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Cannabis, Alcohol and Cigarettes: Substitutes or Complements?

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This paper uses individual level data from the National Drug Strategy Household Surveys to estimate the price responsiveness of participation in cannabis, alcohol and cigarette use. In addition to own price effects, we estimate cross price effects and the impact of decriminalizing cannabis use. We find that participation is responsive to own prices. There is some evidence that cannabis is a substitute for alcohol and a complement to cigarettes, and that alcohol and cigarettes are complements. The liberalization of cannabis laws in South Australia may have led to a temporary increase in cannabis use among the over-30 age group.

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 on 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, criminalizing 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. Cigarettes 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

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unintended consequences for the use of other drugs.[1]

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, cigarettes and cannabis in Australia. The Australian literature that does exist has used time-series data to examine the demand for alcohol (Clements *et al.* 1997) and cigarettes (Bardsley and Olekalns 1999), and alcohol and cannabis (Clements and Daryal 1999). Other studies of an economic nature examine illicit drug use in Australia by attempting to quantify the costs and benefits of Australian Drug Policy; see for example Marks (1991). There have been no studies that use micro-data to investigate the price responsiveness of use of these drugs and the time-series studies do not directly examine the inter-relatedness of demand by estimating cross-price elasticities. This study attempts to overcome this shortcoming in the literature by examining own and cross-price elasticities of 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 decriminalization 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.[2] 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 organized as follows. Section II surveys the empirical literature on cannabis use and the substitutability between cannabis, alcohol and cigarettes. Section III discusses the legal sanctions against cannabis use in Australia. Section IV discusses the data. In Section V, the methodology is introduced and the results are discussed in Section VI. Section VII concludes.

II Previous Literature

An empirical literature based on studies from the USA has sought to establish the relationship between alcohol, cigarettes and cannabis, and the effect of various government 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 decriminalization of cannabis, drinking age laws, and taxes on alcohol and cigarettes to capture the full price of these drugs.

The US 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 decriminalization. Higher drinking ages were found to have a significant positive effect on cannabis participation, while decriminalization 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 (1991, 1993) reached a similar conclusion.

[1] This issue arose recently in the USA during debate over proposals which would have seen large price increases used to discourage youth tobacco use. Opponents suggested that, even if the cigarette price increases did discourage youth from using tobacco, they would lead them to substitute towards cannabis (Chaloupka *et al.* 1999).

[2] 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. Also, the cannabis price series for the Northern Territory begins in 1992. Since there are very few price observations for the period under analysis, we omit observations from the Northern Territory from the sample.

She based this on the observation that a high percentage of violence in the USA is alcohol-related and that US states with more liberal cannabis laws have lower violent crime rates, particularly homicide rates (Model 1991), 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 decriminalization 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 decriminalized are more likely to use alcohol.[3] 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, decriminalization was found to have no effect on alcohol use.

There have also been conflicting findings within studies. Pacula (1998a) found that although youths in states which had decriminalized 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 decriminalization 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 *et al.* (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 cigarette use is far more limited. There are only two studies of which we are aware. Chaloupka *et al.* (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 1998b; Farrelly *et al.* 1999), while studies based on adults and youth, or just adults tend to find that decriminalization 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 uses micro level data to examine the relationship between the price of cannabis and its use, Clements and Daryal (1999) analyse this relationship using aggregate data. They construct a time series of annual ounces of cannabis consumed in Australia. They do this using information on the number of cannabis users and their frequency of use obtained from the National Drug Strategy Household Surveys in the years 1988, 1991, 1993 and 1995. They assume the cannabis price is constant over time and estimate a cannabis price elasticity by exploiting changes in the relative price between cannabis and alcohol. They estimate the price elasticity of demand to be -0.5. The paper also reports on the findings of a survey of 281 first-year economics undergraduates students enrolled at the University of Western Australia who were asked about their current cannabis use and how they would respond to the legalization of cannabis use. The authors conclude that legalizing cannabis use would result in current users increasing their level of consumption, but that the change in legal regime would have no impact on current non-users.

