SUBSTITUTES OR COMPLEMENTS? ALCOHOL, CANNABIS AND TOBACCO

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Substitutes or Complements?
Alcohol, Cannabis and Tobacco.

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Abstract

This paper estimates the price responsiveness of cannabis, alcohol and cigarette use. Individual level data from four waves of the National Drug Strategy Household Survey are merged with previously unavailable state level data on cannabis prices, and ABS alcohol and tobacco price indices. In addition to own price effects, we estimate cross price effects and the impact of differing legal regimes for cannabis on the use of these three drugs. Establishing the nature of the interdependencies between cannabis, alcohol and cigarettes is important in the development of drug policy so that a policy directed at one drug does not unintentionally affect the demand for other drugs. We find that participation in the use of all three drugs is responsive to own prices and that decriminalisation of cannabis leads to higher cannabis use. Cannabis is found to be a substitute for alcohol and a complement to tobacco. Alcohol and tobacco are found to be complements.

JEL: D1, I1

Key words: drug use, price responsiveness, participation, decriminalisation.

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I. Introduction

This study investigates the use of three commonly used drugs in Australia: cannabis, alcohol and tobacco. In particular, we seek to determine the responsiveness of drug use to each drug's own price, and the price of the other drugs. We also examine the extent to which criminal status impacts upon drug use. These issues are key to drug policy development. For example, if cannabis use is negatively related to its price, then deterring use through price provides an alternative policy instrument to the criminal justice system. The use of price rather than criminal sanctions may offer substantial social benefits. As is often noted, criminalising cannabis use groups it with the more socially harmful illicit drugs This leaves users of cannabis at greater risk of exposure to sellers of harder illicit drugs, and the attendant criminal activity. These undesirable consequences could be avoided by policies which regulate cannabis use through the price system, rather than the criminal justice system.

Notwithstanding their licit status, alcohol and cigarette use are also subject to regulation. While these regulations are developed to address the use of each drug separately, there is reason to believe that the demand for cannabis, alcohol and cigarettes may be interrelated. Tobacco and cannabis share smoking as the route of administration, while the effect of alcohol use resembles cannabis in terms of its intoxicating and euphoric effects. Understanding the interdependencies of demand for various drugs is important to ensure that a policy aimed at influencing the use of one drug does not have unintended consequences for the use of other drugs.

Despite the increased awareness of the harm associated with drinking and smoking, and the emergence of drug policy as a central issue facing legislators, very little has been written on the demand for alcohol, tobacco and cannabis in Australia. The Australian literature that does exist has used time-series data to examine the demand for alcohol (Clements, Yang and Zheng, 1997) and tobacco (Bardsley and Olekalns, 1998). There have been no studies that use micro-data for this purpose and the time-series studies do not attempt

to look at cross-price elasticities. The only studies of an economic nature that examine illicit drug use in Australia are attempts to quantify the costs and benefits of Australian Drug Policy (Marks, 1991 for example). This study attempts to overcome this shortcoming in the literature by examining alcohol, cigarette and cannabis use in Australia.

Cannabis prices are the key to being able to study the interdependence between cannabis and legal drug use. In this study we use previously unavailable data on cannabis prices which were provided by the State Commissioners of Police. We merge state level cannabis price data with individual level observations on drug use from four waves of the National Drug Strategy Household Surveys. The data cover the years 1988, 1991, 1993 and 1995 and each Australian State and Territory. We also use Australian Bureau of Statistics (ABS) state level data on the consumer price indices for alcohol and tobacco. A comparison of South Australia and the other states allows us to examine the effect of decriminalisation of cannabis. In 1987 South Australia reduced the legal sanctions against the possession of small amounts of cannabis. The ACT followed suit in 1992 as did the Northern Territory in 1996.[1] In 1999 Victoria also moved to a system of partial prohibition. Given the current policy climate, our research is both important and timely.

The rest of the paper is organised as follows. In Section 2 we survey the empirical literature on illicit drug use and the substitutability between cannabis, alcohol and cigarettes. Section 3 discusses the legal sanctions against cannabis use in Australia. Section 4 discusses the data. In Section 5 the methodology is introduced and the results are discussed in Section 6. Section 7 concludes.

I. Previous Literature

An empirical literature based on studies from the U.S. has sought to establish the relationship between alcohol, tobacco and cannabis, and the effect of various government

[1] While the ACT also introduced a system of expiation for minor cannabis offences during the period under analysis, no price data was obtained for cannabis. Therefore, we omit the ACT from our analysis. The Northern Territory is excluded for the same reason.

policies on the use of these drugs. Interestingly, these studies do not typically use data on cannabis prices, since this data is not consistently available. In the absence of price data, much of the literature includes policy variables such as decriminalisation of cannabis, drinking age laws, and taxes on alcohol and cigarettes to capture the full price of these drugs.

The U.S. evidence regarding the relationship between alcohol and cannabis use is mixed. The earliest studies found alcohol and cannabis to be substitutes. DiNardo and Lemieux (1992) merged data on youth drug use with data on legal drinking age laws, the price of alcohol and a variable indicating cannabis decriminalisation. Drinking age laws were found to have a significant positive effect on cannabis participation, while decriminalisation had a significant negative effect on alcohol use. They concluded on this basis that the two drugs were substitutes, although the price of alcohol was found to have no effect on cannabis use. In a series of papers, Model (1992, 1993) reached a similar conclusion. She based this on the observation that a high percentage of violence in the U.S. is alcohol-related and that U.S. states with more liberal cannabis laws have lower violent crime rates, particularly homicide rates (Model, 1992), and less (non-cannabis related) emergency room episodes (Model, 1993).

