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CANNABIS USE WHEN IT'S LEGAL

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Abstract

This paper uses information about prime age individuals living in Amsterdam, to study whether the use of alcohol, or tobacco stimulates the use cannabis, i.e. whether alcohol or cannabis are stepping stones for cannabis. The special element of the study is that it concerns the use in an environment where not only alcohol and tobacco but also cannabis is a legal drug. It turns out that alcohol and cannabis are intertemporal substitutes while tobacco and cannabis are intertemporal complements. Only tobacco is a stepping stone for cannabis use.

JEL codes: C41, D12, I19
Keywords: alcohol, tobacco, cannabis, stepping stone

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1 Introduction

In many countries cannabis is an illicit drug, i.e. the sale and use of cannabis is illegal. In the Netherlands however, cannabis can easily be bought in retail outlets. The use of cannabis and to some extent the sale of cannabis is legal. Different from other countries in terms of law enforcement there is no particular reason to abstain from cannabis use. Therefore, it is rather surprising that many Dutch do not use cannabis. In fact, it is remarkable that cannabis use in the Netherlands is even lower than in neighboring countries with a more strict cannabis policy. In the year 2000 life time prevalence among young adults in Denmark was 45%, in France 40%, in Germany 31%, in the UK 43% and in the Netherlands 32%.[1]

The fact that cannabis use in the Netherlands is legal makes it particularly interesting to study its determinants. If an individual wants to use cannabis it is not particularly difficult to buy the stuff. If an individual is asked whether he or she uses cannabis there is no particular reason for that individual to deviate from the truth. This paper investigates intertemporal relationships in the demand for drugs with a particular interest in the question whether the use of alcohol and tobacco affects the use of cannabis. Demand relationships between these drugs have studied both in a contemporaneous and an intertemporal setting.

Previous studies that investigated contemporaneous demand relationships using US data find conflicting results. Chaloupka and Laixuthai (1997) find that alcohol and marijuana are economic substitutes for youth. Both the frequency of drinking and the probability of heavy drinking are negatively related to state marijuana decriminalization status. Thies and Register (1993) using data from the National Longitudinal Surveys of Youth also find that state decriminalization status affects alcohol use (although not marijuana use). Pacula (1998b) finds that

[1]European Monitoring Center for Drugs and Drug Addiction (2003). Reinarman et al. (2004) who compare cannabis use in Amsterdam and San Francisco conclude that there are no big differences between the two despite the difference in drug policy.

current and past cigarette prices have a negative effect on current marijuana use. So, again she finds that tobacco and cannabis are complements. Chaloupka et al. (1999) also find that higher cigarette prices have a negative effect on the consumption of cannabis; if cigarette prices go up both the probability and the frequency of marijuana use are reduced. Saffer and Chaloupka (1999) find that alcohol and illicit drugs (cannabis, cocaine, heroin) are complements. Farrelly et al. (2001) studies how policies and prices affect the demand for tobacco and cannabis. They find that higher cigarette taxes decrease the probability and intensity of marijuana use. So, tobacco and cannabis have a complementary relationship. They also state that cigarette smoking is considered as a gateway drug by some because youths who start with tobacco and alcohol use are more likely to progress to marijuana and other drug use. DiNardo and Lemieux (2001) study the relationship between alcohol use and cannabis use based on Monitoring the Future data. In their analysis they find that the increase in minimum drinking age that occurred in the US in the 1980s reduced the prevalence of alcohol use but increased the prevalence of marijuana use among high school seniors. They suggest that alcohol and cannabis are substitutes and discuss various reasons for the conflicting results of different studies. [2] Conflicting results are also found for studies based on non-US data. Cameron and Williams (2001) use Australian data from the National Drug Strategy Household Survey finding that cannabis is a substitute to alcohol but complement to tobacco. However, Williams and Mahmoudi (2004) also using Australian data find that alcohol and cannabis are complements.

[2] An important reason is that studies differ in the assumptions regarding exogeneity or endogeneity of variables. An example is income, which some studies assume to be potentially endogenous because drug use may affect the earnings capacity. Another example is beer tax, which some studies treat as exogenous with respect to cannabis use. To the extent that authorities take potential substitutability between alcohol and cannabis into account this may be a wrong assumption. Another reason for the difference in results in US studies is that parameter estimates are sensitive to the inclusion of state and year fixed effects. Since there is often no direct information about cannabis prices a state level indicator of for example decriminalization is used as a proxy variable for prices. However, this may induce spurious correlations in the use of alcohol, tobacco and cannabis due to for example state differences in tastes and preferences concerning drugs use.