The National Drug Strategy Household Surveys have also been the basis of a series of reports into the impact of the system of expiation on cannabis use in South Australia (Christie 1991; Donnelly and Hall 1994; Donnelly *et al.* 1995; Ali *et al.* 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 *et al.*

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

(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.

III Australian Cannabis History

Australia's policy on cannabis has been guided by the numerous international conventions to which it is a signatory.[4] 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.[5] Under 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.[6] 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, characterized 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 liberalize 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 (Ali and Christie 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 quantities remain, but cannabis use, or the possession of small quantities for personal use is not an offence.

IV 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.[16] 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-institutionalized civilian population aged 14 years and older in Australia.[18] To minimize 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

[14] The USA has been a major influence in developing and promoting these conventions.

[15] 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 shops' to individuals over the age of 16.

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

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

[18] We dropped individuals aged over 70 from the sample.

the interviewer being aware of their answers.[9] 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. As shown in Table 1, 14.3 per cent of the sample report that they have used cannabis in the last 12 months, 81.2 per cent have consumed an alcoholic beverage and 31.7 per cent are cigarette smokers. The table also illustrates the close relationship between cannabis use and the use of the other drugs: 95.8 per cent of cannabis users drink alcohol, and 63.6 per cent of cannabis users are cigarette smokers. Only 2.1 per cent (0.3 per cent of the entire sample) use cannabis but neither of the two other substances. Interestingly, only 2.8 per cent 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.

In addition to drug use, detailed socioeconomic and demographic information is collected in the surveys.[10] 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 merged with price data which varies by state and year. The alcohol and cigarette prices are from the Consumer Price Index, Tobacco and Alcohol: Group, Subgroup and Expenditure Class Index Numbers. These unpublished state-level quarterly data for the cigarettes and tobacco subgroup and alcoholic drinks subgroup were provided by the ABS. In addition to this, we have quarterly cannabis price data for each state.[11] These data were previously unavailable and have been supplied by the State Commissioners of Police. The prices are those elicited by police during undercover buys. The prices are recorded to correspond to one of

- a gram of 'head' which is the flowering top of the cannabis plant and has the highest concentration of the active ingredient, THC
- a pound of head
- a gram of 'leaf' which is the chopped leaf of the plant
- a pound of leaf.

We do not have a full set of prices for any of these price types. However, we do have sufficient observations of each type of price for each state to enable us to convert the four price series to an annual standardized cannabis price. Table 2 provides some descriptive statistics of the raw price data.

(i) Standardizing Prices

Following the method outlined in Saffer and Chaloupka (1995), we construct a standardized

TABLE 1
Summary of Participation Patterns

% of sample who use	Cannabis	Alcohol	Cigarettes
Cannabis only	0.3	—	—
Alcohol only	—	47.3	—
Cigarettes only	—	—	2.5
Cannabis and Alcohol only	5.0	5.0	—
Cannabis and Cigarettes only	0.4	—	0.4
Alcohol and Cigarettes only	—	20.2	20.2
Cannabis and Alcohol and Cigarettes	8.7	8.7	8.7
Column Total	14.3	81.2	31.7

[9] Surveys of illicit drug use probably underestimate the prevalence of use. Illicit drug users may be undersampled 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 the 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 minimizing these problems is to assure confidentiality for participants in the survey.

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

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

TABLE 2
Cannabis Prices

	N	Mean	Std Dev.	Min	Max
Leaf/gram	168	23.10	8.19	7.50	50.00
Leaf/pound	172	2409.30	991.28	750.00	5500.00
Head/gram	101	32.18	10.66	15.00	50.00
Head/pound	165	4318.79	998.46	2000.00	7000.00

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, and 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 and allow the difference between the price of head and the price of leaf to differ across states by interacting state with head.[12]

$$P_{jt}^{\text{MARIJ}} = \alpha + \beta_1 state_j + \beta_2 year_t + \beta_3 pound_{jt} + \beta_4 head_{jt} + \beta_5 (state^* head)_{jt} + \varepsilon_{jt} \quad (1)$$

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. All prices have been converted into real prices by dividing by the CPI.