Other studies have however concluded that alcohol and cannabis use have a complementary relationship. For example, Thies and Register (1993) combine data on youth drug use, drinking age laws and decriminalisation indicators to measure the full price of alcohol and cannabis respectively. They find that individuals who live in states where the use of cannabis is decriminalised are more likely to use alcohol.[2] Saffer and Chaloupka (1998), using nationally representative household surveys on drug use, found a negative relationship between cannabis use and the price of alcohol and so also concluded that they are complements. However, decriminalisation was found to have no effect on alcohol use.

[2] They also find that drinking age laws have no effect on cannabis use.

There have also been conflicting findings within studies. Pacula (1988a) found that although youths in states which had decriminalised the use of cannabis had lower rates of alcohol use, indicating that the two goods are substitutes, states with higher taxes on beer had lower levels of cannabis use, indicating complementarity. Mixed findings are also reported by Chaloupka and Laixuthai (1997). Their study of youth finds that cannabis decriminalisation reduces alcohol use, and that alcohol use is positively related to the wholesale price of cannabis, suggesting the two drugs are substitutes. However, a complementary relationship is implied when the retail price of cannabis is used. Farrelly, Bray, Zarkin, Wendling and Pacula (1999) find a negative relationship between alcohol prices and cannabis use for youth but not for adults.

The literature on the interdependency between cannabis and tobacco use is far more limited. There are only two studies of which we are aware. Chaloupka, Pacula, Farrelly, Johnston, O'Malley, and Bray (1999) augment individual level data with state level information on jail sentences and fines for cannabis use to measure the full price of cannabis, the money price of cigarettes and tobacco control policies to measure the full price of cigarettes. The variables related to the full price of cannabis are not significant in the cigarette use equation, nor is the price of cigarettes significant in the cannabis participation equation. However, the price of cigarettes is found to have a negative and significant effect on the average level of cannabis used. Similarly, Farrelly et al. (1999) report the price of cigarettes to have a negative effect on cannabis use, but these results are only significant for youth and not for adults.

In addition to the interdependencies between cannabis, alcohol, and cigarette use, the studies discussed above examine the effect of the legal status, fines and sentences on cannabis use. In general, studies based on youths find no effect of criminal status on cannabis use (DiNardo and Lemieux, 1992; Thies and Register, 1993; Pacula, 1998; Farrelly et al., 1999), while studies based on adults and youth, or just adults tend to find that

decriminalisation increases cannabis use (Model, 1993; Saffer and Chaloupka, 1998), and that cannabis use is negatively related to fines and sentences (Farrelly et al., 1999).

While we are aware of no research in Australia which examines the relationship between the price of cannabis and its use, there have been a series of reports into the impact of the system of expiation on cannabis use in South Australia using the National Drug Strategy Household Surveys (Christie, 1991; Donnelly and Hall, 1994; Donally, Hall and Christie, 1995; Ali, Christie, Lenton, Hawks, Sutton, Hall and Allsop, 1998). These reports found no evidence of an increase in the population rates of cannabis use in South Australia relative to the rest of Australia up until 1993. However, Ali, Christie, Lenton, Hawks, Sutton, Hall and Allsop, (1998) find that a comparison between 1985 and 1995 indicates an increase in self-reported lifetime cannabis use in South Australia relative to the average of other states. They conclude that the increase is unlikely to be due to the introduction of the system of cannabis expiation notices (CEN) on the basis of three observations. First, similar increases in reported lifetime use occurred in Tasmania and Victoria, where there was no change in the legal status of the drug. Second, there was no change in weekly cannabis use in South Australia relative to the average for Australia, and third, there was no increase in cannabis use among young adults aged 14-19 in South Australia relative to the average of the other states.

II. Australian Cannabis History

Australia's policy on cannabis has been guided by the numerous international conventions to which it is a signatory.[3] The 1925 Geneva Convention on Opium and Other Drugs required that cannabis availability and use be limited to medical and scientific purposes. This convention remains in force today, with a legislative system of total prohibition as the most common status of cannabis in the international community.[4] Under

[3] The United States has been a major influence in developing and promoting these conventions.
[4] The Netherlands is an exception. Cannabis receives less punitive treatment compared to other drugs, with small quantities of cannabis products (hashish and marijuana), being legally sold in 'youth centres' and 'coffee

total prohibition, possession, cultivation, importation, sale and distribution of any amount of cannabis is prohibited, and the law is enforced with criminal penalties which may include imprisonment and fines. A number of committees of inquiry into drug use and trafficking in Australia have rejected the legislative model of total prohibition, recommending the removal of criminal penalties for offences relating to the personal use of cannabis.[5] The basis of this recommendation has been the undesirable and unintended consequences associated with the imposition of total prohibition of cannabis. Under total prohibition with criminal penalties, the market for cannabis is a black market, characterised by higher prices and profits relative to a legal competitive market. These features of the market make selling cannabis more attractive to providers of harder drugs, bringing consumers of cannabis into contact with these more dangerous drugs. Also, the higher prices may induce crimes of acquisition for the purpose of obtaining money for buying cannabis. Further, it is perceived that the harm imposed on cannabis users by way of a criminal record, and the imposition of fines and imprisonment, outweighs the social harm of cannabis use.

