Marijuana and Related Drug Consumption in Australia - Some Microeconometrics Evidence*

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ABSTRACT

This paper presents some econometric analysis on Australian individuals' consumption of marijuana and related drugs using unit record data from the National Drug Strategy Household Survey. We investigate the effects of individual socioeconomic and demographic factors and drug prices on participation probability and levels of marijuana consumption. We use multivariate probit models to study the relationship of marijuana participation with related legal drugs tobacco and alcohol and illegal drugs heroin and cocaine, accounting for effects of both observable and unobservable personal characteristics on multi-drug consumption. An endogenous switching probit model is used to estimate the effect of marijuana decriminalisation on participation, which allows for potential endogeneity of decriminalisation and flexibility in behaviour. The estimated effect is compared with results from its three nested models (probit, endogenous bivariate probit and two-part switching models) and propensity score matching method.

Keywords: marijuana consumption, illicit drugs, multivariate probit, endogenous switching models.

JEL Classification: C3, D1, I1.

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1. INTRODUCTION

The use of illicit drugs is widespread around the globe. Excessive and chronic use of psychoactive drugs not only affects the users, with research evidence linking to psychiatric illnesses amongst other harms, but also imposes significant costs on the society through its impacts on health, criminal justice and social welfare systems.

Marijuana is commonly considered a soft drug among illicit drugs. However, it has remained the most widely produced, trafficked and consumed illicit drug worldwide (UNODC, 2003). According to the 2004 Australian National Drug Strategy Household Survey (NDSHS 2004), one in three Australians aged fourteen or above had consumed marijuana at some stage of their lives, and 11% reported marijuana uses in the previous 12 months. Clements and Daryal (2005) estimated that the size of the marijuana market in Australia is something like twice of that for wine. The popularity of marijuana, the size of the underground economy, its unique tax-free status, the on-going debates surrounding the government policies regarding decriminalization or legalization, and the notion of gateway effects of marijuana leading to consumption of harder drugs for the young have all make micro level research on marijuana consumption worthwhile.

There is an existing body of economic literature investigating the determinants of illicit drug consumption. Demand for drugs has been considered the result of consumer utility maximisation under budget constraint and is related empirically to drug prices, income, as well as personal socioeconomic and demographic characteristics to account for taste heterogeneity (for example, Sickels and Taubman 1991; Grossman and Chaloupka 1998; Saffer and Chaloupka 1999). A theory of rational addiction has also been proposed formulating the consumer behaviour of addictive good consumption (Becker and Murphy 1988), but scarcity in inter-temporal consumption data often restricts the empirical application of the model.

Empirical studies have found significant effects of observable socioeconomic and demographic characteristics on marijuana consumption. The lack of reliable price data often hinders empirical estimation of price responsiveness. Price elasticities are often reported in terms of participation due lack of data on quantities of consumption, and results vary widely across studies (see for example

Saffer and Chaloupka 1999; Cameron and Williams 2001; Farrelly, et al. 2001; Zhao and Harris 2004). Marijuana, being the most popular illicit drug, has attracted the most attention in empirical studies and much has also been studied on its relationships with drug policies (Pacula 1998a; DiNardo and Lemieux 2001). In Australia, using data from the NDSHS, several studies have investigated the consumption of marijuana (Cameron and Williams 2001; Williams 2004; Zhao and Harris 2004).

Anecdotal observation suggests that marijuana is closely related to other legal drugs such as tobacco and alcohol as well as illegal drugs such as heroin and cocaine. For example, marijuana is frequently mixed with tobacco to smoke. Other drugs may also serve similar needs as marijuana in the consumers' minds. As a result, consumption of marijuana needs to be studied in conjunction with the consumption of other drugs to allow for the effects of both observable and unobservable individual characteristics in the study of joint consumption. The economic relationships across different drugs have been studied via cross price responses (Cameron and Williams 2001; Zhao and Harris 2004). Additionally, much of the discussion has also focused on the gateway effect between soft and hard drugs (e.g. Pacula 1998b). It has been postulated that the use of softer drugs may provide a gateway to the use of harder drugs, due to psychological or physiological needs, exposure to harder drug dealers, or misinformation on the harms of harder drugs (Pudney 2003). Empirical evidence has unambiguously pointed out that an individual using one illicit drug is more likely to be also using other illicit drugs. However, it is very difficult to disentangle the empirically observed correlation into the effects of observable and unobservable individual characteristics and causality of gateway effect controlling for individual heterogeneity. The gateway effect is particularly difficult to estimate without longitudinal data on the dynamic information of the onset and progression of consumption of various drugs. When such information is available, there is evidence that the apparently strong gateway effects are mostly due to joint effects of unobservable personal characteristics on the uses of all illicit drugs rather than causality (Pudney 2003; van Ours 2003).

This paper summarises some empirical studies the authors have conducted in the past few years on Australian individuals' consumption of marijuana and related drugs, using modern econometric techniques and unit-record data from the Australian National Drug Strategy Household Surveys

(NDSHS 2004). The NDSHS dataset is described and consumption trends over time are presented in the next section. Socioeconomic and demographic characteristics of marijuana users are presented in section 3 and effects of these personal characteristics and drug prices on the probability of marijuana participation are estimated using a probit model. In section 4, the relationships of marijuana participation with consumption of legal drugs tobacco and alcohol and illegal drugs cocaine and heroin are analysed using two sets of trivariate probit models, allowing both observable and significant unobservable individual characteristics to be accounted for in the joint analysis of multiple drug consumption. In section 5, we move our focus from participation decision to differentiating heavy and occasional users, looking at factors relating to the probabilities of different levels of marijuana consumption. The effect of marijuana decriminalization on participation is the focus of section 6, where estimates from several alternative econometric modelling approaches are presented and compared. Some concluding discussion is presented in the final section.

2. DATA DESCRIPTION AND DRUG CONSUMPTION TRENDS

The most comprehensive data source for Australian individuals' consumption of recreational drugs is the National Drug Strategy Household Surveys (NDSHS). They are nationally representative surveys of the non-institutionalised civilian population aged 14 and above in Australian households. The surveys collect information on individuals' knowledge, attitudes and behaviour in relation to drugs. NDSHS has been conducted eight times since 1985, with the latest survey being in 2004.

Households were selected by a multi-stage, stratified area sample design in order to provide a random sample of households within each geographical stratum. Once a household was contacted, the respondent selected was the person with the next birthday. While the earlier surveys covered a few thousand individuals each time, almost 30,000 people were involved in each of the 2001 and 2004 surveys. The questionnaire has also become more and more comprehensive over the years, with many more questions added to more recent surveys. More rigorous measures have also been put in place in the more recent surveys to ensure confidentiality

and to reduce under reporting. In the last two surveys in 2001 and 2004, the self-completed "drop-and-collect" method and the computer-assisted telephone interview method were utilised.

According to the most recent NDSHS conducted in 2004 (AIHW 2005), 11.3% of the respondents have used marijuana at least once in the past 12 months. The average age at which the Australians first used marijuana is 18.7 years old. Around one-fifth (20.6%) of the population said they were offered or had the opportunity to use marijuana in the preceding 12 months of the survey. This availability measure is lower than the 24.2% in the 2001 survey. Support for the legalisation of marijuana has decreased, with 27.0% of the population (or 30% of males and 24% of females) in 2004 compared to 29.1% in 2001. Interestingly, support for tougher penalties for the sale or supply of marijuana has also decreased slightly from 61.1% in 2001 to 58.2% in 2004.

Table 1 lists the participation rates for marijuana for the five surveys since 1993, in comparison with the prevalence of several other legal and illegal drugs for the same period. As can be seen in the first row of Table 1, about one-third of the population said they have tried or used marijuana at some time of their life, and this percentage has fluctuated only slightly in the past ten years. The figures in the second row indicate the prevalence of recent/current usage of marijuana. The percentage of Australians who used marijuana in the preceding 12 months has shown a decline to below 12% of the population for the first time in 2004 from all previous surveys in the past decade.

Frequently considered a soft drug, marijuana is the most commonly used substance among illicit drugs. As can be seen in Table 1, participation rates for other illicit drugs are much lower. Non-medical uses of speed (meth/amphetamine) and ecstasy (“designer drugs”) are the next popular, with recent participation rates on the rise during the past decade. Over 3% of the Australians 14 years of age or older have used either speed or ecstasy in the past 12 months in 2004. The prevalence rates of heroin and cocaine have shown a decline after the 1998 survey. This may in part be due to the “heroin drought” experienced in Australia since late 2000, resulting from a shortage in world supply relating to opium production in Afghanistan and the crackdowns of several major trafficking groups supplying Australia.

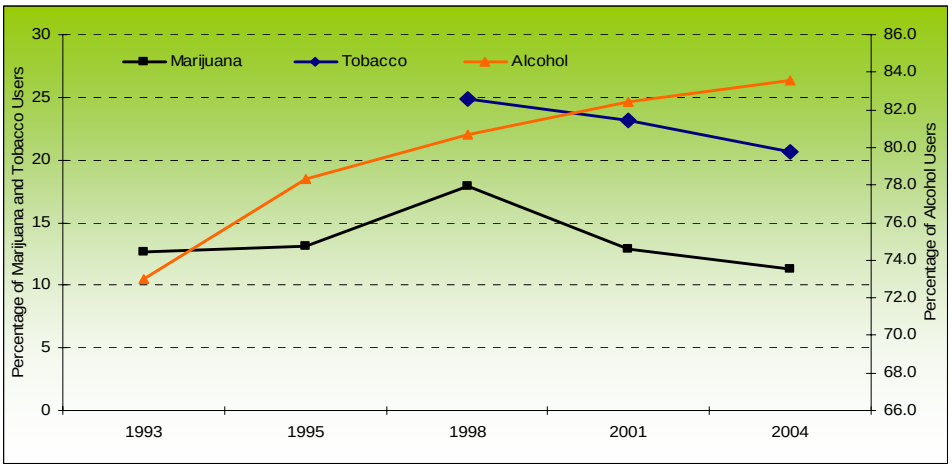
Table 1. Participation Rates: proportion of the population aged 14 and over

	1993	1995	1998	2001	2004
Marijuana:					
Ever used	34.7	31.1	39.1	33.1	33.6
Recently used[(a)]	12.7	13.1	17.9	12.9	11.3
Recent use of other drugs:					
Meth/amphetamine (speed)[(a)(b)]	2.0	2.1	3.7	3.4	3.2
Ecstasy (Designer drugs)[(a)]	1.2	0.9	2.4	2.9	3.4
Cocaine[(a)]	0.5	1.0	1.4	1.3	1.0
Heroin[(a)]	0.2	0.4	0.8	0.2	0.2
Tobacco[(a)]	n.a.	n.a.	24.9	23.2	20.7
Alcohol[(a)]	73.0	78.3	80.7	82.4	83.6

(a): figures relate to usage in last 12 months. For tobacco and alcohol, 'recent use' means daily, weekly and less-than-weekly smokers and drinkers respectively. **(b)**: For non-medical purposes. Source: AIHW (2005).