Intertemporal demand studies are less contradictory. Pacula (1998a) finds that prior use of alcohol and tobacco increases the likelihood of current cannabis use. From this she concludes that both alcohol use and tobacco use are a gateway to cannabis. Beenstock and Rahav (2002) using data from Israel and find a causal gateway effect from cigarettes to cannabis.[3] Pudney (2004) analyzes British data and concludes that early onset of cannabis use raises subsequent rates of consumption substantially.[4]

The current paper investigates contemporaneous relations in the demand for drugs and studies in particular wether alcohol and/or tobacco are stepping stones for cannabis use. The empirical analysis in this paper is based on data that were collected in 1994, 1997 and 2001 in Amsterdam surveys.[5] An interesting and novel element of the study is the availability of information about cannabis use of parents. The estimation results indicate that prevalence of cannabis use is influenced by the same personal characteristics as prevalence of alcohol use and prevalence of tobacco use i.e. by age, education, marital status, presence of children, birth cohort and parental cannabis use. Starting rates for alcohol, tobacco and cannabis are influenced by education, age, parental cannabis use and unobserved personal characteristics. The analysis also shows that the different starting rates are correlated through these unobserved characteristics. After accounting for the correlation between the starting rates through both observed and unobserved characteristics there is a negative effect of alcohol use on the starting rate for cannabis use and there is a positive effect of tobacco use on the starting rate for cannabis. Apparently, alcohol and cannabis are intertemporal substitutes while tobacco and

[3]They do not find a causal effect from cannabis to hard drugs. They conclude that people who are susceptible to drug abuse initiate both cannabis and hard drugs sooner. If one does not account for this, a spurious gateway effect is found. See Van Ours (2003) for a similar result on Dutch data.

[4]He also finds that heavy cannabis consumption is related to family background. A fatherless cannabis user has a much higher consumption level than an otherwise similar individual from a 'normal' family background.

[5]Within the Netherlands it is especially the capital Amsterdam that has a reputation as a drug users city. In 2001 of the Amsterdam population of 12 years and older 38 % had ever used cannabis. Average for the Netherlands this was 17 % (Abraham et al., 2003).

cannabis are intertemporal complements. Tobacco is a gateway to cannabis; policies that reduce tobacco use will also reduce cannabis use.

The paper is set up as follows. Section 3 describes cannabis use in Amsterdam in general terms and presents stylized facts concerning prevalence of use. It also presents the results of logit estimates for current use and describes starting rates for alcohol, tobacco and cannabis. Section 4 presents the analysis of the starting rates and possible stepping stone relationships. Section 5 concludes.

2 Cannabis use in Amsterdam

As indicated in the introduction, the Netherlands has a special type of drug policy. The main aim is to protect the health of individual users, the people around them and society as a whole.[6] There are clinics for the treatment of addicts and care services, which aim to reach as many addicts as possible to assist them in efforts to rehabilitate, or to limit the risks caused by their drug habit. Methadone programs enable addicts to lead reasonably normal lives without causing nuisance to their immediate environment, while needle exchange programs prevent the transmission of diseases such as AIDS and hepatitis B through infected needles. The services also provide counselling.

Regulations on drugs are laid down in the Opium Act, which draws a distinction between hard drugs and soft drugs. The distinction that is drawn relates to the health risks involved in drug use. Hard drugs are those substances which can seriously harm the health of the user and include heroin, cocaine and synthetic drugs such as ecstasy. Soft drugs, i.e. cannabis derivatives marijuana and hashish cause far fewer health problems. The possession of hard drugs is a crime. However, since 1976 the possession of a small quantity of soft drugs for personal use is a minor

[6]See Ministry of Health, Welfare and Sport (1997) from which most of the information in this section is derived. An international perspective on Dutch drug policy is given in Boekhout van Solinge (1999).

offence.

The data used in the analysis are collected in Amsterdam, which has a population of 700.000 inhabitants and around 300 recognized, so-called "coffee-shops" were soft drugs can be purchased. The sale of small quantities of cannabis is technically an offence, but prosecution proceedings are only instituted if the operator or owner of the shop does not meet certain criteria. These criteria are that no more than 5 g per person may be sold in any one transaction, no hard drugs may be sold, the coffee-shop must not cause any nuisance, no drugs may be sold to persons under the age of 18, and the sale of soft drugs may not be advertised.[7] The mayor may order a coffee-shop to be closed.