In particular, the concern over separating cannabis markets from harder drug markets has led several state legislators to liberalise the legal status of cannabis. The first state to do so was South Australia, where a system of expiation was adopted in 1987. The Report of the National Task Force on Cannabis (1994) describes expiation as prohibition with civil penalties. Under this model, possession and cultivation of small amounts of cannabis for personal use is dealt with by civil penalties such as fines, rather than court imposed fines or imprisonment. Criminal sanctions still apply to the possession, cultivation and distribution of large quantities of cannabis. Similar schemes have also been introduced in the ACT in 1992, and the Northern Territory in 1996. Victoria has recently moved to a system of partial prohibition. Under this system, controls on the production and distribution of commercial

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shops' to individuals over the age of 16.

[5] The most recent of these inquiries was carried out by the National Task Force on Cannabis (1994).

quantities remain, but cannabis use, or the possession of small quantities for person use is not an offence.

III. Data

The data used in this research are drawn from the National Drug Strategy Household Surveys (NDSHS) for the years 1988, 1991, 1993 and 1995.[6] The NDSHS was initiated by the Drugs of Dependence Branch of the Federal Department of Human Services and Health and is designed to provide data on the extent of drug use by the non-institutionalised civilian population aged fourteen years and older in Australia[7]. To minimise under reporting of drug use, respondents filled out a sealed section of the questionnaire which allowed them to indicate their level of drug use without the interviewer being aware of their answers.[8] Both legal and illegal drugs are included. In this study we pool the cross-sections into one data set, resulting in a sample size of 9,744.

The three dependent variables used in our analysis are indicators for use of cannabis, alcohol or cigarettes in the last twelve months. Table 1 provides some summary statistics of participation behaviour. 14.3% of the sample report that they have used cannabis in the last 12 months. 81.2% have consumed an alcoholic beverage and 31.7% are cigarette smokers. The table also illustrates the close relationship between cannabis use and the use of the other drugs. 96% of cannabis users also drink alcohol. 63.6% of cannabis users are cigarette smokers. Only 2% (0.3% of the entire sample) use cannabis but neither of the two other substances. Interestingly only 2.8% of cannabis users are smokers but not drinkers. This suggests that the relationship between cannabis and alcohol is closer than that between cigarettes and cannabis. Alcohol and cannabis may meet the same needs.

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[6] There is also a 1985 survey but the questionnaire in that year differed in such a way to make it inappropriate for this study.

[7] We drop individuals aged over 70 from the sample.

[8] Surveys of illicit drug use probably underestimate the prevalence of use. Illicit drug users may be under-sampled in household surveys because they are more heavily represented in populations not included in the surveys, and those who are contacted may be reluctant to take part for fear of legal consequences of admitting an illegal act. Also, those users who take part in the survey are likely to underestimate frequency of use and amounts used. One means of minimising these problems is to assure confidentiality for participants in the

In addition to use drug use, detailed socioeconomic and demographic information is collected in the surveys.[9] We include as potential determinants of drug use the following individual specific variables: age, gender, marital status, the presence of children in the household, an indicator for still in school, highest level of education attained, and an indicator for residing in a capital city. A full definition of variables and descriptive statistics is given in the appendix.

The individual level survey data is merge with price data which varies by state and year. The alcohol and tobacco prices are from the Consumer Price Index, Tobacco and Alcohol: Group, Subgroup and Expenditure Class Index Numbers. This unpublished, state level quarterly data for the cigarettes and tobacco subgroup and alcoholic drinks subgroup was provided by the Australian Bureau of Statistics. In addition to this we have quarterly cannabis price data for each state.[10] These data were previously unavailable and have been supplied by the State Commissioners of Police. The price are those elicited by police during undercover buys. We have prices for purchases of grams and pounds of "head" which is the flowering top of the cannabis plant and has the highest concentration of the active ingredient, THC, and also for grams and pounds of "leaf" which is the chopped leaf of the plant. All prices are converted into real prices by dividing by the CPI. We convert the four price series to an annual standardised cannabis price, as is described below.

Standardising Prices

Following the method outlined in Saffer and Chaloupka (1995), we construct the standardised cannabis price by regressing the log of price, P_{jt}^{MARIJ}, on a dummy variable, *pound*, that equals 1 if the price is for a pound of the drug and 0 if it is for a gram of the drug, a dummy variable, *head*, that equals 1 if the price is for "head" and 0 for "leaf". We also include vectors of state and year dummies.

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survey.

[9] Some, but not all years provide individual and household income data.

$$P_{jt}^{MARIJ} = \alpha + \beta_1 pound_{jt} + \beta_2 head_{jt} + \beta_3 state_j + \beta_4 year_t + \varepsilon_{jt} \quad (1)$$

We then predict the price of a gram of head quality cannabis in each year for each of the states using the coefficients that result from OLS estimation of equation 1. This is the cannabis price that is used in the participation equations estimated below. It is worth noting that by estimating the prices in this way we also eradicate any concern associated with the possible endogeneity of the prices. The use of predicted prices removes any correlation that may have existed between the actual prices and the error term in the participation equation.