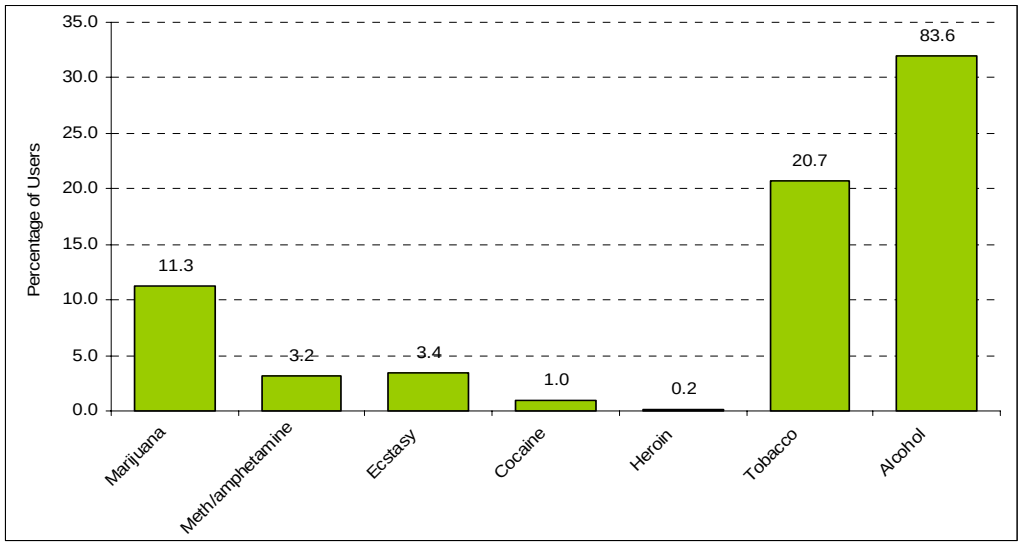
Being legal, tobacco and alcohol are the most commonly used recreational drugs. Time trends for participation rates for tobacco and alcohol are plotted in Figure 1 in comparison to that for marijuana. One in five Australians smoke cigarette in 2004, and the proportion of tobacco users has decreased by a significant 4 percentage points since 1998. On the other hand, more Australians are drinking alcohol; the proportion of alcohol usage has increased over the past decade by 10 percentage points. These trends contrast the slight declining trend for marijuana participation. Participation rates for all drugs for 2004 are depicted in Figure 2.

Figure 1. Participation Rates over Time: Marijuana, Tobacco and Alcohol



Source: Table 1.

Figure 2. Participation Rates for 2004*



* Bar for alcohol is not drawn to scale. Source: Table 1.

3. MARIJUANA PARTICIPATION ANALYSIS

3.1 Sample Descriptive Statistics - Who Uses Drugs?

The NDSHS collected detailed information on socio-economic and demographic characteristics of individual respondents. This allows us to study the correlations between individuals' drug-related behaviour and personal characteristics. Such information is invaluable for identifying important factors relating to drug taking behaviour and therefore the vulnerable groups in the Australian society, which is crucial to the effective design and implementation of well-targeted public health and drug education programs and policies. In the following, we present some descriptive statistics on the various socio-economic and demographic aspects of marijuana consumption. We do not include the 2004 data here to be consistent with the econometric analysis presented in the paper, which were conducted when 2004 unit-record data were not released. Pooled data from the 1998 and 2001 surveys are used in the analysis below. This involves over 36,000 individuals in the combined sample. We first look at marijuana participation, defined as consumption in the preceding 12 months.

Table 2 presents the observed marijuana participation rate by individual socio-economic and demographic groups, in comparison with several other licit and illicit drugs. It highlights the

differences in marijuana prevalence by factors such as gender, education and income. These differences are also illustrated in Figure 3. Note that the figures in Table 2 are computed using the pooled unit record data for 1998 and 2001 and refer to the proportions of the relevant groups who have used a particular drug in the past 12 months. They are comparable to the 'recent use' figures reported in Table 1 by AIHW (2005) for all drugs except for tobacco and alcohol. The 'recent use' figures for the two legal drugs in Table 1 refer to daily, weekly and less-than-weekly users, which are not strictly comparable to those in Table 2 where users of once or twice a year are also included.

As shown in Table 2 and Figure 3, while marijuana participation rate among the overall Australian population is 14.4%, 17.1% of males and 12.4% of females use marijuana. Single individuals (28.4%) are significantly more likely to have used marijuana in the past 12 months than the married or de facto partnered (8.6%). In terms of main activity, the group of retired, pensioners and home duties reports significantly lower participation rate (at only 5.9%) than people who work (16.4%), study (24.9%), or unemployed (28.8%). The prevalence rates for different education levels show that people with year-12 education have the highest chance of participation (over 19%) in comparison to people with lower or higher education (between 12%-14.5%).

An individual is also more likely to participate if he/she is of Aboriginal or Torres Strait Islander (ATSI) origin and lives in a capital city. A single-parent with dependent child/children has a 25.4% chance of being a recent marijuana user, relative to the 13.7% for the rest. In terms of personal income, low income individuals with annual income between $20,000 and $30,000 show the highest participation rate relative to people with higher income or people with very low income. For income beyond $30,000, the higher the personal income, the less likely a person is observed to be using marijuana.

The relationship between the observed participation percentages and age is illustrated in Figure 3-(C). Young Australians between the ages of 17 to 23 are most likely to use marijuana, with the group of 19-year-olds reporting the highest participation rate of nearly 40% of that age group. Prevalence rate beyond the age of 19 declines as individuals get older.

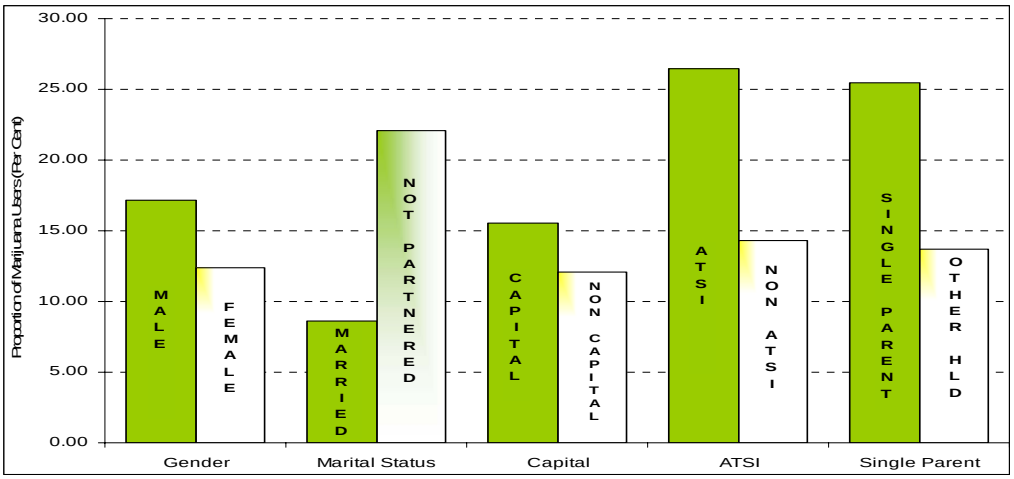
Table 2. Participation Rate for Marijuana and other Drugs (unit: percent)[*]

	Marijuana	Cocaine	Heroin	Tobacco	Alcohol
Overall	**14.4**	**1.4**	**0.5**	**24.0**	**82.7**
MALE	17.14	1.61	0.57	25.04	85.76
FEMALE	12.42	1.15	0.43	22.45	80.66
MARRIED OR DE FECTO	8.61	0.68	0.25	20.03	84.68
NON-PARTNERED	22.07	3.05	1.04	28.16	80.81
YOUNGKIDS	12.98	1.27	0.32	26.62	86.52
NOYOUNGKIDS	14.75	1.36	0.52	23.00	82.54
CAPITAL CITY	15.57	1.70	0.57	23.27	83.44
NON-CAPITAL CITY	12.09	0.54	0.33	24.37	81.75
ATSI	26.45	2.20	1.10	44.08	76.39
NON-ATSI	14.30	1.34	0.48	23.24	83.16
SINGLE PARENT	25.42	1.82	1.20	40.10	83.34
NON-SINGLE PARENT	13.72	1.32	0.44	22.41	83.15
WORK	16.43	1.74	0.45	26.06	89.95
STUDY	24.93	2.05	0.68	19.46	73.96
UNEMPLOYED	28.80	1.60	1.52	42.91	82.43
OTHERACT (RETIREE/HOME DUTY)	5.87	0.40	0.39	18.76	74.87
DEGREE	13.35	1.76	0.33	15.58	88.21
DIPLOMA	14.49	1.38	0.36	26.04	87.07
YR12	19.14	1.79	0.75	27.42	85.15
LESSYR12	12.27	0.73	0.55	24.29	76.56
INCOME:					
$0-$9,999	14.78	0.99	0.65	23.07	75.54
$10,000-$19,999	16.60	1.38	0.34	28.38	85.74
$20,000-$29,999	17.56	1.94	0.52	27.99	89.54
$30,000-$39,999	14.40	1.98	0.32	23.57	91.66
$40,000-$49,999	14.21	1.02	0.76	23.61	93.72
$50,000-$59,999	12.34	1.26	0.21	19.38	92.75
$60,000 or more	11.49	1.92	0.14	17.59	94.26

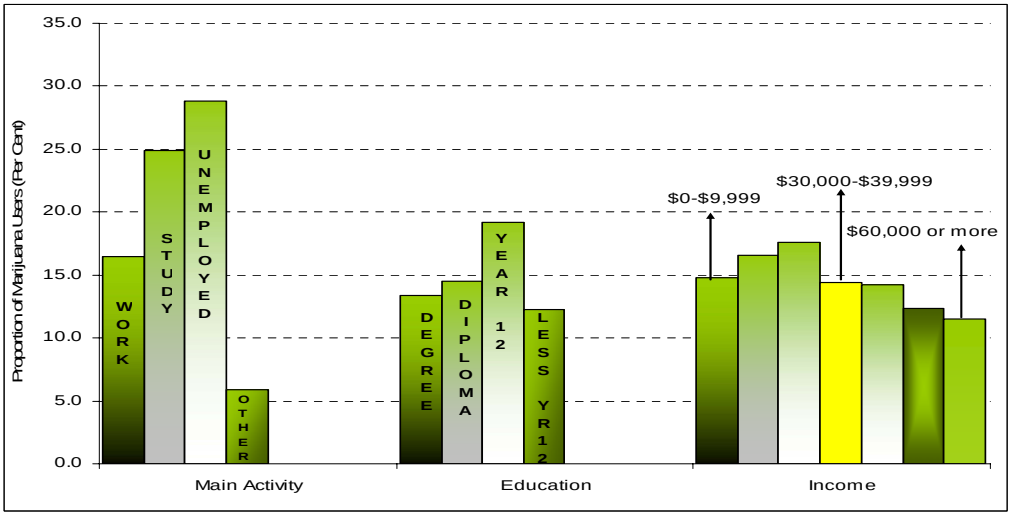
[*] Results relates to percentages of the relevant population groups of participation in the past 12 months, based on the pooled sample from 1998 and 2001 surveys (NDSHS, 2001).

