teenager of 15 whose probability of consumption is only around 23 per cent. The participation probability of beer shows an interesting inverted U-shaped age profile. People between 30 to 35 years of age are most likely to consumer beer, while the probability declines sharply for younger people and declines slowly when older than 35 years. Opposite to wine, the age effect on spirits participation is almost linear with the highest probability of participation among teenagers. This is the result of the popularity of pre-mixed drink among young people.

Figure 3: Effect of Age on Predicted Participation Probabilities

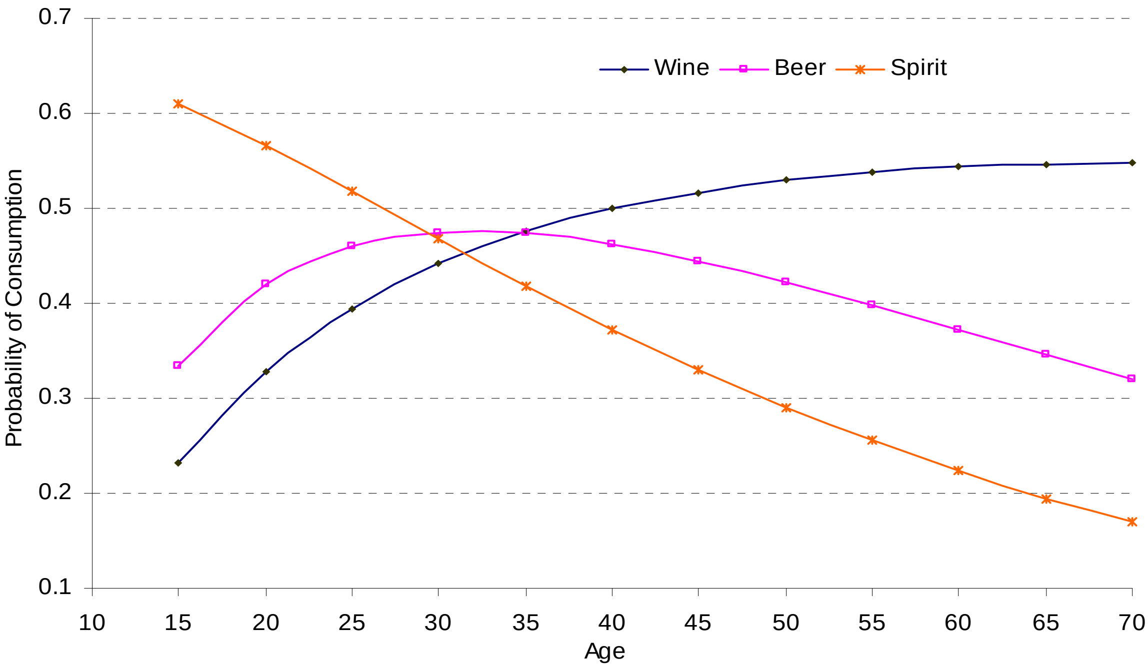
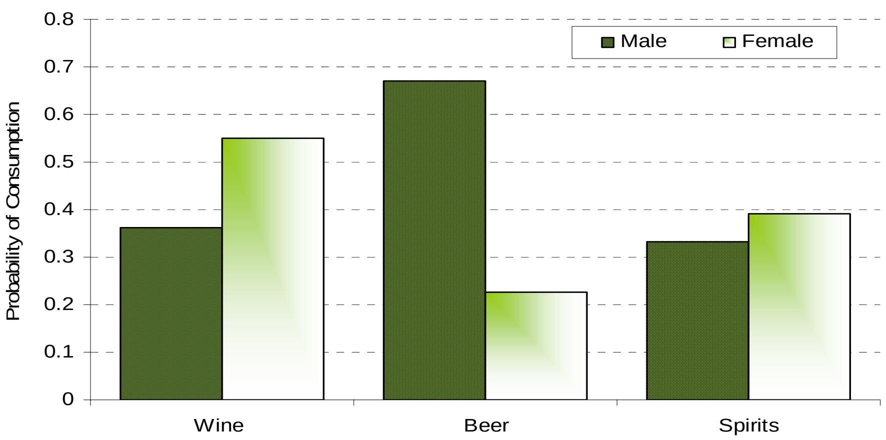