The data collected refer to all inhabitants of Amsterdam of 12 years and older. The analysis is based on information from prime age males and females, i.e. individuals between age 26 and 50 at the time of the survey. The individuals in this age category have finished their education and usually have made the choice about whether or not to use a particular drug. Because some studies find individuals from ethnic minority groups to underreport drug consumption individuals not born in the Netherlands and individuals without a Dutch nationality are omitted. After removing observations with incomplete information on observed characteristics of individuals the net sample contains 2227 females and 1970 males (see the appendix for details concerning the data).

Three common indicators of drug use are lifetime prevalence, last year prevalence and last month prevalence. Usually last year prevalence numbers are substantially smaller than life time prevalence numbers and last month prevalence numbers are substantially smaller than last year prevalence numbers. The difference between the last two indicators could suggest that many individuals have stopped using in the past year. However, it is also possible that

[7]Therefore, the shop is called 'coffee-shop'.

some individuals use infrequently, i.e. less than once a month. Therefore, last year use is considered as recent use and last month use is considered to be current use.

Table 1 gives an overview of various indicators of alcohol, tobacco and cannabis use. Of the Amsterdam prime age females in the sample about 48% has ever used cannabis, while for males this is 58%. For the indicators of recent and current cannabis use the numbers for males are twice as large as for females. Recent cannabis use for females is about 10%, while it is about 20% for males. About 6% of the females and about 12% of the males are current cannabis users. For alcohol there is also a difference between lifetime use and current use but the difference is not that large. Apparently, if one starts consuming alcohol one is not very likely to stop doing so. For tobacco use there is such a substantial difference. About 77% of both males and females have ever used tobacco, while currently less than 50% uses tobacco. So, here indeed many individuals have stopped smoking. The lower part of Table 1 shows the relevance of parental cannabis use in the explanation of drug use. All drug use indicators have a higher value if parents have used cannabis. Current cannabis use is about 24% for females with parental cannabis use and only about 5% without parental cannabis use. Also for males the differences are huge. Current cannabis use is about 35% for males with parental cannabis use and only about 11% if parents have not used cannabis. For alcohol use and tobacco use the differences are smaller but still substantial. Note also that *all* males with cannabis using parents have used alcohol.

Table 2 presents the overlap in use of alcohol, tobacco and cannabis. As shown about 5% of the females and about 10% of the males currently use all three drugs while about 12% of the females and about 6% of the males currently do not use any of these drugs. The largest group only uses alcohol, the second largest group currently uses both alcohol and tobacco but no cannabis. This situation is similar when it comes to recent use but changes when it comes

to lifetime use. The largest group is the one that has used alcohol, tobacco and cannabis. This holds for about 44% of the females and about 52% of the males. Less than 2% of the individuals has never used any of the three drugs. The group that has only used cannabis and no alcohol or tobacco is virtually absent as is the case for the group that uses tobacco and cannabis but no alcohol.

3 Explaining drug use

3.1 Recent drug use

To analyze the determinants of recent drug use a discrete choice model is used. The variable c_j indicates whether or not an individual used drug type j. There are three types of drugs, alcohol ($j = a$), tobacco ($j = b$), and cannabis ($j = c$). The choices of individuals are related to personal characteristics using a logit model:

$$\Pr(c_j = 1) = \Lambda(\beta_j' X_j) \text{ and } \Pr(c_j = 0) = 1 - \Lambda(\beta_j' X_j)$$

where the notation $\Lambda(.)$ indicates the logistic cumulative distribution function, the x_j are vectors of personal characteristics affecting the probability to be a user of drug j and the β_j are vectors of parameters.

Table 3 presents the parameter estimates, which are first discussed for females and then for males. Recent alcohol use for females increases with age and education, is higher for single females, lower for females with children and higher for females with parental cannabis use. Tobacco use is affected by age, while education has a negative effect on recent tobacco use. For cannabis there is a negative effect of age, which is probably due to a cohort effect, i.e. more recent cohorts are more likely to use cannabis. Education has no effect. The effects of marital status, presence of children and parental cannabis use are similar for tobacco use and cannabis

use. Single females, females without children and females with parental cannabis use are more likely to use tobacco and cannabis than their counterparts.