V Method

Following standard consumer theory, we model individuals as maximizing 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 maximization 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.[13] 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 capture the full price of the drug by using a dichotomous indicator that reflects the criminal nature of cannabis use in the individual's place of residence. *DECRIM* equals 1 if cannabis is licit and zero if illicit.

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

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

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

[12] We also experimented with a less restrictive model that interacted all of the variables in the model with all state and year dummies. In addition, we tried a more restrictive model that did not interact state with head. The model presented in (1) however gives the best fit. The results reported below are not sensitive to the way in which the cannabis prices are standardized.

[13] This formulation ignores the dynamic aspect of consumption and so does not recognize the addictive character of the legal and illegal drugs. This is an extension worthy of further research. The theoretical model also does not allow the individual's income to be affected by drug use. Adding this aspect to the model results in an additional term in the first-order condition which reflects the marginal (dis)utility associated with the change in income associated with drug use. In terms of estimation strategy, endogenizing income would imply the need to instrument this regressor in order to obtain consistent estimates. In our case, we have no empirical measure of income. We attempt to control for income through variables correlated with income such as education, age and gender, giving our estimating equations a reduced form interpretation. Therefore, endogenizing income would not affect the estimation strategy. In particular, if drug use affects income, then the coefficients on the exogenous explanatory variables in the participation equations will capture this effect. We plan to examine the labour market effects of drug use in a subsequent paper.

$$\frac{\partial Z}{\partial D_j} \leq 0, D_j \geq 0 \text{ and } D_j \frac{\partial Z}{\partial D_j} = 0 \text{ for } j = 1, \ldots, J$$
$$\frac{\partial Z}{\partial x_k} \leq 0, x_k \geq 0 \text{ and } x_k \frac{\partial Z}{\partial x_k} = 0 \text{ for } k = 1, \ldots, K$$
$$\frac{\partial Z}{\partial \lambda} = 0 \quad (3)$$

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

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

where

$$\frac{\partial Z}{\partial D_j} = \frac{\partial U}{\partial D_j} + \lambda P^{D_j} \quad \text{and so} \quad \frac{\partial U}{\partial D_j} = -\lambda P^{D} \quad (4)$$

This is just the standard optimization 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

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

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.

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 normalizing 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

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

where $j = \{\text{alcohol, cigarettes, cannabis}\}$, 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 cannot 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 this paper, we focus on the decision to use cannabis, alcohol and cigarettes, and not on the frequency of use. Therefore, our dependent variable is

$$\begin{aligned} I_j = 1 \quad &\text{if} \quad D_j > 0 \\ = 0 \quad &\text{if} \quad D_j \leq 0 \end{aligned}$$

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

$$\begin{aligned} P(D_j > 0) &= P(\beta' x + e_j > 0) \\ &= F(\beta' x) \end{aligned}$$

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

VI Results

Table 3 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 4.[14] 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 holding other variables constant at the sample average. We will first focus on the price effects and later summarize the effects of the demographic variables.

General to specific modelling was used to arrive at the preferred model for each drug. We started with models that included the full set of price interaction variables. If the interaction terms were

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

insignificant, they were dropped from the specifications reported in Table 3.[15]

It is important to note that, in this paper, we are estimating participation equations, not demand equations. As such, the coefficient estimates only tell us about the probability of using the drug, not how much of the drug is used. It is likely that quantity consumed is more sensitive to price than participation but our results do not shed light on this issue which is an area we plan to address in future research.