Figure 4: Predicted Participation Probabilities - By Gender



In terms of gender, while males are more likely to consume beer, females have greater probability of consuming wine and spirits (Figure 4), other factors controlled. The marginal effects show that males are 46 per cent more likely to consume beer than females but 19 and 6 per cent less likely to participate in wine and spirits consumption respectively. Married individuals are more likely to consume wine but have lower chances of consuming beer and spirits than single individuals. Divorcees as well are less likely to consume beer and spirits than single individuals (Figure 5). The higher the number of dependent children in the house the lower is the probability of participation in any of these three alcoholic beverages. Aboriginals/ Torres Strait Islanders (ATSI) are 13 per cent less likely to consume wine than non-ATSI. However, there seems to be no significant difference between these two groups in the prevalence of beer and spirits consumption. People living in capital cities have 8 per cent higher probability of consuming wine but 4 per cent less chances of participating in beer consumption than those living in other regions. However, no significant difference is observed for spirits consumers.

Figure 5: Predicted Participation Probabilities – By Marital Status

Figure 6 shows the effects of main activity. When other factors are controlled at sample means, people who work and study are more likely to drink wine and people who mainly study are least likely to drink spirits. It is interesting to compare the observed sample probabilities by main activity in Table 4 and the predicted probabilities in Figure 6 when other factors are controlled. For example, while we observe the lowest wine participation rate in the sample for people who study, once all other factors including age are being equal, the marginal effect of "Study" is actually positive and the highest. On the other hand, while students are observed to have the highest spirits participation in the sample statistics is Table 4, once age and other factors are controlled, the fact that one's main activity is studying will in fact predict the lowest probability for spirits participation in contrary to the sample observation. Main activity does not seem to matter that much for beer consumption once other factors are controlled, even the sample observation shows significant disparity by main activity.

Turning to the marginal effects of education in Table 5, the results for wine indicate that relative to the reference category of those who did not complete year 10, all other higher educated groups are more likely to consume wine. For instance, relative to individuals with less than year 10 qualification, degree holders are 36 per cent more likely, diploma or year-12 qualifications are about 16 to 18 per cent more likely, and year-10 qualification are 9 per cent more likely to consume wine. For beer, those who have qualifications of a diploma or year-12 are about 3 to 4 per cent more likely to consume beer than individuals with less than year-10 education. However, there does not seem to be significant difference in the prevalence of beer consumption between those who have less than year-10 qualifications and the other educational categories. The absence of significant education effects for beer is in contrast to wine for which education is highly relevant. Finally, for spirits, the education profile shows an inverted U-shaped relationship. The predicted participation probabilities are shown in Figure 7. Again, it is revealing to compare the sample observation of participation rates by education and the marginal effects of education in Table 5 and Figure 7 where other factors such as income are controlled.

Figure 6: Predicted Participation Probabilities – By Main Activity

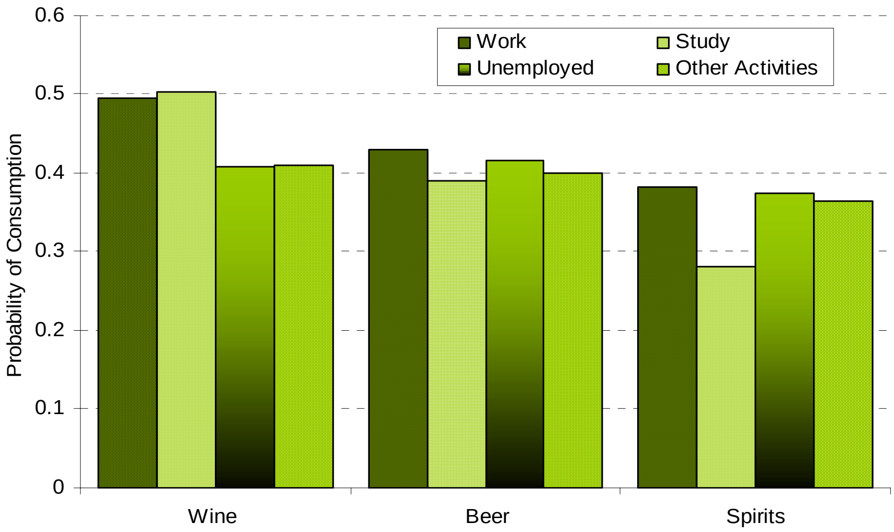
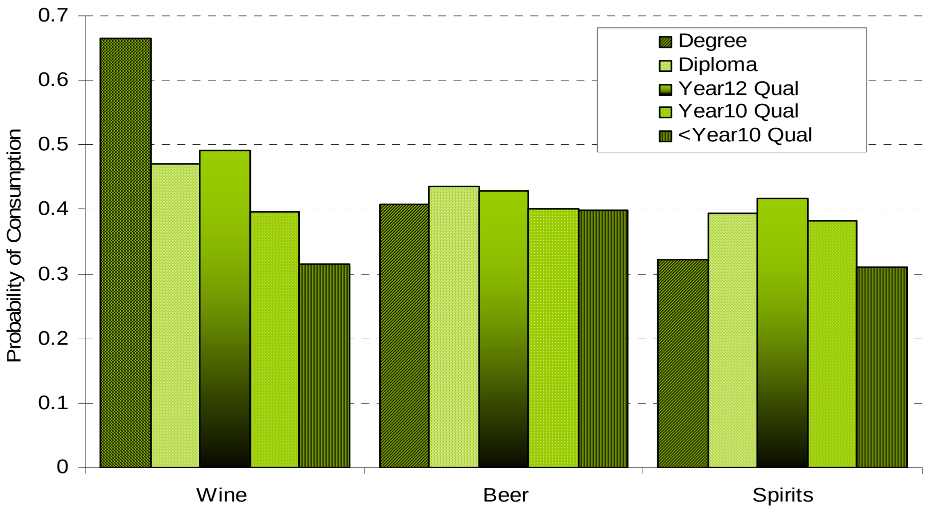