IV. Method

Following standard consumer theory, we model individuals as maximising utility subject to a budget constraint. We assume that utility is a function of the amount of each good consumed and partition the choice set of goods into D, which consists of the drugs, alcohol, cigarettes and cannabis; and the remaining goods *X*. The maximisation problem is thus:

$$\underset{D,X}{Max}\, U(D,X) \text{ s.t. } P^D.D + P^X.X \leq INC$$

where *INC* is the individual's disposable income, P^D is the vector of drug prices and P^X is the vector of prices for all other goods.[11] In modelling illicit drug use, we control for the full price of the drug, as opposed to just the money price. The full price reflects the additional cost associated with legal and social sanctions against drug use. We adopt a general specification that allows the legal status to affect cannabis use directly, and indirectly through responsiveness to money price. The former effect is captured using a dichotomous indicator that reflects the criminal nature of cannabis use in the individual's place of residence. *CRIM*

[10] We only have limited data for the Australian Capital Territory (ACT) and the Northern Territory (NT) and so exclude individuals in these localities from the sample.

[11] This formulation ignores the dynamic aspect of consumption and so does not recognise the addictive character of the legal and illegal drugs. This is an extension worthy of further research.

equals 1 if cannabis is illicit and zero if licit. The latter effect is modelled by interacting the money price of cannabis with the indicator *CRIM*.

The individual's problem can be expressed by the Lagrangean equation:

$$Z = U(D, X) + \lambda(P^D.D + P^X.X - INC) \tag{2}$$

Solving for the optimal choice of X and D and allowing for corner solutions produces the following first order conditions:

$$\frac{\partial Z}{\partial D_j} \leq 0,\ D_j \geq 0 \ \text{ and } \ D_j \frac{\partial Z}{\partial D_j} = 0 \text{ for j} = 1,.....J$$

$$\frac{\partial Z}{\partial x_k} \leq 0,\ x_k \geq 0 \ \text{ and } \ x_k \frac{\partial Z}{\partial x_k} = 0 \text{ for k} = 1,....K. \tag{3}$$

$$\frac{\partial Z}{\partial \lambda} = 0$$

Hence, if the individual engages in the use of drug *j*,

$$D_j > 0 \text{ and } \frac{\partial Z}{\partial D_j} = 0$$

where

$$\frac{\partial Z}{\partial D_j} = \frac{\partial U}{\partial D_j} + \lambda P^{D_j} \ \text{ and so } \frac{\partial U}{\partial D_j} = -\lambda P^{D_j} \tag{4}$$

This is just the standard optimisation condition which states that the individual consumes to the point where the marginal utility of consumption equals the marginal disutility associated with foregoing goods that would otherwise have been bought and consumed.

However it is also possible that :

$$\frac{\partial Z}{\partial D_j} > 0,\ D_j = 0 \ \Rightarrow \frac{\partial U}{\partial D_j} < -\lambda P^{D_j} \tag{5}$$

In this case we have a corner solution and the individual does not consume any of the jth drug because higher utility is attained by allocating resources to the consumption of the other goods. In this case the individual does not participate in the use of this particular drug.

The demand for each of the drugs, D_j, is hence a function of the (full) price of each good relative to the other goods. Because we are focusing on the consumption of drugs we have implicitly included the price of other goods by normalising the drug prices with respect to the CPI. We include interactions between the different prices in the empirical analysis to allow for the most flexible functional form. D_j will also be a function of individual income, and variables that affect the utility function of the individual.

We can thus write:

$$\begin{aligned} D_j = {} & \alpha + \gamma_1 \hat{P}^{ALC} + \gamma_2 \hat{P}^{CIG} + \gamma_3 \hat{P}^{MARIJ} + \gamma_4 \left(\hat{P}^{ALC} \times \hat{P}^{CIG}\right) + \gamma_5 \left(\hat{P}^{ALC} \times \hat{P}^{MARIJ}\right) \\ & \gamma_6 \left(\hat{P}^{CIG} \times \hat{P}^{MARIJ}\right) + \gamma_7 CRIM + \gamma_8 CRIM \times \hat{P}^{MARIJ} + \eta Y + e_j \\ & = \beta' x + e_j \end{aligned} \tag{6}$$

where j={alcohol, cigarettes, cannabis}, Y is a vector of demographic variables that are likely to be correlated with individuals' tastes and e_j is a standard normal random variable. In the analysis below the vector Y consists of the age of the individual, gender, marital status, presence of children in the household, educational attainment and whether the individual lives in a capital city. Unfortunately most years of the NDSHS do not provide data on individual or household income. Income would enter the participation index via the budget constraint and might also affect people's tastes. Although we can't control for income in this study, its effect is captured by those demographic variables that are correlated with income: age, education, gender and capital city residency. In addition to picking up differences in tastes across age groups, the age variables may also pick up the effect of changes in availability and trends in drug use over time.

In this paper, we focus on the decision to use cannabis, alcohol and tobacco, and not on the frequency of use. Therefore, our dependent variable is

$$I_j = 1 \quad if \ D_j > 0$$
$$= 0 \quad if \ D_j \leq 0$$

where I_j, is an indicator for the unobserved level demand for good j, D_j, and we refer to $\beta' x$ as the underlying participation index. Note that:

$$P(D_j > 0) = P(\beta' x + e_j > 0)$$
$$= F(\beta' x)$$

We assume F to be the standard normal distribution function and so participation in drug use has the standard probit formulation.

V. Results

Table 2 presents the probit estimates of the participation equations for cannabis, alcohol and cigarettes. To aid interpretation only the marginal effects and their t-statistics are reported. The probit coefficients are shown in Table A2 in the appendix. [12] The marginal effects are interpreted as the change in the probability of participation that results from a one unit increase in a continuous variable and from a change from zero to one for dummy variables. We will first focus on the price effects and later summarise the effects of the demographic variables.