The only other point of interpretation that needs to be made before we examine the results is that, in practice, our indicator o

TABLE 4
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}	−1.222	0.149	−1.637	−0.952
$P^{ALC} \times P^{CIG}$	0.017	0.018	−0.002	0.057
$P^{ALC} \times P^{MARIJ}$	−0.051	0.037	−0.124	0.040
$P^{CIG} \times P^{MARIJ}$	−0.313	0.314	−0.777	0.364
DECRIM	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
Age 20–24	0.092	0.289	0	1
Age 25–29	0.104	0.305	0	1
Age 30–34	0.119	0.324	0	1
Age 35–39	0.107	0.309	0	1
Age 40+	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

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.[16]

(i) 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 in addition to the money price. The routine way to control for the full price is to include a dummy variable that reflects the legal status of the drug ($DECRIM = 1$ if the drug is decriminalized, 0 otherwise). This is the approach taken in column 1 of Table 3, which reports the results for the participation in cannabis use equation. Of the price interaction terms, only ($P^{ALC} \times P^{CIG}$) was statistically significant, so the others were dropped.

The cannabis participation equation strongly supports the hypothesis that, like most goods, cannabis use is price responsive. The coefficient on the cannabis money price is strongly statistically significant ($p < 0.001$) and negative. It suggests that a 10 per cent increase in the money price of cannabis decreases the probability of cannabis participation by 1.27 percentage points. The other component of the full cannabis price is the legal sanctions imposed if detected using the drug. Cannabis participation is also shown to be responsive to this non-money price, with the coefficient on the *DECRIM* indicator positive and statistically significant ($p = 0.02$). The point estimate suggests that, holding all else equal, the probability that an individual uses cannabis is expected to be 2.0 percentage points higher if the individual lives in South Australia compared to the other states. The finding that decriminalization coincides with a higher probability of participation is consistent with US studies which use data on adults and youth, although studies based on youth only found no such effect of decriminalization on use.[17]

Columns 2 and 3 of Table 3 report the results of the alcohol and cigarette participation equations. Again some price interaction terms were not significant and were dropped. 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 3. To aid interpretation Table 5 reports the total marginal effects of price changes in each of

[16] One way to strengthen our interpretation of the South Australian dummy as a decriminalization effect is to include other variables that vary across the states and to which the different participation behaviour could possibly be attributed. We experimented with including the percentage of the population under the age of 24 in each state as an explanatory variable. The logic being that a larger proportion of the population in this age group (which was the age group that was found to participate the most in cannabis use) may have spill over effects on the rest of the population. This variable was, however, found to be statistically insignificant.

[17] Saffer and Chaloupka (1995) found that decriminalization in the USA led to increased participation in the range of 4–7 per cent. Our result shows participation increasing 0.02/0.144, i.e. 13.9 per cent. One reason that our estimated effect is higher may be that our decriminalization dummy is picking up a 'South Australian' effect, in addition to a decriminalization effect.

TABLE 5
Marginal Price Effects

	Cannabis (eqn. 1)	Alcohol (eqn. 2)	Cigarettes (eqn. 3)
P^{MARIJ}	**−0.127 (−5.62)***	−0.008 (−0.24)	−0.132 (−3.41)*
P^{ALC}	0.417 (2.50)*	**−0.379 (−1.72)****	0.220 (0.79)
P^{CIG}	0.003 (0.15)	−0.127 (−4.73)*	**−0.138 (−4.31)***

Notes: t-values in parentheses,* indicates significance at the 5% level, ** indicates significance at the 10% level.

the equations.[18] Both alcohol and cigarette use are found to be own-price responsive. A 10 per cent increase in the real price of alcohol decreases the probability of participation by 3.79 percentage points. A 10 per cent increase in the real price of cigarettes decreases the probability of smoking by 1.38 percentage points.

Table 6 converts all of the price effects to participation elasticities. This allows a comparison of the magnitude of the own price effects, standardizing 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.[19] The participation elasticities are −0.888 for cannabis, −0.467 for alcohol and −0.436 for cigarettes. These are in the range of estimates found internationally. For example, Chaloupka *et al.* (1999) reports own price cigarette participation elasticities that range from −0.42 to −0.66.

TABLE 6
Participation Elasticities

	Cannabis (eqn. 1)	Alcohol (eqn. 2)	Cigarettes (eqn. 3)
P^{MARIJ}	**−0.888***	−0.010	−0.416*
P^{ALC}	2.920*	**−0.467****	0.693
P^{CIG}	0.020	−0.156*	**−0.436***

Notes: * indicates significance at the 5% level,
** indicates significance at the 10% level).