By and large the parameter estimates for males are similar to those for females. For alcohol use age, marital status and presence of children are not that important probably because the share of users is so high anyway. Only education and parental cannabis use have clear positive effect. For tobacco use and cannabis use the effects of age, education, marital status, presence of children and parental cannabis use are similar for males and females.

For most individuals the age of onset for cannabis use is much higher than the age of onset for alcohol use and tobacco use (see Figures 1 and 2 which will be discussed in more detail below). It could be that individuals that use alcohol or tobacco at an early age are more likely or less likely to use cannabis later on. To investigate this, indicators for early alcohol use and early tobacco use were also introduced as additional explanatory variables in the recent cannabis use equation. Both early alcohol use and early tobacco use appear have a significant positive effect on the probability of recent cannabis use.[8]

The main conclusions concerning these exploratory analyses are the following. Age, education, marital status, presence of children and parental cannabis use have clear effects on use of alcohol, tobacco and cannabis. So, there is contemporaneous correlation in the use of these drugs working through the observed characteristics of individuals. And, conditional of the observed characteristics there is also a positive effect of early alcohol use and early tobacco use on cannabis use. Note however that this positive effect could come from correlation of unobserved individual characteristics, i.e. through a positive or negative inclination toward drug use. An alternative explanation is that there is a causal effect from alcohol and tobacco to cannabis. In

[8]Early use refers to age of onset below age 16. For females the relevant coefficients (t-statistics) are 0.32 (1.9) for early alcohol use and 0.70 (4.4) for early tobacco use. For males these numbers are 0.25 (1.9) and 0.59 (4.5).

the next section this will be investigated in more detail.

3.2 Starting rates

Although the analysis of recent drugs use gives some information about the dynamics of drug use, studying the age of onset of drug use provides more detailed information. Based on the age of onset empirical starting rates can be calculated indicating the probability to start using at a particular age conditional on not having started consuming up to that age.

Figure 1 shows the empirical starting rates for alcohol, tobacco and cannabis use.[9] For females the starting rates for alcohol and tobacco become large after age 14, for cannabis this is the case from age 15 onwards. There are clear spikes at age 16, 18, 20, 25, 30 and 35. For example at age 16 about 40% of the females that didn't drink up to then started drinking alcohol and about 20% of the females that didn't smoke up to then started smoking tobacco. These spikes obviously have to do with the memories of the individuals in the survey. For example, age 16 is the age at which individuals are allowed to drive a small motorcycle, and at age 18 they are allowed to drive a car (provided they have a drivers' license). Figure 1b shows similar patterns for males. For males that did not drink until age 16 even 50% started to drink alcohol at age 16. In terms of smoking and drinking nothing much happens after age 20. If an individual did not start to drink or smoke (s)he is very unlikely to do so at a higher age. The same holds for cannabis, but then after at 25. If an individual did not start to consume cannabis before age 25 (s)he is very unlikely to do so at a higher age.

Figure 2 shows the cumulative starting probabilities based on the empirical starting rates. The cumulative starting probability for alcohol reaches its maximum right after age 20 at a level of about 90% for females and 95% for males. This indicates that it there is a group of

[9] An individual who did not use alcohol, tobacco or cannabis but is below age 50 is considered to have an incomplete duration of non-use, i.e. is assumed to be 'right censored'.

about 5-10% that will not use alcohol at all. For smoking the group of abstainers is about 25%, for cannabis use the groups of abstainers are about 55% for females and 45% for males.

Some interesting conclusions that can be derived from Figures 1 and 2, in combination with the stylized facts in Tables 1 and 2 are the following. Adoption of a drug occurs at an age up to 20 (alcohol, tobacco) or 25 (cannabis). If an individual did not use drugs up to that age then (s)he is very unlikely to do so at a later age. Furthermore, it is clear that a large share of the population uses alcohol, tobacco or cannabis at a particular stage of their life. Nevertheless, since current and recent use are substantially below lifetime use there is not a lot of addiction involved. Apparently, a high share of individuals that uses a particular drug can stop using that drug. If the ratio of current or recent use to lifetime use would be used as an indicator of addictiveness alcohol would be the most addictive and cannabis would be the least addictive with tobacco having an intermediate position.