General to specific modelling was used to arrive at the preferred model for each drug. The most general model included a full set of price interaction variables. If the interaction terms were insignificant, they were dropped from the specifications reported in Table 2.

Own Price Elasticities

As discussed above, it is important to control for the full price of an illicit drug when modelling its demand. The full price includes the expected legal and social sanctions associated with drug use. The routine way to control for the full price is to include a dummy

[12] The probit coefficients represent the contribution of the explanatory variables to the underlying participation index and are ordinal rather than cardinal.

variable that reflects the legal status of the drug (*CRIM* =1 if the drug is illicit and 0 if decriminalised). This is the approach taken in column (1A) of Table 2. In Column (1B) we allow criminalisation to operate via the price mechanism by the inclusion of the variable ($CRIM \times P^{MARIJ}$). This allows criminalisation to affect the responsiveness of use to the money price. It may be that when illicit, even very low money prices will not greatly induce participation, but that when legal sanctions are relaxed, price changes will result in behavioural changes. Ideally one would like to include both *CRIM* and ($CRIM \times P^{MARIJ}$). However, in the current context these two terms are very highly correlated and multicollinearity results. The approach taken here is to control for each separately and report both sets of results.

One further point bears mentioning before interpreting the estimation results. In practice, our indicator for criminal status of cannabis is identical to a (1-South Australian dummy variable) because South Australia was the only state to have relaxed legal sanctions against cannabis included in our sample. The indicator *CRIM* is intended to account for the impact of cannabis laws on drug use. It is conceivable, however, that other differences between South Australia and the rest of Australia, such as prevailing attitudes and behaviours, are being picked up by this variable.

Columns (1A) and (1B) of Table 2 report the results for the participation in cannabis use equation including *CRIM* and ($CRIM \times P^{MARIJ}$) respectively. Only the price interaction term ($P^{ALC} \times P^{CIG}$) was statistically significant, so the others were dropped. The coefficient on the variable *CRIM* in column (1A) shows that cannabis participation is on average 1.9 percentage points lower in states in which use is a criminal offence. The price of cannabis is negatively correlated with participation but is not statistically significant.

However, the results in Column (1B) suggest that cannabis use is price responsive. In states where cannabis has been decriminalised a 1% increase in the real price of cannabis decreases the probability of participation by 0.044 percentage points, and this effect is

statistically significant.[13] When the drug is illicit, then the price effect is the sum of the coefficient on P^{MARIJ} and ($CRIM$ x P^{MARIJ}). The resulting point estimate suggests that the probability of participation decreases 0.031 percentage points in response to a 1% increase in price. This accords with intuition, since under a harsh penalty regime one might reasonably expect that demand would be less responsive to money prices because the money price is a smaller component of the full price.

Column 1A and 1B of Table 3A summarise the total marginal effect of price on cannabis use and the corresponding t-stats. Column 1B shows that the responsiveness of use to own price in states where it is a criminal offence is insignificantly different from zero. This suggest that participation may not be price responsive at all in states where the possession of small quantities is a criminal offence. This is consistent with the insignificant coefficient on P^{MARIJ} in model (1A) since this coefficient captures only the average price effect across the six states, of which only one state has decriminalised cannabis use. The lack of price responsiveness in the other five states dominates the model (1A) result.

Models 1A and 1B are also consistent in terms of predicting that participation is highest in South Australia. This is because, although decriminalisation increases price responsiveness of cannabis use, South Australia enjoys much lower cannabis prices relative to the other states. The latter effect dominates to the extent that model (1B) predicts participation to be the greatest in South Australia in accordance with model (1A). The average participation rate in SA is 2.5 percentage points higher than Victoria's, 2.1 percentage points higher than for WA, 2.0 percentage points higher than for NSW, 1.7 percentage points higher than for Queensland and 1.2 percentage points higher than in Tasmania.

In summary, we do not reject the hypothesis that cannabis use is price responsive once legal sanctions have been liberalised. This price responsiveness combined with lower

[13] Note that the price terms are all measured in logs and so the marginal effects are the change in the

prices in South Australia (which are possibly a result of this liberalisation) have induced higher participation. The finding that decriminalisation coincides with higher participation rates is consistent with the U.S. studies although the magnitude of the effect is larger here.[14]

Columns 2 and 3 of Table 2 report the results of the alcohol and cigarette participation equations. Again some price interaction terms were not significant and were dropped. For both legal drugs we control for the effect of the legal status of cannabis through the inclusion of the dummy variable *CRIM*.[15] The results provide no evidence that the criminal status of cannabis use has a direct effect on participation in alcohol or cigarette use.[16] Our findings with respect to alcohol and cigarette use are consistent with the findings of Saffer and Chaloupka (1998), and Chaloupka, Pacula, Farrelly, Johnston, O'Malley and Bray (1999).

Both alcohol and cigarette use are clearly own-price responsive. The inclusion of the price interaction terms makes it difficult to assess the total marginal effect of say an increase in the price of alcohol on alcohol consumption by just examining the individual marginal effects in Table 2. To aid interpretation Table 3A reports the total marginal effects of price changes in each of the equations.[17] A 1% increase in the real price of alcohol decreases the probability of participation by 0.61 percentage points. A 1% increase in the real price of cigarettes decreases the probability of smoking by 0.15 percentage points.

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participation probability for a 100% increase in the variable in levels.