Figure 7: Participation Probabilities- Educational Attainment



Finally, the marginal effects of the year dummies seem to indicate that the participation in wine increased significantly from the 1991 level. For instance, in 2001, individuals were 32 per cent more likely to consume wine than in 1991, controlling for other explanatory factors. This seems to be in line with the observed proportions set out in Table 1. Participation in beer consumption shows no significant increase in 1993 as compared to 1991 but it picked up in the subsequent years. In 2001, individuals were 16 per cent more likely to consume beer than in 1991. The prevalence of spirits consumption declined in 1993 but started to increase in the later years such that in 2001 individuals were 25 per cent more likely to consume spirits than in 1991.

Conditional and Joint Probabilities

In addition to marginal probabilities of participation for individual alcohol types, the multivariate model also allows us to estimate joint and conditional probabilities using information on cross commodity correlation via the unobservable characteristics. Such information is not available in a univariate approach assuming zero correlation across the error terms. For example, in the case of a high correlation coefficient, information on participation in one drink could significantly alter the predicted probability of participation in another drink, and hence the conditional and unconditional probabilities could be significantly different. Although the estimated ρ's in our application are small, they still provide extra information for a better prediction of multivariate probabilities.

Table 7: Predicted Probabilities

	Wine			**Beer**	
	MVP	**UVP**		**MVP**	**UVP**
$P(Y_W = 1 \mid \bar{X})$	0.4642 (0.2600)	0.4641 (0.2544)	$P(Y_B = 1 \mid \bar{X})$	0.4150 (0.2527)	0.4148 (0.2534)
$P(Y_W = 1 \mid Y_B = 0, Y_S = 0, \bar{X})$	0.4125 (0.2627)	0.4641 (0.2544)	$P(Y_B = 1 \mid Y_W = 0, Y_S = 0, \bar{X})$	0.3972 (0.2391)	0.4148 (0.2534)
$P(Y_W = 1 \mid Y_B = 1, Y_S = 1, \bar{X})$	0.5716 (0.2674)	0.4641 (0.2544)	$P(Y_B = 1 \mid Y_W = 1, Y_S = 1, \bar{X})$	0.4696 (0.2382)	0.4148 (0.2534)
$P(Y_W = 1 \mid Y_B = 1, \bar{X})$	0.5059 (0.2574)	0.4641 (0.2544)	$P(Y_B = 1 \mid Y_W = 1, \bar{X})$	0.4523 (0.2491)	0.4148 (0.2534)
$P(Y_W = 1 \mid Y_S = 1, \bar{X})$	0.5338 (0.2515)	0.4641 (0.2544)	$P(Y_B = 1 \mid Y_S = 1, \bar{X})$	0.4385 (0.2500)	0.4148 (0.2534)
	Spirits			**Joint**	
	MVP	**UVP**		**MVP**	**UVP**
$P(Y_S = 1 \mid \bar{X})$	0.3638 (0.2488)	0.3632 (0.2452)	$P(Y_W = 1, Y_B = 1, Y_S = 1 \mid \bar{X})$	0.0912 (0.1393)	0.0699 (0.0884)
$P(Y_S = 1 \mid Y_W = 0, Y_B = 0, \bar{X})$	0.3061 (0.2469)	0.3632 (0.2452)	$P(Y_W = 0, Y_B = 0, Y_S = 0 \mid \bar{X})$	0.2295 (0.2055)	0.1997 (0.1636)
$P(Y_S = 1 \mid Y_W = 1, Y_B = 1, \bar{X})$	0.4344 (0.2498)	0.3632 (0.2452)	$P(Y_W = 1, Y_B = 0, Y_S = 0 \mid \bar{X})$	0.1570 (0.1917)	0.1729 (0.1102)
$P(Y_S = 1 \mid Y_W = 1, \bar{X})$	0.4184 (0.2511)	0.3632 (0.2452)	$P(Y_W = 0, Y_B = 1, Y_S = 0 \mid \bar{X})$	0.1454 (0.1752)	0.1416 (0.1367)
$P(Y_S = 1 \mid Y_B = 1, \bar{X})$	0.3844 (0.2509)	0.3632 (0.2452)	$P(Y_W = 0, Y_B = 0, Y_S = 1 \mid \bar{X})$	0.1013 (0.1734)	0.1139 (0.1205)