4 Empirical analysis of starting rates

4.1 Set-up of the analysis

Orphanides and Zervos (1995) present an theoretical model that is helpful in interpreting dynamics in drug use. Their theoretical model has some similarities with job search theory. In their theory, drugs are not equally addictive to all individuals. Since individuals do not have information about their addictive nature the only way to find out about it is to experiment with drug use. In deciding to do so, individuals balance the instant pleasure derived from drug use experimenting with the probabilistic disutility that they may get addicted to the drug. So, in the theory of Orphanides and Zervos experimenting with drug use is important.[10] In the

[10]Experimentation may also explain why current use is often substantially below life time prevalence; apparently many individuals started using drugs but only few remained doing so.

same way as job seekers are confronted with a flow of job offers youngsters are confronted with offers to use drugs irrespective of whether they are actively seeking for these offers. And, in the same way as job seekers may decide to accept or reject job offers youngsters may decide to accept or reject an offer to use drugs. Therefore, the starting rate of drug use can be thought of consisting of two components, the offer arrival rate and the acceptance probability. In this framework it is relatively easy to introduce the stepping stone hypothesis. The stepping stone claim is that the use of one drug increases the starting rate for the use of the next drug. In that case, for example individuals that have experience with tobacco use have a higher starting rate for cannabis than individuals that don't have that experience.[11]

The set-up of the analysis is similar to the analysis in Van Ours (2003) where the relationship between cannabis use and cocaine use is studied. To investigate the determinants of the starting rates of alcohol, tobacco, and cannabis we use a multivariate mixed proportional hazard model with a flexible baseline hazard. Differences between individuals in the rate by which they start using a particular drug are characterized by the observed characteristics, the elapsed duration of time they are exposed to potential use and unobserved characteristics. We take age 10 to be the time at which this potential exposure to drugs starts.

The starting rate for alcohol, tobacco, and cannabis, at time (age) t conditional on observed characteristics x and unobserved characteristics v is specified as:[12]

$$\theta_j(t \mid x, v_j) = \lambda_j(t) \exp(x'\beta_j + v_j) \text{ for } j = a, b \tag{1}$$

[11]Note that this could work through the offer arrival rate if tobacco use increases the probability to get into contact with a supplier of cannabis. The effect may also work through the acceptance probability if it is easier to accept an offer to use cannabis after initiation to tobacco use. Note that in the empirical analysis below it is not possible to make a distinction between offer arrival rate and acceptance probability. However, from a policy point of view it is only the net effect on the starting rate that is important. Note that the theory of Orphanides and Zervos may also explain why the starting rates for drug use are high in particular age categories and small at higher ages. After experimenting with various aspects of life individuals get settled say after age 25. Then, they no longer get offers to use drugs or if they get offers they are unlikely to accept them.

[12]omitting a subscript for individual

$$\theta_j(t \mid x, v_j, t_a, t_b) = \lambda_j(t) \exp(x'\beta_j + \delta_a I(t_a < t) + \delta_b I(t_b < t) + v_j) \text{ for } j = c \tag{2}$$

where $\lambda(t)$ represents individual age dependence[13], v represents individual specific unobserved heterogeneity, as before the subscript a represents alcohol, the subscript b tobacco, and the subscript c cannabis. The δ's indicate whether or not alcohol and tobacco influence the starting rate for cannabis use.

We model flexible age dependence by using a step function:

$$\lambda_j(t) = \exp(\Sigma_k \lambda_{jk} I_k(t)) \text{ for } j = a, b, c \tag{3}$$

where k (= 1,..,21) is a subscript for age-interval and the $I_{jk}(t)$ are time-varying dummy variables that are one in subsequent age-intervals. From age 10 onwards every year is represented separately. The last interval refers to age over 30. Because a constant term is also estimated, λ_{j1} is normalized to 0.

The conditional density functions of the completed durations of non-use can be written as

$$f_j(t_j \mid x, v_j) = \theta_j(t_j \mid x, v_j) \exp(-\int_0^{t_j} \theta_j(s \mid x, v_j) ds) \text{ for } j = a, b \tag{4}$$

$$f_j(t_j \mid x, v_j, t_a, t_b) = \theta_j(t_j \mid x, v_j, t_a, t_b) \exp(-\int_0^{t_j} \theta_j(s \mid x, v_j, t_a, t_b) ds) \text{ for } j = c \tag{5}$$

The possible correlation between the unobserved components is taken into account by specifying the joint density function of the three durations of non use t_a, t_b, and t_c conditional on x as

$$f(t_a, t_b, t_c \mid x) = \int_{v_c} \int_{v_b} \int_{v_a} f_a(t_a \mid x, v_a) f_b(t_b \mid x, v_b) f_c(t_c \mid x, t_a, t_b, v_c) dG(v_a, v_b, v_c) \tag{6}$$