[14] As mentioned in Section 2, Saffer and Chaloupka (1995) found that decriminalisation in the U.S. led to increased participation in the range of 4 to 7%. Our result shows participation increasing 0.019/0.144=13.2%.

[15] We experimented with instead including $CRIM \times P^{MARIJ}$ but the reported models fit the data better.

[16] Column (2) shows that on average alcohol participation is lower (1.9 percentage points) in states where use remains a criminal offence, although this effect is statistically insignificant. This is identical in magnitude to the predicted decrease in cannabis participation in these states. Although we should not make too much of a statistically insignificant result, as discussed earlier, we cannot differentiate between the effects of decriminalisation and prevailing attitudes and behaviours in South Australia. That is to say, we may be detecting a "South Australia" effect rather than a "decriminalisation" effect. Since other states have subsequently liberalised laws on the use of cannabis, this is an issue that can be addressed in the future when data on these states can be utilised to better identify the effects of these laws.

[17] Note that the marginal effect of a change in the price of alcohol, for example, is calculated as

$$\frac{\partial F}{\partial P^{ALC}} + \frac{\partial F}{\partial (P^{ALC} * P^{CIG})} \cdot \bar{P}^{CIG} + \frac{\partial F}{\partial (P^{ALC} * P^{M})} \cdot \bar{P}^{M} = -5.02 + 3.20 \times 0.27 - 2.93 \times -1.214.$$

t-values are calculated using the delta method.

Table 3B converts all of the price effects to participation elasticities. This allows a comparison of the magnitude of the own price effects, standardising for the mean level of use and allows a comparison with the results of previous studies which often report their results in terms of elasticities.[18] The participation elasticities are –0.306 for decriminalised cannabis, -0.756 for alcohol and–0.484 for cigarettes. These are in the range of estimates found internationally. For example, Chaloupka et al. (1999) reports own price cigarette elasticities that range from –0.42 to –0.66.

Cross-Price Elasticities

The U.S. studies provide mixed evidence on whether alcohol and cannabis are substitutes. The results from the cannabis equation in Table 3 suggest that in Australia, alcohol and cannabis are economic substitutes. The coefficients on the price of alcohol shows that a 1% increase in the real price of alcohol increases the probability of cannabis use by 0.35 percentage points, and this effect is statistically significant.[19] The strength of this finding is somewhat weakened by the results for the alcohol equation, which show cannabis prices to have an insignificant negative effect on participation in alcohol use.

Table 3 also shows that the marginal effect of the price of cigarettes on cannabis use is negative which suggests that on average cannabis and tobacco are complements, although the coefficient is statistically insignificant. We can look to the cigarette equation for further evidence on the nature of the relationship between cannabis and cigarettes. In this equation the price of marijuana is statistically significant and has a negative total marginal effect on cigarette use. A 1% increase in the price of cannabis reduces the percentage of smokers by 0.09 percentage points. This is consistent with the cannabis equation in suggesting

[18] The participation elasticities show the predicted percentage change in participation for a 1% change in the respective price. They are calculated by dividing the total marginal effect for each variable by the mean of the dependent variable.

[19] Chaloupka et al (1999) similarly estimate a cannabis participation equation and also a quantity demanded equation. They include beer taxes as a proxy for the price of beer. They find that the beer tax does not significantly affect the probability of consuming cannabis (participation) but significantly increases the quantity

complementarity. Hence, we conclude that cigarettes and cannabis are complements. The complementary relationship between cigarettes and marijuana is consistent with the two U.S. studies (Chaloupka et al., 1999; Farelly et al., 1999) that have examined this issue.

The alcohol and cigarette equations also provide evidence on the relationship between these two legal drugs. The effect of the price of cigarettes on alcohol participation is negative and strongly significant while the price of alcohol is positive but insignificant in the cigarette equation. This is taken as evidence that on average, cigarettes and alcohol are complements.

Demographic Variables

The relationship between the demographic variables and participation are generally significant and robust to specification. The effect of age varies across the three drugs. People in the 20-24 year old age group are more likely to have used cannabis in the last 12 months compared to the less than 20 age group, whereas individuals over 30 years of age are less likely to have used cannabis relative to the under 20 year olds. In terms of cigarette use, those aged 20-34 are more likely to have smoked in the last 12 months compared to under 20 year olds, while the over 40 year olds are less likely to have smoked than those under 20 years of age. The probability of an individual drinking alcohol does not vary with age, except that the over 40 age group are significantly less likely to have had a drink in the last 12 months.

Men are significantly more likely to use all drugs. Interestingly the effect of gender on participation hardly varies with the type of drug. Men are about 6 percentage points more likely to use each drug than women. Marriage reduces the probability of smoking both cannabis and tobacco but does not affect alcohol participation. The presence of children in the household decreases the probability of smoking cannabis and drinking slightly but does not affect cigarette participation.

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of cannabis used.

The highest level of educational attainment can be taken to proxy social class. Cannabis participation is largely insensitive to education levels. This is in contrast to the other categories of drugs. The better educated are less likely to smoke cigarettes. Those who hold a degree are 14 percentage points less likely to be cigarette smokers than are people whose highest level of education is year 10 at high school. The opposite is true of alcohol participation. Degree holders are 10.2 percentage points more likely to drink alcohol than are those with a year 10 education. Cannabis participation rates are on average 1.5 percentage points higher in the states' capital cities than elsewhere whereas residency does not affect alcohol and tobacco consumption.