Figure 3. Observed Marijuana Participation Rates

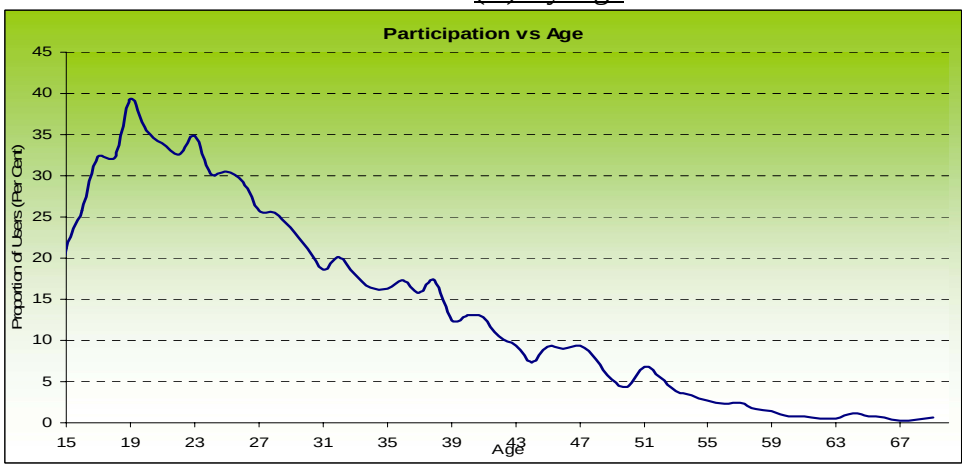
(A) By Demographic/Social Groups



(B) By Sicio-economic Groups



(C) By Age



Finally, we look at how the user characteristics for other drugs compare with that for marijuana in Table 2. Overall, all three illicit drugs in Table 2 and tobacco are associated with similar groups while alcohol is rather different. Males are more likely to use all five drugs than females. Single parents are also more likely to use all drugs than individuals in other household types, though this is to a lesser extent for alcohol. Single and ATSI individuals are more likely to use all drugs than partnered and non-ATSI persons respectively for all drugs except alcohol. People in capital cities are more likely to use all three illicit drugs and alcohol, but non-capital city residents are slightly more likely to smoke tobacco.

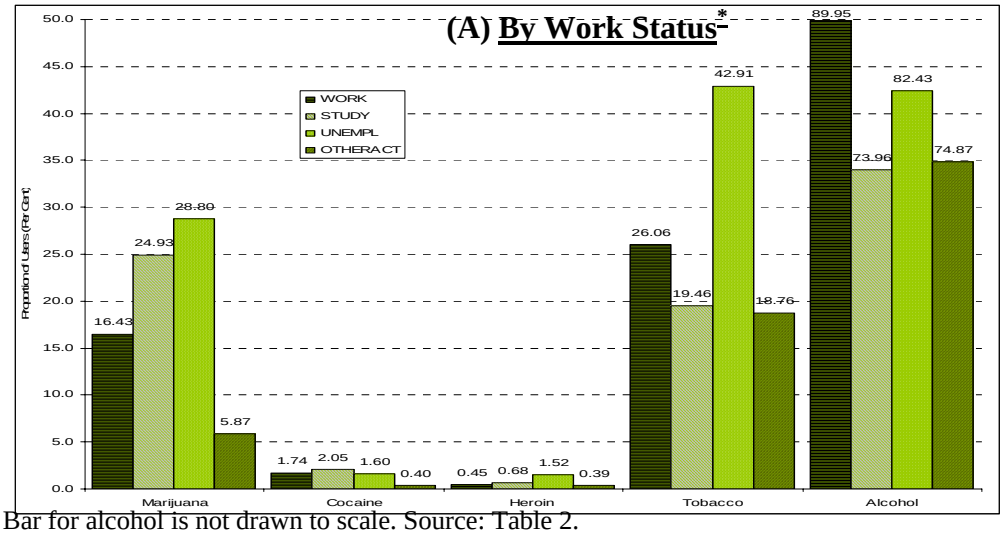
It is also interesting to compare the relationships with income for the five drugs. While marijuana and tobacco are clearly more likely to be associated with low income and alcohol participation is associated with higher income, the observation for cocaine and heroin are less straightforward. For the combined data from 1998 and 2001, heroin participation is highest among people with personal income between $40,000 and $50,000 and people with lower than $10,000 annual income. On the other hand, cocaine is more associated with people with very high income of over $60,000 and people on lower middle income of $20,000 to $40,000.

Association between drug participation and work status, education and age are illustrated in Figure 4 (A)-(C). In terms of work status or main activity, unemployed individuals exhibit the highest participation rate than the other three groups for marijuana, tobacco and heroin. Interestingly for cocaine, the student group has the highest participation while people who work or unemployed are similarly ranked second highest. Different from all other drugs, alcohol participation is highest among people who are employed, with unemployed people having the second highest participation.

Turning to education, alcohol participation again shows a different pattern from the other drugs in that its participation is positively related to education attainment. For all other four drugs, people with Year-12 education have the highest participation rates than the less-than-year-12 group and people with higher than Year-12 education. Broadly speaking, marijuana shows a closer pattern to that of tobacco. Results for cocaine is interesting again in that the highest participation rates are observed among the Year-12 educated and tertiary degree holders.

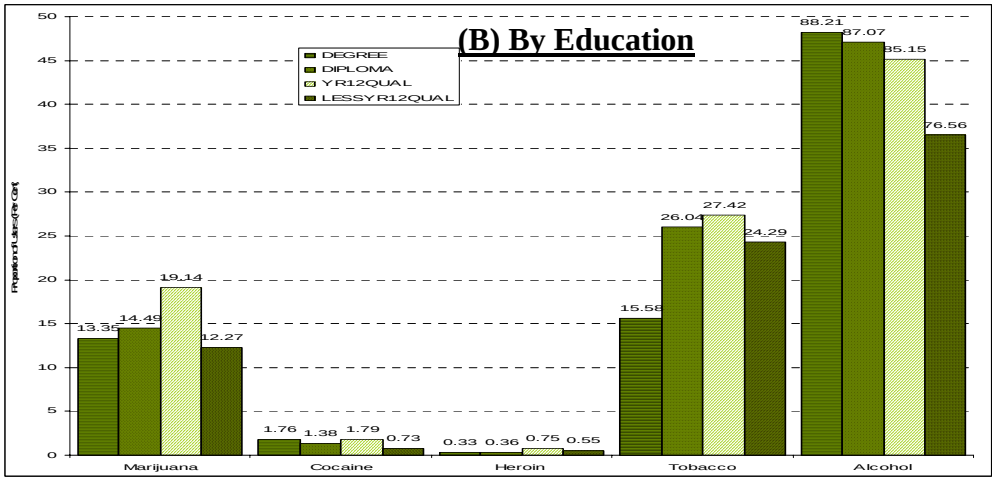
Figure 4. Observed Participation Rates for all Drugs

(A) By Work Status*



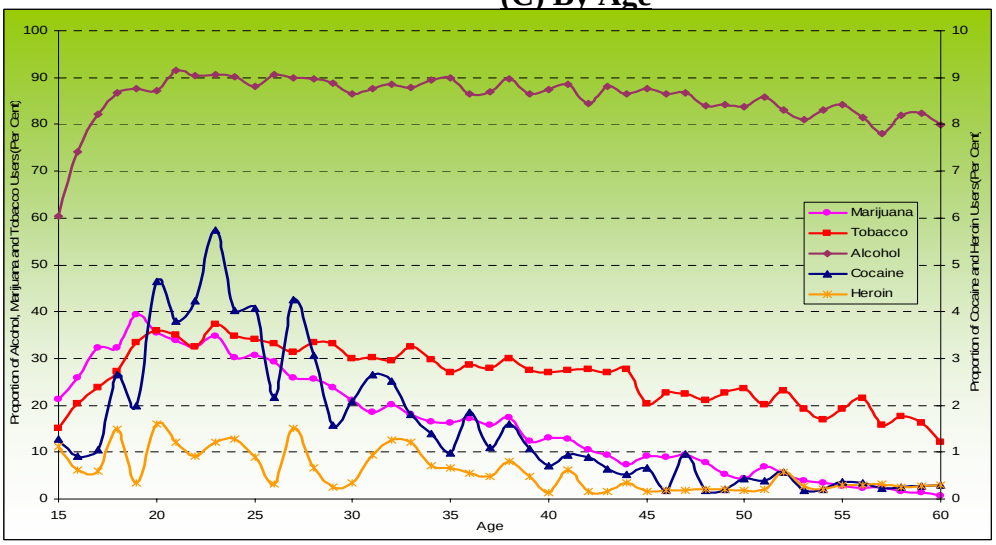
* Bar for alcohol is not drawn to scale. Source: Table 2.

(B) By Education



* Bar for alcohol is not drawn to scale. Source: Table 2.

(C) By Age



Lastly, we turn to participation rates by age for all five drugs as shown in the last panel of Figure 4. For marijuana and cocaine, participation rates are highest among young people, with marijuana participation peaking around late teens to early twenties before declining steadily and cocaine peaking over an older and wider age range of early to late twenties. For heroin, age is less important than the other illegal drug; participation rate does not start to decline until the age of thirty-five or forty. Turning to the legal drugs, participation for alcohol is steady after the age of twenty and only start to decline slowly after the age of forty-five. For tobacco, the highest participation rate is for the twenty to thirty age group, then there is a slight decline for the thirty to forty age group before a more significant decline at around the age of forty-five.

3.2 A Probit Model for Marijuana Participation

In the above, we have looked at some *observed* sample descriptive statistics on the correlations between individuals' marijuana consumption and socio-economic and demographic factors. However, as personal characteristics are often correlated, descriptive statistics as presented in Table 2 can not isolate the effects of individual factors on drug taking behaviour and can sometimes even be misleading. For example, while we observe significantly higher marijuana participation rate among the unemployed population, it is often the case that these people also have low level education, have lower income, are single, and perhaps are of ATSI background. So the observed significantly higher prevalence for the unemployed than the rest of the population may be partly due to the effects of these other factors rather than the factor of unemployment alone. Econometric models will allow the observed difference in participation to be attributed to individual characteristics.

A probit model is estimated in Ramful and Zhao (forthcoming) estimated that relates the probability of marijuana participation to individual socio economic and demographic characteristics and drug prices, using pooled data from the two surveys of 1998 and 2001. Table 3 summarises the estimated coefficients of the probit model and the marginal effects on marijuana participation probabilities for individual covariates. In the case of a continuous explanatory variable, the marginal effect relates to the actual change in participation probability

in response to a unit change in the explanatory variable, while in the case of a dummy variable it is the change in participation probability when the dummy variable changes from 0 to 1, all evaluated at the sample means of all explanatory variables[1]. Standard errors are reported in parentheses.

Looking at the marginal effects of individual explanatory variables in Table 3, we can see that, holding all other explanatory variables fixed at sample means, Australian males are 4.7% more likely to have recently used marijuana than females. All other factors being equal, married or *de facto* partnered people have 6.9% lower probability of using marijuana relative to individuals without a partner. It is interesting to compare this marginal effect of variable 'MARRIED' with the observed sample statistics in Table 2; the *observed* frequency of marijuana usage in Table 2 for the married or partnered individuals is almost 20% lower than the non-partnered when other factors are not controlled.

Comparison of marginal effects of other explanatory variables in Table 3 to the observed sample frequencies by personal attributes in Table 2 further illustrates how an econometric model allows for the partial effects of individual factors to be isolated holding other factors fixed. Individuals with Aboriginal or Torres Strait Island (ATSI) background have a marginal effect of 3.5% higher participation probability than the non-ATSIs, and sole-parents are 2.3% more likely to use marijuana than otherwise. These marginal effects are significantly lower than the observed differences in the sample statistics in Table 2. In terms of main occupation, only unemployment is shown to have a significantly non-zero marginal effect (4.9% lower probability) relative to the base group of retired people and homemakers, while the sample statistics show that all three groups of employed, students and unemployed have at least 10% higher observed probability than the base group. Similarly for education attainment, once other factors are controlled equal, only tertiary degree is shown to have a significant effect in lowering participation probability (1.3% lower) comparing to the base group of less-than-year-12 education, whilst the observed probabilities show the middle two groups of Year-12 and Diploma educated have the highest disparities from the lowest educated base group in the observed probabilities. In fact, we actually

[1] An alternative way is to compute the average marginal effect over all individuals. Harris, Ramful and Zhao (2006) computed the marginal effects for a different discrete choice model using both ways and found that the differences

observed a 1% higher participation rate for the degree owners than the base group but the econometric model tells us that the marginal effect of tertiary education is significant and negative once other factors are controlled.