Table 7 presents some predicted joint, conditional and marginal probabilities for an individual with mean values of all explanatory variables, using both the multivariate probit (MVP) and univariate probit (UVP) models. For example, the probability of wine consumption for an "average" individual in the general population is predicted 46.4 per cent. However, if we already know that he/she is participating in both beer and spirits consumption, the predicted probability of wine consumption for the person is increased to 57.2 per cent using a MVP model. A UVP model would predict the same probability as if the extra information is not available. Also, the joint probability of an average individual consuming all three beverages is predicted 9.1 per cent with a MVP, while it would be 7.0 per cent using a UVP.

Table 8: Marginal Effects of Joint and Conditional Probabilities

	P(W=1,B=1,S=1)		P(W=1|B=0,S=0)		P(W=1|B=1,S=1)		P(W=1,B=1|S=1)		P(W=1)	
	ME	**SE**	**ME**	**SE**	**ME**	**SE**	**ME**	**SE**	**ME**	**SE**
CONSTANT	-1.205	(0.897)	-1.786	(0.729)**	-1.972	(0.740)**	-2.923	(1.053)**	-2.294	(0.685)**
PRW	-0.050	(0.116)	-0.849	(0.251)**	-0.919	(0.250)**	-0.305	(0.210)	-0.875	(0.228)**
PRB	-0.060	(0.077)	0.126	(0.092)	0.140	(0.100)	-0.174	(0.121)	0.113	(0.092)
PRS	0.091	(0.108)	0.586	(0.178)**	0.627	(0.173)**	0.440	(0.174)**	0.612	(0.164)**
AGE	0.662	(0.468)	0.862	(0.300)**	0.966	(0.272)**	1.427	(0.501)**	1.160	(0.278)**
AGESQ	-0.100	(0.063)	-0.088	(0.035)**	-0.102	(0.039)**	-0.189	(0.063)**	-0.135	(0.034)**
MALE	0.049	(0.073)	-0.192	(0.065)**	-0.215	(0.068)**	0.176	(0.119)	-0.189	(0.050)**
MARRIED	-0.015	(0.016)	0.075	(0.027)**	0.079	(0.028)**	0.016	(0.022)	0.066	(0.023)**
DIVORCED	-0.015	(0.012)	0.037	(0.019)*	0.038	(0.021)*	-0.007	(0.017)	0.029	(0.017)*
WIDOW	-0.021	(0.048)	-0.002	(0.083)	-0.006	(0.089)	-0.015	(0.070)	-0.015	(0.084)
WORK	0.023	(0.019)	0.072	(0.025)**	0.080	(0.023)**	0.051	(0.024)**	0.084	(0.024)**
STUDY	-0.007	(0.016)	0.100	(0.027)**	0.105	(0.028)**	0.042	(0.022)*	0.094	(0.023)**
UNEMP	0.005	(0.005)	-0.004	(0.007)	-0.004	(0.007)	0.007	(0.007)	-0.002	(0.007)
#DEPCHIL	-0.007	(0.007)	-0.002	(0.009)	-0.003	(0.010)	-0.009	(0.008)	-0.006	(0.009)
ATSI	-0.025	(0.022)	-0.119	(0.036)**	-0.132	(0.035)**	-0.055	(0.031)*	-0.134	(0.034)**
DEGREE	0.062	(0.054)	0.328	(0.094)**	0.360	(0.089)**	0.163	(0.080)**	0.361	(0.087)**
DIPLOMA	0.052	(0.037)	0.131	(0.042)**	0.148	(0.039)**	0.085	(0.036)**	0.161	(0.039)**
YR12QUAL	0.059	(0.043)	0.148	(0.047)**	0.167	(0.044)**	0.088	(0.041)**	0.182	(0.045)**
YR10QUAL	0.030	(0.022)	0.067	(0.022)**	0.077	(0.020)**	0.033	(0.018)*	0.086	(0.021)**
CAPITAL	0.004	(0.014)	0.078	(0.028)**	0.086	(0.028)**	0.012	(0.024)	0.083	(0.026)**
YR93	-0.005	(0.015)	0.084	(0.023)**	0.088	(0.024)**	0.048	(0.021)**	0.078	(0.020)**
YR95	0.106	(0.077)	0.290	(0.088)**	0.324	(0.081)**	0.204	(0.081)**	0.347	(0.083)**
YR98	0.131	(0.093)	0.307	(0.095)**	0.345	(0.087)**	0.237	(0.091)**	0.377	(0.091)**
YR01	0.139	(0.097)	0.247	(0.082)**	0.284	(0.074)**	0.209	(0.079)**	0.325	(0.078)**