I. Conclusions

In conclusion, our results suggest that participation in the use of both licit and illicit drugs is price sensitive. Participation is sensitive to own prices and the price of the other drugs. In particular, we conclude that cannabis and alcohol are economic substitutes, cannabis and tobacco are complements, as are alcohol and tobacco.

The results also suggest that the liberalised legal status of cannabis in South Australia coincides with higher cannabis participation. There is some evidence, that decriminalisation may work via the price mechanism. In South Australia, where cannabis is no longer a criminal offense, cannabis use is more price responsive. The increased sensitivity to price, in concert with the lower prices for cannabis under decriminalisation, results in a higher predicted level of cannabis use.

Decriminalisation per se, does not seem to significantly affect participation in the use of the legal drugs. Even if the link between decriminalisation and lower cannabis prices is causal, we find no evidence that lower cannabis prices significantly reduce alcohol or cigarettes use. In terms of cigarette use, our results indicate that lower cannabis prices are

associated with increased cigarette participation, while alcohol participation is unaffected by cannabis prices.

This study has only examined the sensitivity of participation decisions to contemporaneous drug prices and does not attempt to examine either the frequency of use or explicitly model the addictive nature of these goods. Frequency may be expected to be more sensitive to price changes than participation. Further investigation of these issues is likely to prove a fruitful area for future research.

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Table 1: Summary of Participation Patterns

Drugs	Proportion of Sample
Cannabis	14.3%
Alcohol	81.2%
Cigarettes	31.7%
Multiple Drug Use:	
Cannabis & Alcohol & Cigarettes	8.7%
Alcohol and Cigarettes only	20.2%
Alcohol and Cannabis only	5.0%
Cigarettes and Cannabis only	0.4%
Alcohol only	47.3%
Cigarettes only	2.5%
Cannabis only	0.3%
N=9744	

Table 2: Probit Estimation of Participation Decision

Marginal Effects and t-values.

Dependent Variable:	Cannabis				Alcohol		Cigarettes	
	(1A)		(1B)		(2)		(3)	
	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat
Price Variables:								
P^{MARIJ}	-0.030	-1.34	-0.044	-1.96*	0.155	3.07*	-0.204	-4.14*
P^{ALC}	0.807	2.96*	0.835	3.06*	-5.02	-2.95*	0.905	1.86
P^{CIG}	0.072	3.06*	0.072	3.08*	-0.550	-3.39*	0.466	2.53*
$P^{ALC}*P^{CIG}$	-1.77	-3.17*	-1.81	-3.22*	3.20	3.78*	-2.01	-2.07*
$P^{M}*P^{CIG}$					-0.25	-1.98*	0.441	3.19*
$P^{ALC}*P^{M}$					-2.93	-2.22*		
Criminal	-0.019	-2.04*			-0.019	-1.63	0.008	0.54
Crim*P^{MARIJ}			0.013	1.93				
Age Categories:								
20-24	0.033	2.72*	0.033	2.72*	0.025	1.34	0.114	4.88*
25-29	-0.002	-0.16*	-0.002	-0.16	0.007	0.33	0.092	3.86*
30-34	-0.039	-3.67*	-0.039	-3.67*	0.0002	-0.01	0.064	2.71*
35-39	-0.062	-6.14*	-0.062	-6.14*	0.011	0.53	0.040	1.64
40+	-0.196	-18.0*	-0.196	-18.0*	-0.065	-3.64*	-0.083	-4.09*
Male	0.061	10.0*	0.0608	10.04*	0.063	7.95*	0.062	6.42*
Married	-0.092	-11.9*	-0.093	-11.9*	0.005	0.54	-0.116	-9.74*
Kids	-0.017	-2.52*	-0.017	-2.52*	-0.023	-2.58*	-0.004	-0.38
At School	-0.055	-6.69*	-0.055	-6.69*	-0.154	-8.11*	-0.168	-9.57*
Tafe	0.020	2.38*	0.020	2.37*	0.067	6.76*	-0.036	-2.91*
Year 12	0.004	0.50	0.004	0.50	0.066	5.94*	-0.062	-4.43*
Degree	0.005	0.49	0.005	0.48	0.102	8.55*	-0.141	-9.25*
Capital City	0.015	2.25*	0.015	2.26*	-0.001	-0.11	0.014	1.27
Pseudo-R^2	0.19		0.19		0.05		0.05	
N	9744		9744		9744		9744	

* - indicates statistical significance at the 5% level. Note that all prices are in logs, the omitted age category is <20 years and the omitted educational category is Year 10.

Table 3A: Marginal Price Effects

(t-values in parentheses and* indicates significance at the 5% level)

	Cannabis		Alcohol	Cigarettes
	(eqn. 1A)	(eqn. 1B)	(eqn. 2)	(eqn. 3)
$P^{MARIJUANA}$ if illicit if decriminalised	[redacted]	[redacted]	-0.036 (-1.12)	-0.087 (-2.36*)
$P^{ALCOHOL}$	0.336 (2.00*)	0.354 (2.12*)	[redacted]	0.370 (1.26)
$P^{CIGARETTES}$	-0.002 (-0.15)	-0.004 (-0.20)	-0.107 (-4.00*)	[redacted]

Table 3B: Participation Elasticities

(* indicates significance at the 5% level)