Table 3. Marginal Effects on Marijuana Participation Probability[a]

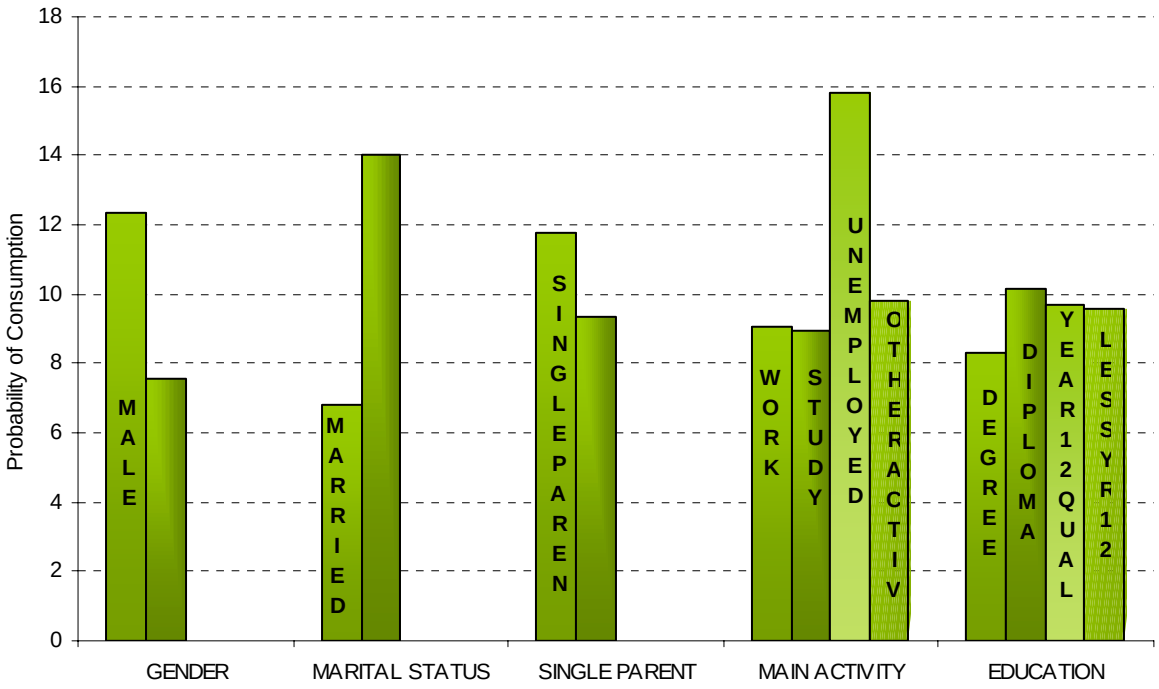
	Coefficient		Marginal Effect	
CONSTANT	-16.966	(1.088)**	-2.862	(0.153)**
PRH	0.162	(0.045)**	0.027	(0.009)**
PRC	0.233	(0.051)**	0.039	(0.013)**
PRM	-0.121	(0.079)	-0.020	(0.013)
INCOME	0.038	(0.016)**	0.006	(0.001)**
CAPITAL	0.020	(0.025)	0.003	(0.002)*
YR01	-0.065	(0.032)**	-0.011	(0.006)*
AGE	9.563	(0.555)**	1.614	(0.045)**
AGESQ	-1.550	(0.079)**	-0.261	(0.006)**
MALE	0.279	(0.022)**	0.047	(0.002)**
MARRIED	-0.410	(0.025)**	-0.069	(0.004)**
WORK	-0.047	(0.037)	-0.008	(0.005)*
STUDY	-0.051	(0.046)	-0.009	(0.009)
UNEMP	0.290	(0.058)**	0.049	(0.004)**
YOUNGKIDS	-0.106	(0.031)**	-0.018	(0.005)**
ATSI	0.208	(0.072)**	0.035	(0.018)*
DEGREE	-0.080	(0.034)**	-0.013	(0.005)**
DIPLOMA	0.033	(0.031)	0.006	(0.004)
YR12	0.008	(0.032)	0.001	(0.004)
SIN-PARENT	0.133	(0.038)**	0.023	(0.010)**

[a] Standard errors are given in parentheses. * indicates significance at 10% level. **indicates significance at 5% level. For each continuous explanatory variable the MEs relate to the actual change in the participation probability 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, all evaluated at the sample means of all explanatory variables.

To further illustrate the partial effects of individual explanatory variables controlling for other factors, the predicted probabilities by various attributes when all other factors are controlled at sample means are illustrated in Figure 5. The bar charts in Figure 5 can be compared with the bar charts in Figure 1 for the observed sample frequencies. There are obvious differences. Finally, the marginal effects of drug prices indicate that marijuana participation responds to own price negatively, and the other two illicit drugs act as substitutes. Although it is not statistically significant at 5% level, at a 7% significance level, the evidence is present that a 10% increase in marijuana price will result in a decrease in marijuana participation probability by 0.2% (or 0.002).

between the two approaches were trivial.

Figure 5 Predicted Participation Probabilities at Sample Means



Source: Ramful and Zhao (2004).

4. RELATIONSHIP WITH OTHER DRUGS – MULTI-DRUG PARTICIPATION ANALYSIS

4.1 Observed Cross-drug Correlation

Anecdotal evidence indicates that consumption of marijuana is closely related to the consumption of other drugs. In this section we aim to quantify the intrinsic relationships between marijuana consumption and that of other legal and illegal recreational drugs due to both observable and unobservable factors. We first look at some raw sample statistics from the NDSHS data on cross-drug relationships. Start with the relationship of marijuana with two related legal drugs of tobacco and alcohol. Tables 4 and 5 present the observed sample frequencies and the estimated conditional and unconditional probabilities in terms of joint consumption of tobacco, alcohol and marijuana, using data from NDSHS 1995, 1998 and 2001.

Table 4. Summary Sample Statistics for Participation in Tobacco, Alcohol and Marijuana[*]

Percent of sample participation in:	Joint	Tobacco	Alcohol	Marijuana
T only	1.9	1.9		
A only	55.4		55.4	
M only	0.2			0.2
T and A only	13.8	13.8	13.8	
T and M only	0.3	0.3		0.3
A and M only	6.0		6.0	6.0
T and A and M	7.7	7.7	7.7	7.7
None	14.7			
Total	**100**	**23.7**	**82.9**	**14.2**

[*] Source: Zhao and Harris (2004) based on pooled data from NDSHS of 1995, 1998 and 2001. **T**: tobacco, **A**: Alcohol, and **M**: Marijuana.

Table 5. Estimated Conditional and Unconditional Participation Probabilities (%)[*]

	***i* = Marijuana**	***i* = Alcohol**	***i* = Tobacco**
$P(Y_i = 1)$	14.2	82.9	23.7
$P(Y_i = 1 \mid Y_M = 1)$	100	96.5	56.3
$P(Y_i = 1 \mid Y_A = 1)$	16.5	100	25.9
$P(Y_i = 1 \mid Y_T = 1)$	33.8	90.7	100

[*] Source: Zhao and Harris (2004) based on pooled data from NDSHS of 1995, 1998 and 2001. Probabilities are multiplied by 100. Y_i is a binary variable representing the participation status for drug i (i = M, A and T).

Table 4 shows that whilst 14.2% of the total population is estimated to participate in marijuana consumption during the three surveys, 14.0% use marijuana in conjunction with at least one of the two legal drugs of tobacco and alcohol and only 0.2% use marijuana only. The estimated conditional and unconditional probabilities in Table 5 based on these sample statistics in Table 4 highlight the correlations across the three drugs. Table 5 shows that the chance of an individual participating in marijuana consumption is much higher if he or she is known to be participating in one of the other two drugs. The chance of marijuana participation is 14.2% for the general Australian population, but this probability increases to 16.5% among alcohol drinkers and to 33.8% among the group of tobacco smokers. On the other hand, while 23.7% of the general population smoke tobacco, the percentage of tobacco smokers among marijuana users is much higher at 56.3%. These empirical statistics confirm the anecdotal observation that marijuana is closely related to tobacco and alcohol in consumption.

Similarly, the NDSHS data also indicate close relationship of marijuana consumption with that of other illegal drugs. For example, Table 6 and 7 show an even stronger correlation between the

consumption of marijuana and that of cocaine and heroin. For example, while 14.55% of the respondents used marijuana in the two surveys of 1998 and 2001, 86.23% of cocaine users and 90.06% of heroin users consumed marijuana. If an individual is known to use both cocaine and heroin, he/she is almost certainly a marijuana user with an odd of 94.78% which is much higher than the unconditional probability of 14.55%. Similarly, while only 1.35% of the general population is expected to use cocaine, the chance of cocaine use increases to 8.03% for the group of marijuana users and to 66.87% among people who use both marijuana and heroin.

Table 6. Summary Sample Statistics for Participation in Marijuana, Cocaine and Heroin*

Percent of sample participation in:	Joint	Marijuana	Cocaine	Heroin
M only	13.23	13.23		
C only	0.17		0.17	
H only	0.03			0.03
M and C only	0.87	0.87	0.87	
M and H only	0.15	0.15		0.15
C and H only	0.02		0.02	0.02
M and C and H	0.30	0.30	0.30	0.30
None	85.23			
Total	**100**	**14.55**	**1.35**	**0.50**

* Source: Ramful and Zhao (2004) based data from NDSHS of 1998 and 2001. **M**: marijuana, **C**: cocaine, and **H**: heroin.

Table 7. Estimated Conditional and Unconditional Participation Probabilities*

	***i* = Marijuana**	***i* = Cocaine**	***i* = Heroin**
$P(Y_i = 1)$	14.55	1.35	0.50
$P(Y_i = 1 \mid Y_M = 1)$	100.00	8.03	3.07
$P(Y_i = 1 \mid Y_C = 1)$	86.23	100.00	23.28
$P(Y_i = 1 \mid Y_H = 1)$	90.06	63.54	100.00
$P(Y_i = 1 \mid Y_C = 1, Y_H = 1)$	94.78	100.00	100.00
$P(Y_i = 1 \mid Y_M = 1, Y_H = 1)$	100.00	66.87	100.00
$P(Y_i = 1 \mid Y_M = 1, Y_C = 1)$	100.00	100.00	25.59

* Source: Ramful and Zhao (2004) based data from NDSHS of 1998 and 2001. Probabilities are multiplied by 100. Y_i is a binary variable representing the participation status for drug i (i = M, C and H).

4.2 Multivariate Probit Models for Multi-Drug Consumption

While we observe significant correlation across marijuana participation and that of other drugs through the conditional and unconditional frequencies in Tables 5 and 7, some of the observed cross-drug correlation may be explained by their joint relationships with observable personal characteristics (such as education levels) or price variations, while some will be due to unobservable personal characteristics such as those related to addictive personalities or family

upbring. These unobserved factors are difficult to quantify, but can play a major role in an individual's decision of using various drugs. For example, if we know that an individual is 20-year-old, male, single, and is unemployed, we would expect that the chance of him using marijuana in a year and place that marijuana price is low is higher than an average Australian in a time and place the marijuana price is high. However, if we also know that he is using both cocaine and heroin, we may predict an even higher probability for his chance of using marijuana. As indicated below, a multivariate systems econometric model will allow us to examine the observed cross-drug correlations due to both observed personal characteristics as well as unobservable factors after controlling for differences in observable individuals socio-economic and demographic characteristics.