Standard errors are given in parentheses. * indicates significance at 10% level. **indicates significance at 5% level.

Information on the marginal effects of individual explanatory factors on different conditional and joint probabilities is also very important for targeting alcohol related educational programs for sub-population groups. To illustrate, Table 8 shows the estimated marginal effects on a few joint and conditional probabilities relating to wine consumption, as compared to the marginal effects on the *unconditional* probability of wine consumption. The results provide some interesting insights. For instance, referring to variable "MARRIED", while married people are 6.6 per cent more likely to consume wine than the singles in the general population, among the subpopulation of drinkers of both beer and spirits, married people are 7.9 per cent more likely to drink wine. On the other hand, being married does not make any significant difference to the probability of an individual consuming all three drinks. Conditional on consuming neither beer nor spirits, degree holders are 32.8 per cent more likely to drink wine than those with less than year-10 qualifications but have 36.1 per cent more chances to do so among the general population. People living in capital cities have 8.3 per cent more chances of drinking wine in general, but there is little difference between people in capital cities and otherwise in terms of the probability of consuming all three drinks.

Finally, we note that the joint and conditional probabilities are highly non-linear functions of both parameters and X variables, and analytical expressions of marginal effects and standard errors are cumbersome. The marginal effects presented in Tables 5 to 8 are calculated using numerical gradients. The standard errors of these marginal effects are asymptotically simulated.

5. Conclusions and Limitations

Alcohol is a heterogeneous product. We have shown in this paper that there are some significant differences in individuals' decisions of participation in the three alcoholic beverages of beer, wine and spirits. We have used unit-record data pooled from five nationally representative surveys from Australia between 1991 and 2001 to study the relationship between socioeconomic and demographic factors and individuals' participation in the consumption of each of the three alcoholic beverages. Prior studies that considered demand for separate alcoholic commodities have mostly used aggregated data. Our results show that the three alcohol products relate to rather different population groups in the society. We also find that there is evidence of an alarming proportion of young females participating in spirits consumption due to the increasing popularity of pre-mixed sweet drinks. All three alcoholic beverages are shown to respond negatively to their own prices in participation, with wine having the highest own price participation elasticity and spirits the lowest.

An innovation in our model is that we have allowed for the disturbance terms across the three demand equations to be correlated by estimating a multivariate probit model. This allows for the decisions of consumption of beer, wine and spirits to be correlated for the same individual via unobservable characteristics such as personal taste. In contrast to a previous study that estimated very high levels of correlations across some recreational drugs (Ramful and Zhao, 2006), our estimated error term correlations are not very high. This seems to confirm the notion that beer, wine and spirits are rather heterogenous products so the correlation via unobservable person traits is not high. The paper illustrated how the multivariate approach can help with predicting joint and conditional probabilities that are unavailable from conventional univariate approach.