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

$$\frac{\partial F}{\partial P^{ALC}} + \frac{\partial F}{\partial (P^{ALC} \times P^{CIG})}.\overline{P}^{CIG} + \frac{\partial F}{\partial (P^{ALC} \times P^{M})}.\overline{P}^{M}$$
$$= -6.95 + 2.93 \times 0.27 - 4.74 \times -1.22$$

t-values are calculated using the delta method.

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

(ii) Cross-Price Elasticities

The marginal effect of the price of alcohol in the cannabis equation in Table 5 shows that a 10 per cent increase in the real price of alcohol increases the probability of cannabis use by 4.17 percentage points, and this effect is statistically significant.[20] This suggests that alcohol and cannabis are economic substitutes (although the money price of cannabis has an insignificant negative effect on participation in alcohol use). In contrast though, the decriminalization of cannabis corresponds to higher alcohol participation. The probability of an individual drinking alcohol is 2.8 percentage points higher in SA than elsewhere. This finding is consistent with Thies and Register (1993) and suggests that the drugs may be complements. As discussed earlier, it is not clear whether this result is reflecting the impact of cannabis laws on alcohol use and so the relationship between the drugs, or is simply reflecting prevailing attitudes and behaviours in South Australia. That is, we may be detecting a 'South Australia' effect – that South Australians like to smoke cannabis and drink alcohol more than other Australians – rather than a 'decriminalization' effect.[21] Since other states have subsequently liberalized laws on the use of cannabis, this is an issue that can be addressed in

[20] 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 of cannabis used.

[21] If this is the case, it may also be that the decriminalization of cannabis use in South Australia is to some extent endogenous.

the future when data on these states can be utilized to better identify the effects of these laws.

We find that cannabis and cigarettes are complements. Table 5 shows that the marginal effect of the price of cannabis in the cigarette equation is negative and significant (although the coefficient on cigarette prices in the cannabis equation is statistically insignificant). A 10 per cent increase in the price of cannabis reduces the probability of being a smoker by 1.32 percentage points. The complementary relationship between cigarettes and cannabis is consistent with the US study by Farrelly *et al.* (1999). Unlike alcohol, the decriminalization of cannabis is found to have no impact on the probability of being a cigarette smoker.

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.

(iii) Demographic Variables

The effect of age varies across the three drugs. In terms of cannabis use, the probability of use peaks for people in the 20–24-year-old age group, and declines monotonically for the subsequent age groups. In terms of cigarette use, those aged over 40 are the least likely to be smokers, followed by under 20-year-olds. The probability of cigarette participation decreases monotonically with age once one is over 20. 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 than the other groups.

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 six percentage points more likely to use each drug than women. Marriage reduces the probability of smoking both cannabis and cigarettes 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.

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 1.3 percentage points higher in the states' capital cities than elsewhere (although not quite significant at the 5% level $p = 0.051$) whereas residency does not affect alcohol and cigarette consumption.

(iv) Robustness Tests For the Decriminalization Effect

The standard approach to modelling the effect of decriminalization on cannabis use is to include an indicator variable, as done in the preceding analysis. Aside from the issue of separating decriminalization from state effects faced in this study, the dummy variable approach may be criticized for being too restrictive in the way in which it allows decriminalization to influence participation. As most studies (including this one) pool several waves of survey data, this method forces the effect of decriminalization to be the same for all years covered in the data, and yields an estimate of the average effect across the four years. The dummy variable approach also constrains the impact of decriminalization to be the same for all individuals, irrespective of observable characteristics such as age or gender, which may be associated with a greater propensity to participate. In this section, we attempt to explore these issues. In particular, we examine whether the effect of decriminalization differs over the survey years, and whether it differs across individuals according to observable characteristics.