While it is well accepted that marijuana is closely related to other drugs in consumption, in studies explicitly addressing this relationship, it has mostly been examined through cross-drug price or policy responses (Chaloupka and Laixuthai 1997; Pacula 1998; DiNardo and Lemieux 2001; Cameron and William 2001; Farrelly et al. 2001; Desimone and Farrelly 2003). However, although the responsiveness of marijuana participation with respect to changes in other drug prices or policies are examined, the correlation across decisions of different drugs for the same individual through unobservable characteristics has been ignored. In the following, we present results from two multivariate probit models that separately examine the relationship of marijuana consumption with licit drugs tobacco and alcohol and the relationship with illicit drugs cocaine and heroin, allowing for cross-drug correlations via unobservable factors.

Ramful and Zhao (forthcoming) estimated a trivariate probit model for the joint decision of participation in relation to three illicit drugs of marijuana, cocaine and heroin, using pooled data from the 1998 and 2001 surveys. The trivariate approach allows for correlations across the error terms of all three probit equations, and estimates the three equations as a system. The left panel in Table 8 shows the estimated correlation coefficients across the error terms of the trivariate probit model for the three illicit drugs, and associated standard errors. These indicate that after accounting for the observable covariates in the model, the correlations among the three drugs are still very high: 0.835 between the two hard drugs of cocaine and heroin, 0.651 between marijuana and cocaine, and 0.59 between marijuana and heroin.

Table 8. Cross-Drug Correlation Coefficients of Error Terms*

	Marijuana	Cocaine	Heroin		Marijuana	Tobacco	Alcohol
Marijuana	1	0.651 (28.3)**	0.590 (13.4)**	**Marijuana**	1	0.50 (45.8)**	0.37 (21.2)**
Cocaine	0.651 (28.3)**	1	0.835 (32.1)**	**Tobacco**	0.50 (45.8)**	1	0.20 (14.7)**
Heroin	0.590 (13.4)**	0.835 (32.1)**	1	**Alcohol**	0.37 (21.2)**	0.20 (14.7)**	1

* Results for correlation coefficients for marijuana, cocaine and heroin are for error terms of a trivariate probit model from Ramful and Zhao (forthcoming), and results for marijuana, tobacco and alcohol are from Zhao and Harris (2004). '**' indicates statistical significance at 5% level and figures in parentheses are *t*-statistics.

In a similar model for marijuana, tobacco and alcohol using combined data from the three NDSHS surveys of 1995, 1998 and 2001, Zhao and Harris (2004) estimated the three correlation coefficients after controlling for observed covariates. These are summarised in the right panel of Table 8. The results show that, after accounting for the observed personal characteristics and prices, there is significant correlation between marijuana and the two legal drugs via unobserved factors, with the correlation of marijuana with tobacco being as high as 0.5.

Knowledge of these correlation coefficients can help greatly in the prediction of an individual's marijuana participation probability when knowledge of his/her participation in other drugs is available. Similarly, information on marijuana participation will also help with predicting probabilities of participation in other drugs. Table 9 presents some predicted unconditional, conditional and joint probabilities using both the univariate probit (UVP) models and the multivariate probit models. The UVP models ignore the cross-drug correlations via the unobserved error terms, while the MVP models account for such correlations.

For example, using univariate models where cross-drug correlations via the error terms are restricted to zeros, for an individual with personal characteristics controlled at sample means, the probabilities of him/her being a marijuana user are predicted as 9.5% with or without the knowledge of his/her participation in other drugs. However, when such correlations are accounted for using a multivariate model, the predicted probability of marijuana is increased to 79% if the person is known to be a cocaine user, this probability is increased to 87% if he/she is known to be using both cocaine and heroin. Similarly, with the trivariate probit model for marijuana, alcohol and tobacco, the predicted probability for marijuana participation for an 'average' Australian will change from 10.7% to 27% if extra information is available that the

person uses both alcohol and tobacco. This predicted probability will decrease to only 1.5% if the person is known to be abstaining from both of the two legal drugs.

Table 9. Predicted Probabilities from two Trivariate Probit Models*

Marijuana, Cocaine and Heroin:			**Marijuana, Alcohol and Tobacco:**		
	Univariate	**Trivariate**		**Univariate**	**Trivariate**
$P(Y_M = 1)$	0.0950	0.0948	$P(Y_M = 1)$	0.1071	0.1066
$P(Y_M = 1 \mid Y_C = 1)$	0.0950	0.7943	$P(Y_M = 1 \mid Y_A = 1, Y_T = 1)$	0.1071	0.2687
$P(Y_M = 1 \mid Y_C = 1, Y_H = 1)$	0.0950	0.8697	$P(Y_M = 1 \mid Y_A = 0, Y_T = 0)$	0.1071	0.0145
$P(Y_C = 1 \mid Y_M = 1, Y_H = 1)$	0.0043	0.5692	$P(Y_T = 1 \mid Y_M = 1, Y_A = 1)$	0.2312	0.5564
$P(Y_H = 1 \mid Y_M = 1, Y_C = 1)$	0.0016	0.2308	$P(Y_A = 1 \mid Y_M = 1, Y_T = 1)$	0.8750	0.9732
$P(Y_M = 0, Y_C = 0, Y_H = 0)$	0.8997	0.9043	$P(Y_M = 0, Y_A = 0, Y_T = 0)$	0.0858	0.1064
$P(Y_M = 0, Y_C = 1, Y_H = 0)$	0.0039	0.0007	$P(Y_M = 1, Y_A = 1, Y_T = 1)$	0.0217	0.0516

* Results for marijuana, cocaine and heroin are from Ramful and Zhao (forthcoming) and results for marijuana, tobacco and alcohol are from Zhao and Harris (2004). All predicted probabilities are evaluated at sample means of the whole population. Standard errors are not presented and can be found from the original papers.

The predicted joint probabilities are also different. Accounting for the cross-equation error correlations, the joint probability for an average individual with mean values of personal characteristics to be using all three drugs of marijuana, alcohol and tobacco is predicted to be 5.2%, while the univariate models predict a mere 2.2% probability. This compares to an observed frequency of 7.7% in Table 4 when personal characteristics are not controlled.

Note that the predicted marginal probabilities from the two models are rather different as they used data from 1998-2001 and data from 1995-2001 respectively. Also note slight differences in the predicted marginal probabilities from univariate probit and trivariate probit. This is due to two reasons. There are slight differences in the included sample observations as there are more missing observations for the trivariate model than for a univariate probit for marijuana alone. Secondly, even both models give consistent estimations for the true marginal probability, small differences in different estimations are possible. The differences are small in magnitudes in any case.

Finally, the marginal effects of individual explanatory factors on unconditional and the associated conditional probabilities can also be different. To further illustrate the extra insight afforded by the multivariate approach, marginal effects of personal characteristics and prices on the

unconditional and some conditional probabilities of marijuana participation in the context of a trivariate probit for marijuana, cocaine and heroin are presented in Table 10. The magnitudes and sometimes even the signs can differ for the marginal effects on unconditional versus various conditional probabilities when the population is reduced to subgroups according to status of other drug uses. Marginal effects in all columns will be the same when univariate models are used.

Table 10: Marginal Effects on Selected Probabilities for Marijuana

	P(M=1)	P(M=1|C=0,H=0)	P(M=1|C=1,H=1)	P(M=1|C=1)	P(M=1|H=1)
Constant	-2.862**	-2.667**	-0.713	-1.096	-1.604
PRH	0.027**	0.028**	0.064**	0.109**	0.049
PRC	0.039**	0.039**	0.055**	0.078**	0.068*
PRM	-0.020	-0.024*	-0.126**	-0.131**	-0.198*
INCOME	0.006**	0.006**	-0.002	-0.020**	0.023*
CAPITAL	0.003*	0.001	-0.038**	-0.069**	-0.019
YR01	-0.011*	-0.011**	-0.013	-0.052**	0.028
AGE	1.614**	1.517**	0.743**	0.934**	1.477**
AGESQ	-0.261**	-0.246**	-0.134**	-0.165**	-0.259**
MALE	0.047**	0.046**	0.049**	0.077**	0.056**
MARRIED	-0.069**	-0.065**	-0.036**	-0.049**	-0.064**
WORK	-0.008*	-0.008	0.002	-0.020	0.031
STUDY	-0.009	-0.009	-0.009	-0.048*	0.036
UNEMP	0.049**	0.048**	0.071**	0.094**	0.098**
YOUNGKIDS	-0.018**	-0.017**	-0.024*	-0.012	-0.061**
ATSI	0.035*	0.034**	0.053*	0.052	0.096
DEGREE	-0.013**	-0.013**	0.004	-0.034*	0.053**
DIPLOMA	0.006	0.006	0.024*	0.001	0.070**
YR12	0.001	0.002	0.019	0.003	0.051**
SIN-PARENT	0.023**	0.022**	0.027*	0.055**	0.012

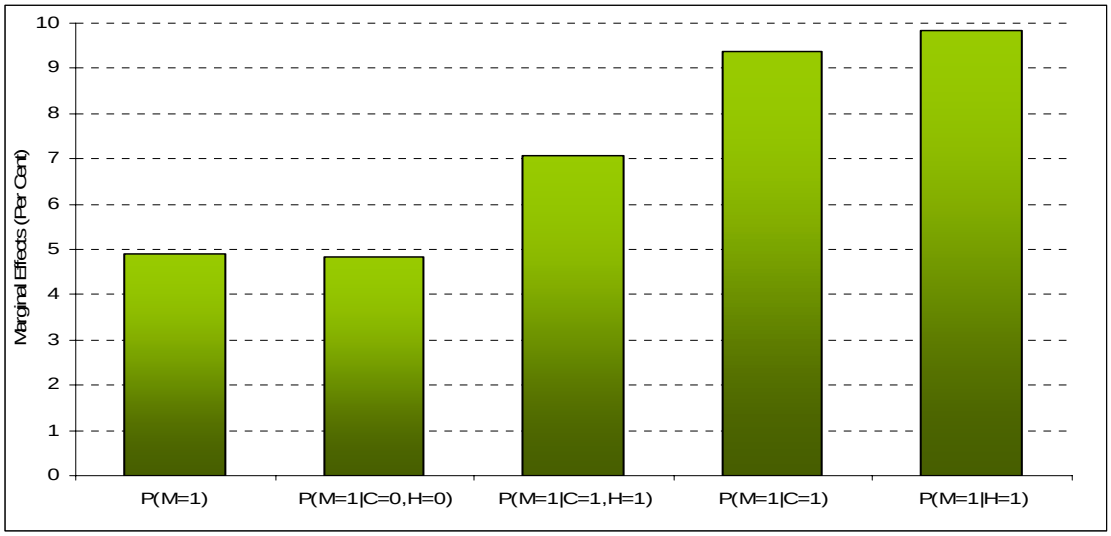
Source: Ramful and Zhao (forthcoming). * indicates significance at 10% level and ** indicates significance at 5% level. Standard errors are not presented but can be found from the original paper.