Alcohol consumption plays an important role in many aspects of a society, and alcohol related policies are an important public health issue. The heterogeneity identified across the three alcoholic beverages in this paper provides useful information for better targeted alcohol education programs. The multivariate approach also provides cross-commodity information so that economic policies and educational campaigns can be considered in a multi-product context to better target sub-populations.

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APPENDIX

Table A.1 Definition of Variables

WINE = 1 if currently consuming wine, 0 otherwise

BEER = 1 if currently consuming beer, 0 otherwise

SPIRITS = 1 if currently consuming spirits, 0 otherwise

PRW =Logarithm of real price index of wine

PRB = Logarithm of real price index of beer

PRS = Logarithm of real price index of spirits

YR91 = 1 for year 1991, 0 otherwise (used as the reference category)

YR93 = 1 for year 1993, 0 otherwise

YR95 = 1 for year 1995, 0 otherwise

YR98 = 1 for year 1998, 0 otherwise

YR01 =1 for year 2001, 0 otherwise

CAPITAL = If the respondent lives in a capital city, 0 otherwise

AGE = Logarithm of age of respondent

AGESQ = Square of AGE variable

MALE = 1 if male, 0 for female

MARRIED = 1 if married or de facto, 0 otherwise

DIVORCED = 1 if divorced, 0 otherwise

WIDOW = 1 if widowed, 0 otherwise

NEVMAR = 1 if never married, 0 otherwise (used as the reference category)

WORK = 1 if working part-time or full-time, 0 otherwise

STUDY = 1 if studying, 0 otherwise

UNEMP = 1 if unemployed, 0 otherwise

HOME = 1 if retired, on pension or performing home duties, 0 otherwise (used as the reference category)

ATSI = 1 if respondent is of Aboriginal or Torres Strait Islander origin, 0 otherwise

DEPCHIL = # of dependent children aged 14 or below in the household

DEGREE = 1 if highest qualification is a tertiary degree, 0 otherwise

DIPLOMA = 1 if highest qualification is a non-tertiary diploma, 0 otherwise

YR12QUAL = if highest qualification is year 12, 0 otherwise

YR10QUAL = if highest qualification is year 10, 0 otherwise

LESSYR10 = if respondent has no qualification, is still at school or highest qualification is less than year 10, 0 otherwise (used as the reference category)

Table A.2: Summary Statistics of Variables

		Mean	Standard Deviation	Minimum	Maximum	Cases
Participation Variables:						
Wine		0.472	0.499	0	1	45975
Beer		0.428	0.495	0	1	45975
Spirits		0.381	0.486	0	1	45975
Price Variables:						
PRW	Log of real wine price	4.647	0.044	4.54	4.75	47281
PRB	Log of real beer price	4.710	0.045	4.62	4.78	47281
PRS	Log of real spirits price	4.709	0.048	4.62	4.79	47281
Time Variables:						
YR91	Year 1991	0.060	0.238	0	1	47284
YR93	Year 1993	0.074	0.262	0	1	47284
YR95	Year 1995	0.081	0.273	0	1	47284
YR98	Year 1998	0.219	0.413	0	1	47284
YR01	Year 2001	0.566	0.496	0	1	47284
Demographic Variables:						
AGE	Log of age	3.641	0.450	2.64	4.58	47280
AGESQ	AGE squared	13.46	3.219	6.96	21.02	47280
MALE	Male	0.448	0.497	0	1	47284
MARRIED	Married	0.569	0.495	0	1	47046
DIVORCED	Divorced	0.101	0.301	0	1	47046
WIDOW	Widowed	0.056	0.231	0	1	47046
NEVMAR	Never married	0.274	0.446	0	1	47046
WORK	Work	0.519	0.500	0	1	46423
STUDY	Study	0.115	0.319	0	1	46423
UNEMP	Unemployed	0.039	0.193	0	1	46423
HOME	Home	0.327	0.469	0	1	46423
#DEPCHIL	#dependent children	0.620	1.172	0	136	45850
ATSI	ATSI	0.095	0.293	0	1	46941
CAPITAL	Capital	0.706	0.455	0	1	47284
DEGREE	Degree	0.191	0.393	0	1	47081
DIPLOMA	Diploma	0.264	0.441	0	1	47081
YR12QUAL	Year-12 qualification	0.150	0.357	0	1	47081
YR10QUAL	Year-10 qualification	0.189	0.391	0	1	47081
LESSYR10	Less than year-10	0.144	0.351	0	1	47081