To examine the effect of decriminalization on cannabis participation over time, we interacted *DECRIM* with year dummies.[22] The results are reported in column 2 of Table 7 and show an interesting pattern. (Column 1 contains the re-

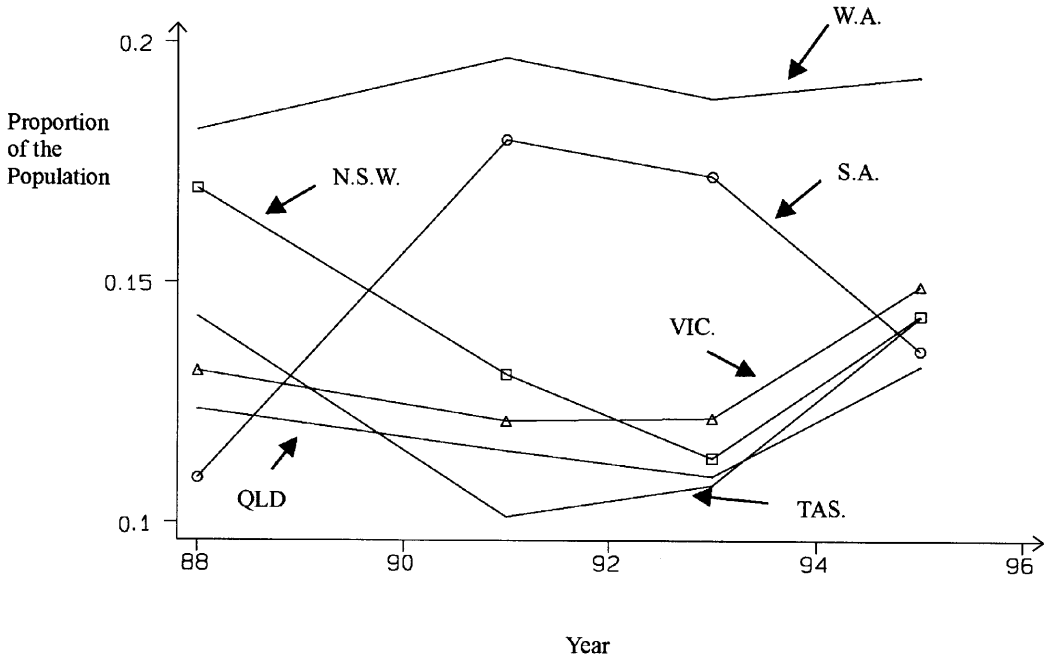
[22] When pooling four cross-sections of data one may be concerned that the relationship between the dependent and explanatory variables has changed over time and so pooling may not be appropriate. The data in this study only span a seven-year period so we do not expect this to be a problem. However, we attempted to examine this issue by estimating the equations on each year separately but it produced very imprecise estimates.

TABLE 7
Robustness of Cannabis Participation Decision: Marginal Effects and t-values