Taking the unemployment dummy and marriage dummy for example, differences in the marginal effects of these two explanatory variables on unconditional and various conditional probabilities for marijuana participation are illustrated in Figure 6. Other factors being equal at sample means, an unemployed person is about 5% more likely to participate in marijuana consumption than the base group of retirees, pensioners and homemakers among the general Australian population. However, among heroin users, or the cocaine users, the effect of unemployment on marijuana use probability is 10% higher relative to the base group. Interestingly, in the subgroup of individuals who use both heroin and cocaine, the marginal effect of unemployment on participation probability is slightly lower at 7%. Note the predicted base probabilities for marijuana

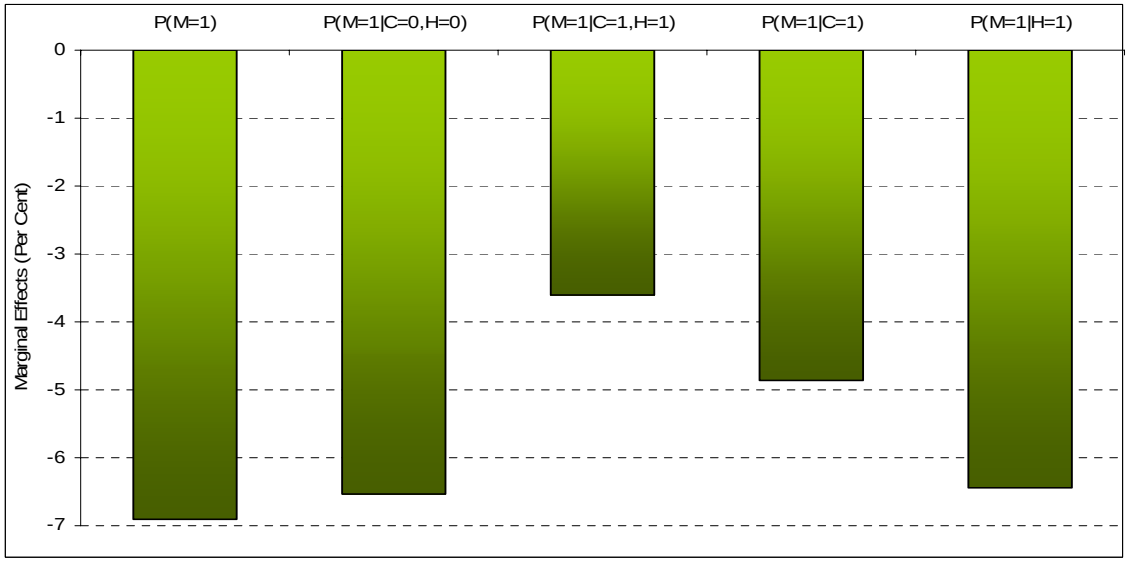
participation among other illicit drug users are also much higher than the unconditional probability as indicated in Table 10. Another example is marriage status. Married or de facto partnered people in general have 6.9% lower probability to use marijuana, but for those who are already using both heroin and cocaine, the marginal effect of being married is only 3.6% lower probability. This seems to suggest that, although in general married people are much more unlikely to use marijuana in general, among serious drug users who use both heroin and cocaine, being married or living with a de facto partner does not reduce the chance of the person also using marijuana as much. Note that, unlike the case of unemployment, the marginal effects of marriage status have an opposite relationship with the magnitudes of the predicted probabilities.

Figure 6 Marginal Effects on Conditional and Unconditional Probabilities

(A) Marginal Effects of Unemployment



(B) Marginal Effects of Marriage/de facto



5. LEVELS OF MARIJUANA CONSUMPTION

5.1 Observed User Characteristics by Levels of Consumption

For respondents who have used marijuana in the preceding 12 months, the surveys also ask for information about the frequency of consumption. This information is important as individuals using marijuana once or twice a year are very different from those using everyday in terms of both health consequence and targeting drug education programs. Table 11 presents the observed percentages for different levels (frequencies to be precise) of marijuana participation for the whole sample, as well as for individual socio-economic and demographic groups, using combined data of 1998 and 2001. Percentages for different levels of participation by gender, main activity, education, income and age are also illustrated in Figure 7.

As indicated in Table 11, overall, within the 14.4% of the whole population who have used marijuana in the past 12 months, 2.3% of the population use every day, 3.4% use less than daily but at least once a week, 1.9% use less frequently than every week but at least once a month, and 6.9% use less frequently than monthly but at least once in the past 12 months. Men are more likely to be in all levels of consumption than women, particularly for the heavy usage categories. Non-partnered individuals have higher proportions in all levels of consumption than married or de facto partnered. In terms of main activity, unemployed individuals are significantly over-represented in all four levels of usage especially the heavy user groups. It is also interesting to observe that while students have much higher participation rate than the employed, employed individuals show a higher proportion for the daily consumption than the students.

In terms of the highest achieved education levels, individuals with Year-12 education are more likely to be in all levels of marijuana consumption than higher or lower educated groups. Individuals with a non-tertiary diploma or trade certificate have the second highest proportions for the heavy consumption levels of weekly and daily. The results for the tertiary educated group are interesting. While people with tertiary degrees have higher marijuana participation rate than the group on the other end of the education scale with less than Year-12 education, degree holder users are mostly infrequent users and they have a significantly less chance to be daily users than all other three education groups.

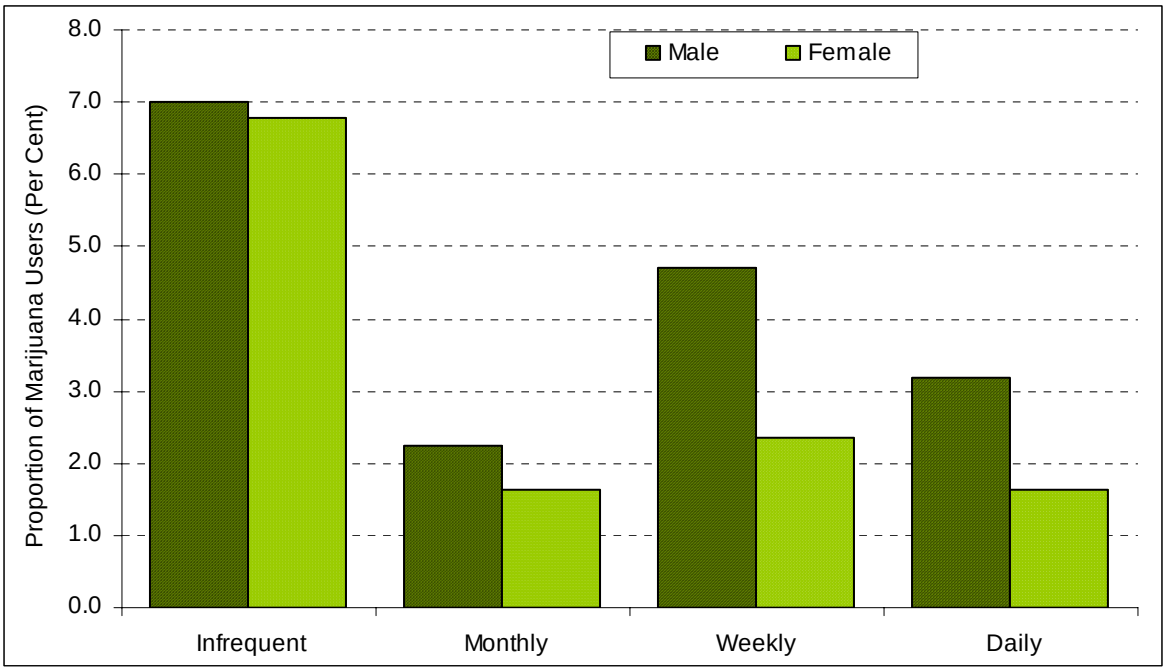
Table 11. Levels of Marijuana Consumption by Groups (unit: percent)[*]

	Abstainers	Infrequent	Monthly	Weekly	Daily
Overall	**85.6**	**6.89**	**1.91**	**3.41**	**2.32**
MALE	82.86	7.01	2.25	4.70	3.18
FEMALE	87.58	6.79	1.63	2.36	1.64
MARRIED	91.39	4.12	1.01	2.02	1.47
NON-PARTNERED	77.93	10.43	3.04	5.18	3.41
WORK	83.57	7.83	2.03	3.94	2.63
STUDY	75.07	14.10	3.88	5.01	1.93
UNEMPLOYED	71.20	8.51	4.41	8.21	7.67
OTHERACT (RETIREE/HOME DUTY)	94.13	2.46	0.71	1.39	1.32
DEGREE	86.65	7.89	1.78	2.82	0.85
DIPLOMA	85.51	6.27	1.74	3.65	2.84
YR12	80.86	9.16	2.59	4.44	2.95
LESSYR12	87.73	5.30	1.65	2.92	2.41
YOUNGKIDS	87.02	6.13	1.67	3.04	2.14
NOYOUNGKIDS	85.25	7.03	1.94	3.45	2.33
ATSI	73.55	9.86	3.29	6.26	7.04
NON-ATSI	85.70	6.82	1.88	3.36	2.24
CAPITAL CITY	84.43	7.65	2.05	3.56	2.31
NON-CAPITAL CITY	87.91	5.11	1.57	3.05	2.37
SINGLE-PARENT	74.58	11.20	3.51	6.37	4.34
NON-SINGLE PARENT	86.28	6.58	1.81	3.17	2.16
INCOME:					
$0-$9,999	85.22	7.11	2.15	3.17	2.34
$10,000-$19,999	83.40	6.82	2.01	4.47	3.31
$20,000-$29,999	82.44	8.03	2.14	4.27	3.10
$30,000-$39,999	85.60	7.47	1.91	3.29	1.73
$40,000-$49,999	85.79	7.87	1.52	3.30	1.52
$50,000-$59,999	87.66	7.16	1.47	2.48	1.22
$60,000 or more	88.51	7.22	1.24	2.41	0.62

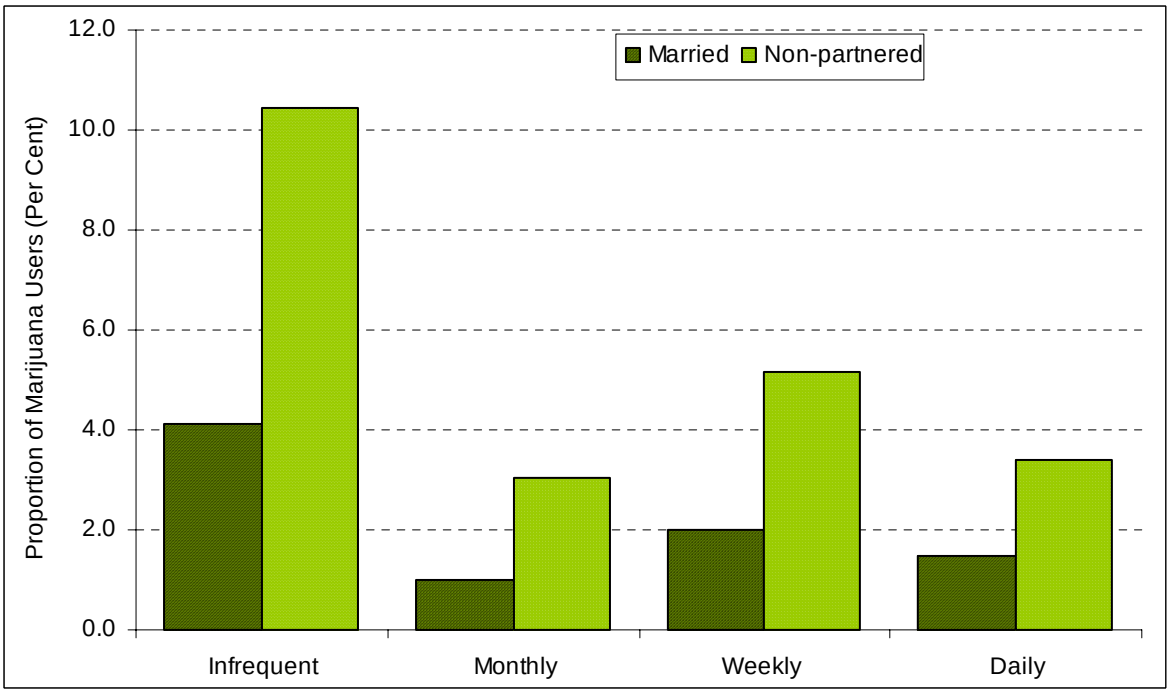
[*] Results relate to percentages of the relevant population groups for different levels of consumption, based on pooled sample from 1998 and 2001 surveys (NDSHS, 2001). *Abstainers*: not used marijuana in the past 12 months; *Infrequent*: used less frequently than monthly but at least once in the past 12 months; *Monthly*: used at least once a month but less frequently than weekly; *Weekly*: less than daily but at least once a week; and *Daily*: used every day.