	Cannabis		Alcohol	Cigarettes
	(eqn. 1A)	(eqn. 1B)	(eqn. 2)	(eqn. 3)
$P^{MARIJUANA}$ if illicit if decriminalised	[redacted]	[redacted]	-0.044	-0.274 *
$P^{ALCOHOL}$	2.33 *	2.458*	[redacted]	1.164
$P^{CIGARETTES}$	-0.014	-0.028	-0.132*	[redacted]

Definitions of Variables

P^{MARIJ}	= log(the predicted price of an gram of head/CPI)
P^{ALC}	= log(ABS alcohol price index/CPI)
P^{CIG}	= log(ABS cigarette price index/CPI)
Decrim	= 1 if the individual resides in a state that has reduced legal sanctions against cannabis use and 0 otherwise.
Male	=1 if the individual is male, 0 otherwise.
Married	= 1 if the individual is married, 0 otherwise.
Kids	= 1 if children live in the individual's household, 0 otherwise.
Age20-24	= 1 if the individual is aged between 20 and 24, 0 otherwise.
Age25-29	= defined as above.
Age30-34	= defined as above.
Age35-39	= defined as above.
Age40	= 1 if the individual is aged 40 or over, 0 otherwise.
School	= 1 of the individuals is still in school
Year12	= 1 if the highest level of education obtained is year 12, 0 otherwise.
Tafe	= 1 if the highest level of education obtained is a tafe degree, 0 otherwise.
Degree	= 1 if the highest level of education obtained is a university degree, 0 otherwise.
Capital City	= 1 if the individual lives in the capital city of his/her State or Territory, 0 otherwise.

Table A1: Descriptive Statistics

N=9744	Mean	Std Dev.	Min	Max
Participation:				
Alcohol	0.812	0.391	0	1
Cigarettes	0.318	0.466	0	1
Cannabis	0.144	0.351	0	1
Prices:				
P^{ALC}	0.042	0.030	-0.027	0.099
P^{CIG}	0.266	0.251	-0.258	0.587
P^{MARIJ}	-1.214	0.163	-1.688	-0.914
$P^{ALC}xP^{CIG}$	0.017	0.018	-0.002	0.057
$P^{ALC}xP^{M}$	-0.050	0.0370	-0.125	0.035
$P^{CIG}xP^{M}$	-0.315	0.301	-0.756	0.327
Decriminalised	0.161	0.367	0	1
Demographic:				
Male	0.464	0.499	0	1
Marry	0.574	0.495	0	1
Kids	0.396	0.489	0	1
Age2024	0.092	0.289	0	1
Age2529	0.104	0.305	0	1
Age3034	0.119	0.324	0	1
Age3539	0.107	0.309	0	1
Age40	0.415	0.493	0	1
School	0.127	0.333	0	1
Year 12	0.141	0.348	0	1
Tafe	0.218	0.413	0	1
Degree	0.118	0.322	0	1
Capital City	0.724	0.447	0	1

Table A2: Probit Coefficients corresponding to Table 2.

Dependent Variable:	Cannabis				Alcohol		Cigarettes	
	(1A)		(1B)		(2)		(3)	
	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat	$\partial F/\partial X$	t-stat
Price Variables:								
P^{MARIJ}	-0.182	-1.34	-0.264	-1.96*	0.603	3.07*	-0.579	-4.14*
P^{ALC}	4.84	2.96*	5.01	3.06*	-19.48	-2.95*	2.57	1.86
P^{CIG}	0.431	3.06*	0.434	3.08*	-2.13	-3.39*	1.32	2.53*
$P^{ALC}*P^{CIG}$	-10.61	-3.17*	-10.84	-3.22*	12.41	3.78*	-5.70	-2.07*
$P^{M}*P^{CIG}$					-0.98	-1.98*	1.25	3.19*
$P^{ALC}*P^{M}$					-11.36	-2.22*		
Criminal	-0.107	-2.04*			-0.077	-1.63	0.023	0.54
$Crim*P^{MARIJ}$			0.078	1.93				
Age Categories:								
20-24	0.178	2.72*	0.178	2.72*	0.102	1.34	0.307	4.88*
25-29	-0.011	-0.16	-0.011	-0.16	0.026	0.33	0.250	3.86*
30-34	-0.268	-3.67*	-0.268	-3.67*	0.0009	-0.01	0.177	2.71*
35-39	-0.480	-6.14*	-0.480	-6.14*	0.043	0.53	0.111	1.64
40+	-1.284	-18.0*	-1.284	-18.0*	-0.248	-3.64*	-0.237	-4.09*
Male	0.357	10.0*	0.357	10.04*	0.246	7.95*	0.177	6.42*
Married	-0.523	-11.9*	-0.523	-11.9*	0.020	0.54	-0.326	-9.74*
Kids	-0.101	-2.52*	-0.101	-2.52*	-0.090	-2.58*	-0.012	-0.38
At School	-0.399	-6.69*	-0.399	-6.69*	-0.514	-8.11*	-0.542	-9.57*
Tafe	0.115	2.38*	0.115	2.37*	0.279	6.76*	-0.105	-2.91*
Year 12	0.025	0.50	0.025	0.50	0.284	5.94*	-0.182	-4.43*
Degree	0.030	0.49	0.030	0.48	0.456	8.55*	-0.443	-9.25*
Capital City	0.093	2.25*	0.093	2.26*	-0.004	-0.11	0.039	1.27
Pseudo-R^2	0.19		0.19		0.05		0.05	
N	9744		9744		9744		9744	

* - all prices are in logs, the omitted age category is <20 years, the omitted educational category is Year 10.