	Cannabis (1)		Alcohol (2)		Cigarettes (3)	
Dependent variable:	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Price variables						
P^{MARIJ}	−0.127	−5.62*	−0.130	−5.74*	−0.130	−5.75*
P^{ALC}	1.115	4.17*	0.683	2.02*	0.691	2.05*
P^{CIG}	0.114	5.02*	0.101	4.35*	0.100	4.32*
$P^{ALC} \times P^{CIG}$	−2.621	−4.84*	−1.722	−2.60*	−1.751	−2.65*
DECRIM	0.020	2.28*			0.930	0.61
Age categories						
20–24	0.032	2.73*	0.032	2.70*	0.031	2.43*
25–29	−0.001	−0.11	−0.001	−0.06	−0.008	−0.64
30–34	−0.039	−3.69*	−0.039	−3.67*	−0.050	−4.55*
35–39	−0.061	−6.12*	−0.061	−6.09*	−0.069	−6.58*
40+	−0.195	−17.9*	−0.195	−18.0*	−0.204	−17.2*
Male	0.062	10.2*	0.061	10.2*	0.063	9.54*
Married	−0.092	−11.9*	−0.092	−11.9*	−0.081	−9.65*
Kids	−0.017	−2.56*	−0.017	−2.56*	−0.016	−2.21*
At School	−0.053	−6.58*	−0.053	−6.58*	−0.058	−6.72*
Tafe	0.020	2.35*	0.020	2.38*	0.022	2.37*
Year 12	0.006	0.67	0.006	0.73	0.003	0.33
Degree	0.005	0.52	0.006	0.54	0.016	1.41
Capital City	0.013	1.95	0.013	1.98*	0.011	1.50
*DECRIM**88			−0.019	−0.75		
*DECRIM**91			0.045	2.72*		
*DECRIM**93			0.033	1.99*		
*DECRIM**95			−0.003	−0.20		
*DECRIM**P^{MARIJ}					0.471	0.62
*DECRIM**P^{CIG}					0.337	0.30
*DECRIM**P^{ALC}					−2.276	−0.33
*DECRIM**20–24					0.013	0.38
*DECRIM**25–29					0.054	1.39
*DECRIM**30–34					0.123	2.71*
*DECRIM**35–39					0.122	2.55*
*DECRIM**40+					0.079	2.00*
*DECRIM**Married					−0.042	−2.52*
*DECRIM**Male					−0.010	−0.64
*DECRIM**Kids					−0.008	−0.48
*DECRIM**Yr12					0.023	0.91
*DECRIM**Tafe					−0.009	−0.41
*DECRIM**Degree					−0.052	−2.32*
*DECRIM**School					0.056	1.66
*DECRIM**Capital					0.014	0.69
Pseudo-R^2	0.194		0.195		0.198	
N	9744		9744		9744	

Notes: * Indicates statistical significance at the 5% level.
All prices are in logs, the omitted age category is < 20 years, and the omitted educational category is Year 10.

FIGURE 1
Cannabis Participation Rates by State and Year



sults from the previous analysis to facilitate comparison.) These results indicate that, *ceteris paribus*, cannabis participation was not higher in South Australia in 1988 than in the other states. However, it was significantly higher in 1991 and in 1993 (4.5 and 3.3 percentage points, respectively). The probability of participating then dropped in 1995 to the same level as in the other states. This inverted U-shaped pattern can also be seen in Figure 1 which plots cannabis participation rates by year and state. The findings suggest that the effect of introducing a more liberal legal regime has only a transient effect on cannabis use. In particular, seven years after decriminalization of cannabis in South Australia, the probability of an individual from SA using cannabis is no different than an individual from one of the other Australian states, all else being equal.

We next consider whether the effect of decriminalizing cannabis differed according to observable characteristics by interacting the decriminalization dummy with all of the explanatory variables. The results are contained in column 3 of Table 7. These results suggest that participation in South Australia increased only among those aged over 30. It also corresponds with lower use among those that are married and have a degree. Given that most people who are married and have a degree are over 30, this suggests overall decriminalization increases the probability of participation among over 30-year-olds and this effect is moderated somewhat if one is married or university-educated.[23]

Taken together, the results in columns 2 and 3 of Table 7 suggest that the introduction of the Cannabis Expiation Notice Scheme in SA led to a transitory increase in participation in cannabis use. This increase in participation was due to older individuals delaying giving up cannabis use, rather than an increase in the initiation of younger users of cannabis. This is consistent with the US literature on the effect of decriminaliz-

[23] We tried estimating an equation which combined the variables in columns 2 and 3 of Table 4. Unfortunately again this resulted in too much multicollinearity, making it difficult to interpret the results.

ation on cannabis use. While studies from the USA based on adults, or which include both adults and youth, find decriminalization to have a positive effect on cannabis participation, studies based on youth only find no such effect. Our data contain both youth and adults and, as does the US literature, we find decriminalization to have a positive impact on cannabis use. We also find the probability of cannabis use to increase through youth up to the 20–24-year-old age group, and to decline monotonically thereafter. Moreover, we find the effect of decriminalization is on the age distribution of use. In particular, we find that decriminalization did not result in increased participation by the younger age groups, rather it simply delayed the exit of the older age groups from participation when the drug was first legalized.