Figure 7. Frequencies of Marijuana Consumption

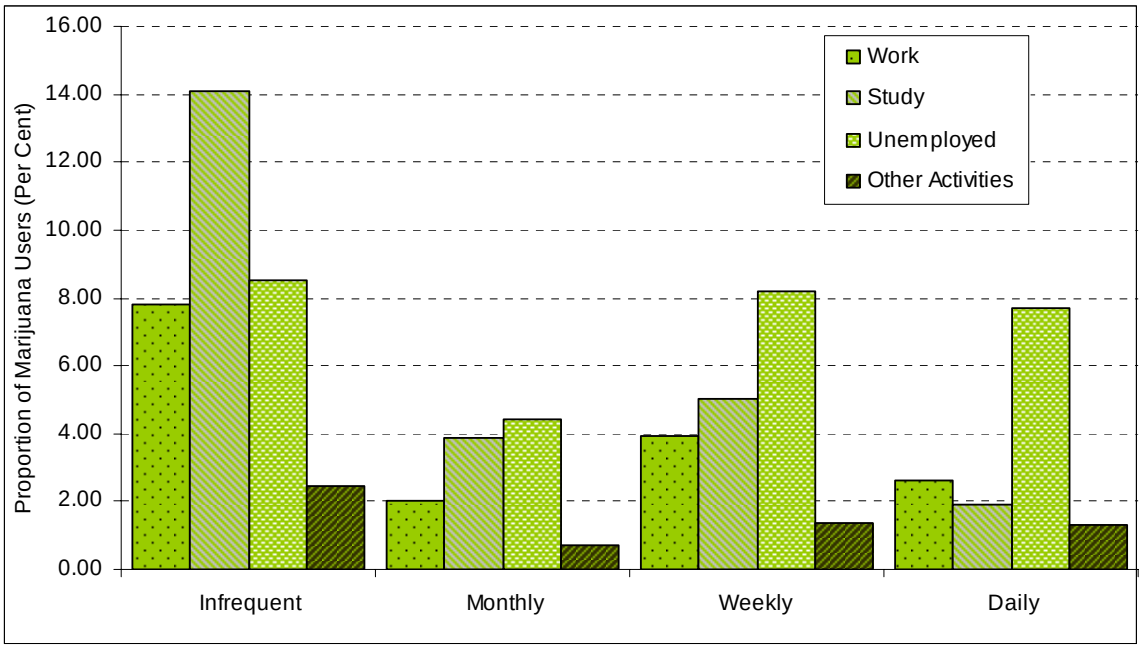
(A) By Gender



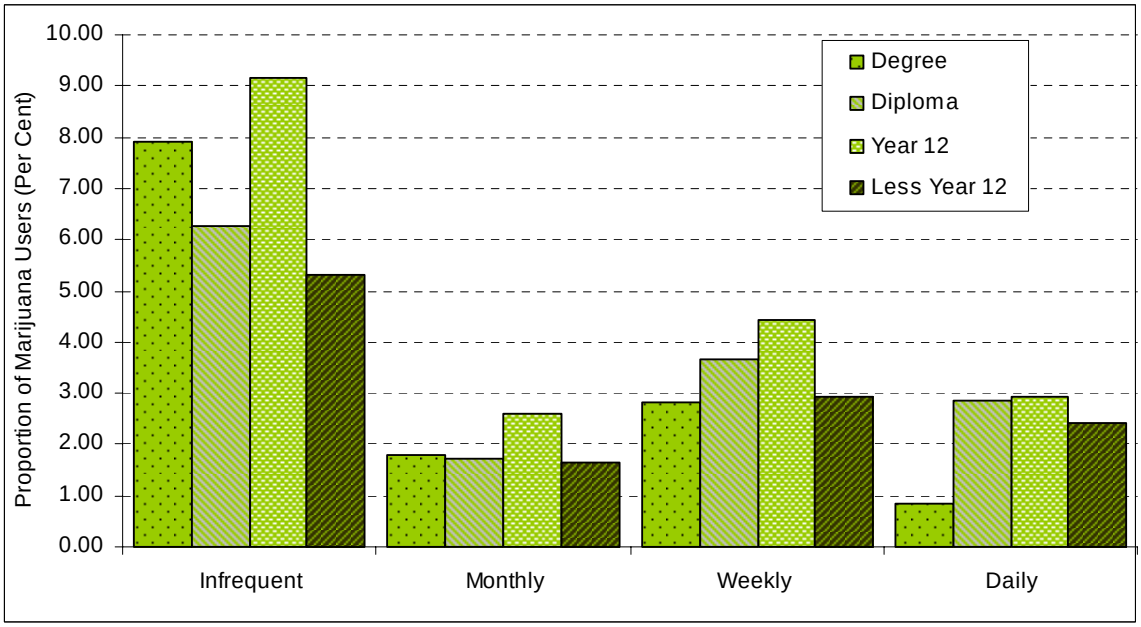
(B) By Marriage Status



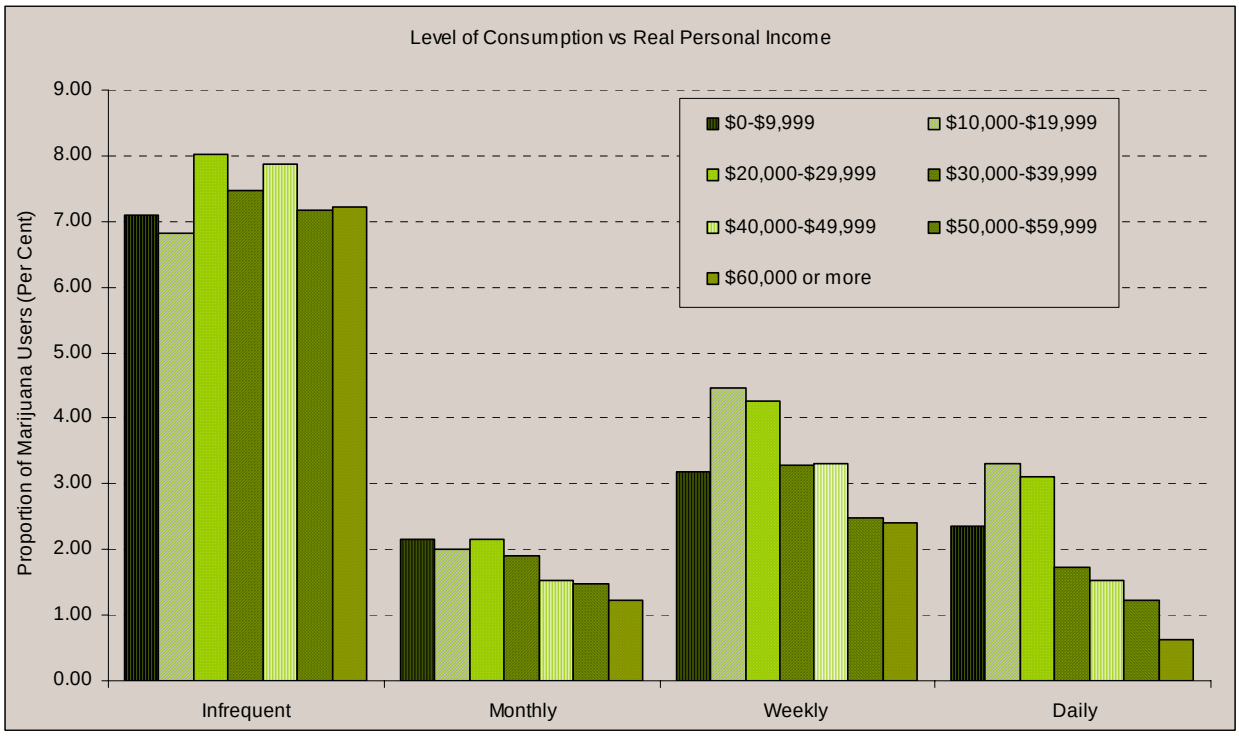
(C) By Main Activity



(D) By Education



(E) By Income



(F) By Age

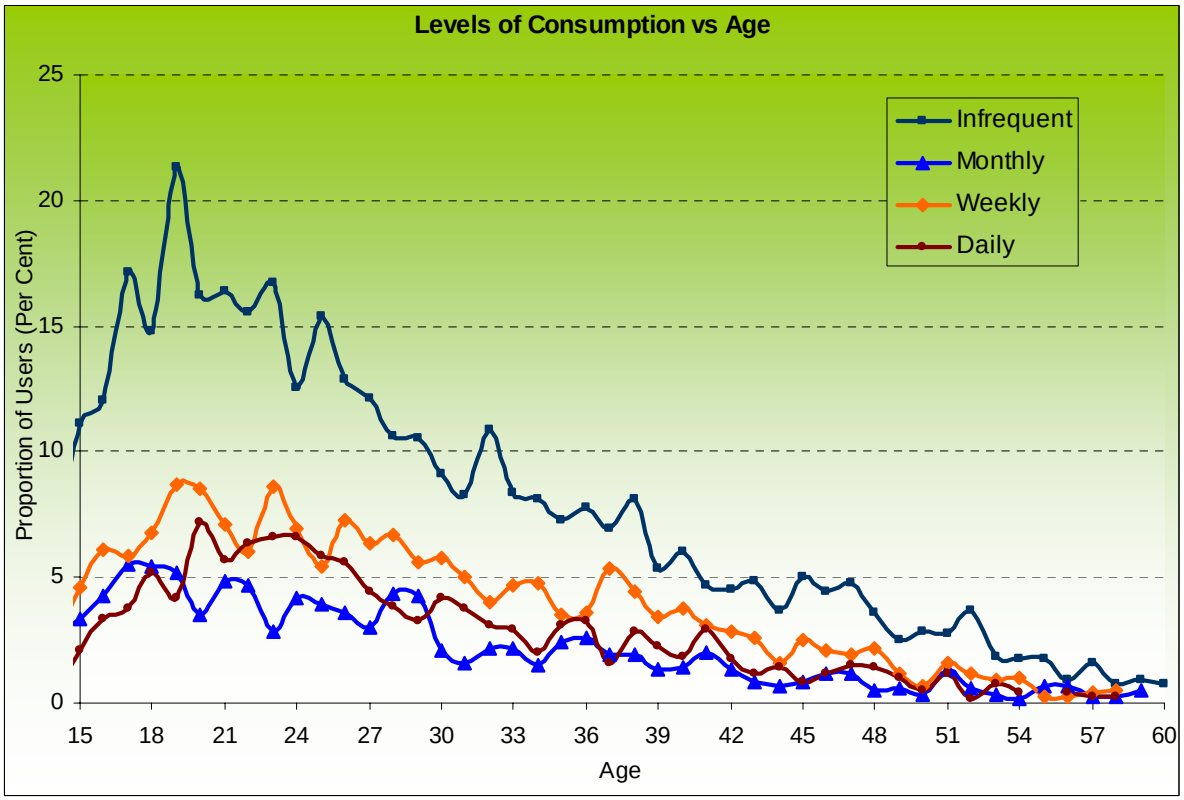


Figure 7-(E) illustrates the relationship between the levels of marijuana participation and levels of personal income. Proportions of infrequent users do not vary greatly by income levels, with people earning $20,000 to $50,000 a year having slightly higher prevalence. However, there seems to be a clear pattern for the weekly and daily categories where the proportions of users decrease as income become higher beyond certain income levels. Low income earners of $10,000 to $30,000 a year have the highest proportion of being daily users. The expected probability of frequent use decreases as income increases beyond $20,000 a year.