VII 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 cigarettes are complements, and there is some evidence to suggest that cannabis and alcohol are substitutes, although decriminalization of cannabis corresponds with higher alcohol use. Alcohol and cigarettes are found to be complements.

The results also show that the liberalized legal status of cannabis in South Australia coincides with higher cannabis participation on average over the period under investigation. In South Australia, where possession of small amounts of cannabis is no longer a criminal offence, the probability of use is estimated to be 2.0 percentage points higher than elsewhere based on the pooled sample of data. Further investigation revealed that although participation increased in South Australia shortly after the liberalization of the cannabis laws, the effect of decriminalization was transitory and had disappeared in seven years. In addition, our results indicate that the increase in participation was due to individuals over 30 delaying giving up cannabis use as a result of its changed legal status, not an increase in use by younger people. This finding provides an explanation of why US studies based on youth fail to find that decriminalization has an impact on the probability of cannabis use, while studies based on adults and youth, or just adults, do find a positive association between decriminalization and participation in cannabis use.

A shortcoming of this study is that we cannot disentangle the effects of decriminalization of cannabis use from a 'South Australian' effect. Therefore, the decriminalization dummy may be picking up other differences between South Australia and the rest of Australia in addition to the legal status of cannabis use. It is not clear what these other effects may be. One possibility is that different state population age profiles may affect attitudes to cannabis use. We investigated this using the proportion of each state's population aged under 24 years as an explanatory variable but it was found to be statistically insignificant. This provides some support for interpreting *DECRIM* as representing the impact of liberalized cannabis laws on use. Since other states have subsequently liberalized laws on the use of cannabis, this is an issue that can be addressed in the future when data on these states can be utilized to better identify the effects of these laws.

It is important to note that 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. Investigation of these issues is likely to prove a fruitful area for future research. Furthermore, many of the issues examined in this paper would benefit from further study when data covering a longer time period become available.

Appendix: Definitions of Variables

P^{MARIJ}	= log(the predicted price of a 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
Age 20–24	= 1 if the individual is aged between 20 and 24, 0 otherwise
Age 25–29	= defined as above
Age 30–34	= defined as above

TABLE A1
Probit Coefficients Corresponding to Table 3

	Cannabis (1)		Alcohol (2)		Cigarettes (3)	
Dependent variable:	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Price variables						
P^{MARIJ}	−0.767	−5.62	0.746	3.35	−0.686	−5.07
P^{ALC}	6.734	4.17	−26.97	−3.74	1.936	1.54
P^{CIG}	0.686	5.01	−0.972	−7.14	1.246	2.26
$P^{ALC} \times P^{CIG}$	−15.83	−4.83	11.365	3.70	−4.931	−1.94
$P^{M} \times P^{CIG}$					1.171	2.77
$P^{ALC} \times P^{MARIJ}$			−18.40	−3.34		
DECRIM	0.117	2.27	0.114	2.51	−0.018	−0.45
Age categories						
20–24	0.179	2.72	0.010	1.31	0.311	4.95
25–29	−0.008	−0.11	0.024	0.31	0.249	3.84
30–34	−0.270	−3.69	0.004	0.04	0.176	2.70
35–39	−0.480	−6.12	0.040	0.50	0.113	1.67
40+	−1.287	−17.97	−0.246	−3.62	−0.237	−4.08
Male	0.364	10.19	0.2464	7.96	0.178	6.47
Married	−0.522	−11.88	0.021	0.56	−0.325	−9.71
Kids	−0.103	−2.56	−0.088	−2.53	−0.012	−0.38
At School	−0.38C2TD(t)Tj0.6011.1960TD()Tj/F11Tf0.7680TD(0)Tj0.5120TD(.4)Tj0.79/F5()Tj/F11Tf0.7680TD(1)T					

Age 35–39 = defined as above
Age 40 = 1 if the individual is aged 40 or over, 0 otherwise
School = 1 of the individuals is still in school
Year 12 = 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

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