Finally, turning to the relationship of consumption levels and age in Figure 5-(F), there seems to be a sharp peak around the 19 years of age for the proportion of infrequent usage, which then decline consistently as age increases. However, for the frequent usage categories, the plateaus seem to span the whole range of late teens and mid-late twenties.

5.2 A Sequential Model for Levels of Marijuana Consumption

We now turn to the relationship between individual characteristics and levels of marijuana consumption. Results in Table 11 have shown how the observed sample frequencies for various levels of marijuana consumption differ by socio economic and demographic groups. However an econometric model is required to isolate the partial effects of individual explanatory factors when other factors are controlled.

Participation studies as the one reported in Section 3 make no distinction between users who only use a couple of times a year and those who smoke every day. Zhao and Harris (2004) further studied the determinants for different levels of marijuana consumption. They assumed that the observed marijuana data on consumption levels are the results of sequential decisions involving the decision of whether to participate in consuming the illicit drug and then the decision of how much to consume once the decision of participation is made. They used a probit model for the first decision for participation, and an ordered probit model for the conditional probabilities in the second decision. It is not unreasonable to expect that the two decisions may relate to different factors or that the same explanatory variable may have different effects on the two decisions.

Table 12. Results for Sequential Model for Marijuana Consumption

	Participation		Level of Consumption (Conditional on Participation)				
		Marginal Effects		Marginal Effects			
	Coeff.	*Participation*	*Coeff.*	*Infrequent*	*Monthly*	*Weekly*	*Daily*
Constant	8.77*		4.77				
YR98	0.34*	0.07*	0.26*	-0.11*	0.00	0.04	0.06*
YR01	0.42*	0.07*	0.39*	-0.16*	0.01	0.06	0.09*
LNAGE	-14.35*	-2.63*	-0.37*	0.15*	-0.01	-0.06	-0.08*
MALE	0.28*	0.05*	0.31*	-0.13*	0.00	0.05	0.07*
MARRIED	-0.35*	-0.07*	0.03	-0.01*	0.00	0.00	0.01
DECRIM	0.13*	0.02*	0.16*	-0.06*	0.00	0.02	0.04
WORK	0.18*	0.03*	-0.11*	0.05*	0.00	-0.02	-0.03
STUD	-0.11*	-0.02*	-0.37*	0.15*	-0.01	-0.06	-0.07
UNEMP	0.39*	0.09*	0.05	-0.02*	0.00	0.01	0.01
CAPITAL	0.07*	0.01*	-0.09*	0.04*	0.00	-0.01	-0.02
ATSI	0.15*	0.03*	-0.04	0.01*	0.00	-0.01	-0.01
ENGLISHS	0.58*	0.08*	0.03*	-0.01*	0.00	0.01	0.01
SCHOOL	-0.77*	-0.09*	-0.34*	0.14*	-0.01	-0.06	-0.07
DEGREE	0.04	0.01	-0.35*	0.14*	-0.01	-0.06	-0.07
DIPLOMA	0.08*	0.01*	-0.08*	0.03*	0.00	-0.01	-0.02
YR12	-0.01	0.00	-0.16*	0.07*	0.00	-0.03	-0.04
DEPCHILD	-0.01	0.00	-0.02	0.01	0.00	0.00	0.00
LNPA	1.13	0.21	6.55	-2.61	0.10	1.02*	1.49
LNPM	-1.64*	-0.30*	-0.51	0.21	-0.01	-0.08	-0.12
LNPT	-8.8*	-1.61*	-7.78	3.10	-0.11	-1.21	-1.77*
LNINC	-0.57*	-0.10*	-1.68*	0.67*	-0.02	-0.26	-0.38*

Source: Results compiled from Zhao and Harris (2004). 'ME' indicate resulted changes in the probabilities for the relevant consumption levels. '*' indicates 5% significance. Standard errors are available from the original paper.

Results for coefficients and marginal effects for both parts of the sequential model for marijuana consumption are presented in Table 12. Looking at the social and demographic effects on the two decisions, factors such as age, income and gender have similar effects on both decisions. For example, males are more likely to participate and also, conditional on participation, more likely to be consuming more frequently than females. However, for some other explanatory variables, the effects on the two decisions are different or even have opposite directions. Being single, unemployed, of ATSI background, or speaking English at home significantly increases the chance of participating in marijuana usage, but among the marijuana users these factors no long have a significant effect on how often the user consumes. In terms of education attainment, higher educated people are not significantly different from the less-than-Year-12 educated in participation, or are even more likely to participate, but among the users, all higher educated groups are less likely to engage in frequent consumption than the less-than-year-12 group. Finally, while being employed increases the probability of participation, people who work are

less likely to smoke heavily compared to those who claim retirement, house keeping or doing volunteer work. The dummy variables for residency in a capital city are significant and have opposite signs in the two equations; people in capital cities are more likely to participate, but among users, heavier smokers are more likely to be residing in non-capital cities.

6. MARIJUANA DECRIMINALISATION

At the center of marijuana related policy debate is whether legal sanction is the best approach to reduce the use and the associated harm of the drug. The ongoing debates of marijuana decriminalization concentrate on potential benefits and costs of such policy, and in particular whether decriminalization will result in an increase in marijuana participation. By the time of the 2001 NDSHS, South Australia, Australia Capital Territory, and Northern Territory had already *decriminalized* small possession and cultivation of marijuana for personal consumption. This policy change provides some natural experiments for evaluating the potential effects of marijuana decriminalization policy.

Cameron and Williams (2001) and Zhao and Harris (2004) have both estimated the decriminalization effects on marijuana participation using the NDSHS data and found a positive and significant marginal effect of about 2% of decriminalization on prevalence. Williams (2004) found decriminalization effect is only significant for the sub-sample of male aged 25 years old or above. In all these studies, probit models are used where the decriminalization dummy variable is treated as an exogenous explanatory variable. However, there is a strong case against the assumption of exogeneity of the decriminalization dummy. There may be unobservable individual/state characteristics for individuals residing in the decriminalized states that are correlated to unobservable factors that also affect the decision of marijuana participation. Individuals may 'self-select' into states and states may make policy decisions as a result of individuals who live there.

In this section we report decriminalization effects on marijuana participation probability estimated in Damrongplasit, Hsiao and Zhao (2007) allowing for endogeneity of decriminalization and flexibility for different marijuana related behaviour by decriminalization

status. In particular, estimates from an endogenous switching probit model and three nested models are presented and compared. In addition, propensity score stratification matching approach is also used to estimate an additional measure of treatment effect of decriminalization.

The endogenous switching probit model consists of three equations. The first is a probit model that endogenises the decriminalization status which relates to individual and state characteristics. The next two equations are two separate probit models for the decision of marijuana participate conditional on the two types of decriminalization status. The error terms for the three equations are allowed to be correlated. The model is a trivariate probit model with partial observability, in the sense that for each individual we only observe his marijuana smoking behaviour in a decriminalized or un-decriminalised state but not both.

It can be shown that this model nest three other models. (i) The first is a simple probit model with decriminalization dummy as an exogenous variable on the right hand side. (ii) The second is an endogenous bivariate probit model that endogenises the decriminalization variable on the right hand side of the participation equation, but the participation equation is the same by dicriminalisation status other than the intercept. (iii) The third nested model is a generalization of the frequently used two-part model, with marijuana participation equation being different by decriminalization status but there being no correlation between the two decisions of decriminalization and participation.

While full results of the model are presented and discussed in Damrongplasit, Hsiao and Zhao (2007), Table 13 summarises the estimated average treatment effects (ATE) of marijuana decriminalization using the four models. Our results in Table 13 show that decriminalization has positive and significant impact on marijuana smoking behavior although their magnitudes differ across different models. When using a simple binary probit model without accounting for endogeneity of treatment and flexibility in behavior, ATE is estimated to be 3.7%. This is very similar to those estimated by Cameron and Williams (2001), and Zhao and Harris (2004). When accounting for endogeneity of treatment as in model (ii), ATE rises to 4%. However, when

allowing for behavioral differences between the treatment and the control groups but ignoring endogenous treatment as in the two-part model, we obtain ATE of 13.7%. Finally, in the most general model (iv), our estimated ATE is found to be 16.3%. All these figures are statistically significant at 1% level. It is clear that the two-part and the endogenous probit switching models provide stronger support to the opponents of marijuana decriminalization policy because they yield substantially larger ATEs than the binary probit and the bivariate probit models.

Table 13 Average Treatment Effects (ATE) of Decriminalisation on Marijuana Participation Probability using Different Models

	Probit	Endogenous Bivariate Probit	Two-Part Switching	Endogenous Switching	Propensity Score Stratification
ATE	**0.037***** (0.0002)	**0.040***** (0.0002)	**0.137***** (0.002)	**0.163***** (0.002)	**0.059 to 0.112** *** (0.020 to 0.026)

Notes: Standard errors are in parentheses. ** indicates significance at 1% (two-tailed test)

Finally, Damrongplasit, Hsiao and Zhao (2007) also estimated the average treatment effects of decriminalization on marijuana participation using propensity score matching approach. We used four different ranges of overlapping region and two different ways of partitioning the propensity scores, and as shown in the last column in Table 13 the resulted ATE varies between 0.059 and 0.112. See details in the paper.

7. CONCLUSION

We present some econometric analysis on Australian individuals' consumption of marijuana and related drugs using unit record data from several waves of the National Drug Strategy Household Survey. We investigate the effects of individual socioeconomic and demographic factors and drug prices on participation and levels of consumption of marijuana, the relationship of marijuana participation with other legal and illegal drugs, and the relationship between marijuana decriminalisation and participation.

A suite of econometric models are used in the studies. In particular, multivariate probit models are used to study the joint participation of marijuana and related licit and illicit drugs, namely tobacco, alcohol, cocaine and heroin, allowing for both observable and unobservable personal

characteristics (such as taste and addictive personality) to impact on the joint decision of multi-drug consumption. Results indicate highly significant cross-drug correlation via the unobservables, which will not be available using a univariate approach. The multivariate probit approach allows for conditional and joint probabilities to be modelled and to be linked to a set of explanatory factors. In addition, an endogenous switching probit model and its three nested models are used to estimate the decriminalisation effects on marijuana participation. Our approach allows for potential endogeneity of the decriminalisation dummy variable and flexibility of different behaviour equations for individuals residing in the decriminalised and undecriminalised states. These more general econometric models are shown to generate different estimates and extra information from previous studies.

Finally, there are some modelling limitations in the reported econometric studies. Harris and Zhao (forthcoming) argue that the large proportion of zero observations or non-users needs to be closely examined. They have proposed a zero-inflated ordered probit model (ZIOP) that focuses on the excessive zeros observed in the data. In particular, they allow for the zeros to be related to two distinct sources driven by different systems of consumer behaviours. For example, in the case of marijuana consumption, zeros will be recorded for genuine non-participants due to health or legal concerns, but also for those infrequent purchasers or potential users who may report zero consumption at the time of the survey but who may become consumers if price falls sufficiently. Another issue relates to the lack of flexibility in the use of ordered probit model. Using a single latent equation, ordered probit is restrictive in modelling different levels of consumption. Harris, Ramful and Zhao (2006) have used an ordered generalised extreme value (OGEV) model that is more flexible but also accounts for the ordered nature of the discrete data.

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