$G(v_a, v_b, v_c)$ is assumed to be a discrete distribution 8 points of support (v_{1a}, v_{1b}, v_{1c}), (v_{2a}, v_{1b}, v_{1c}), (v_{1a}, v_{2b}, v_{1c}), (v_{2a}, v_{2b}, v_{1c}), (v_{1a}, v_{1b}, v_{2c}), (v_{2a}, v_{1b}, v_{2c}), (v_{1a}, v_{2b}, v_{2c}), (v_{2a}, v_{2b}, v_{2c}). The associ-

[13] In the context of a job search model this would be equivalent to duration dependence of the hazard rate.

ated probabilities are denoted as follows:

$$\begin{aligned}
&\Pr(v_a = v_{1a}, v_b = v_{1b}, v_c = v_{1c}) = p_1 \quad \Pr(v_a = v_{2a}, v_b = v_{1b}, v_c = v_{1c}) = p_2 \\
&\Pr(v_a = v_{1a}, v_b = v_{2b}, v_c = v_{1c}) = p_3 \quad \Pr(v_a = v_{2a}, v_b = v_{2b}, v_c = v_{1c}) = p_4 \\
&\Pr(v_a = v_{1a}, v_b = v_{1b}, v_c = v_{2c}) = p_5 \quad \Pr(v_a = v_{2a}, v_b = v_{1b}, v_c = v_{2c}) = p_6 \\
&\Pr(v_a = v_{1a}, v_b = v_{2b}, v_c = v_{2c}) = p_7 \quad \Pr(v_a = v_{2a}, v_b = v_{2b}, v_c = v_{2c}) = p_8
\end{aligned} \tag{7}$$

where p_n $(n = 1, .., 8)$ is assumed to have a multinomial logit specification:

$$p_n = \frac{\exp(\alpha_n)}{\Sigma_n \exp(\alpha_n)} \tag{8}$$

and to normalize $a_8 = 0$. To allow for the possibility that some individuals will never start using a particular drug the second mass points are assumed to be -∞. So, $v_{2a} = v_{2b} = v_{2c} =$ -∞.

4.2 Parameter estimates

The parameters are estimated using maximum likelihood. In the estimates observations of individuals that did not start to consume alcohol, tobacco or cannabis are considered to be right censored durations. The analysis starts with estimates of independent starting rates, i.e. unobserved heterogeneity is assumed to be uncorrelated. This implies that the likelihood factorizes so that each starting rate can be estimated separately. And, initially the potential stepping stone effect of alcohol and tobacco on the starting rate of cannabis is ignored. The parameter estimates are presented in Table 4. With respect to alcohol and cannabis the effects of education and parental cannabis use are very similar, both have a positive effect on the starting rate. For tobacco there is a negative effect of the educational level on the starting rate.

As shown for both females and males the starting rates are influenced by unobserved individual characteristics. For alcohol and tobacco the distribution of unobserved heterogeneity

is similar for males and females. For alcohol 92-95% has a positive starting rate while the remaining 5-8% has a zero starting rate. For tobacco about 75% has a positive starting rate with the remaining 25% being the group of abstainers. For females almost 70% has a positive starting probability for cannabis, while for males this is about 65%.

The last column of Table 4 shows what happens if alcohol use and tobacco use are allowed to affect the starting rate for cannabis. As shown alcohol use has no effect but tobacco use has a significant positive effect on the starting rate for cannabis. The introduction of alcohol use and tobacco use in the starting rate for cannabis affects the distribution of unobserved heterogeneity, but the effect is not large. For females the probability of a positive starting rate goes up from 70% to 75%, for males it goes up from 65% to 70%.

The estimated effects of tobacco on the starting rate for cannabis are quite large. For females that use tobacco the starting rate for cannabis is 2.9 times as high as for females that do not smoke. For males that smoke the starting rate for cannabis is 2.1 times as high as for non-smoking males. However, these effects are estimated under the assumption that there is no correlation between the unobserved components in the starting rates for alcohol, tobacco and cannabis. It could be that part, or all of the positive effect of tobacco use on the cannabis starting rate is due to correlation between unobserved components. If individuals that are more inclined to start smoking are also more inclined to start using cannabis then this will cause a positive correlation between tobacco use and cannabis use irrespective of whether or not there is a causal effect from tobacco use to cannabis use. To investigate to what extent the estimated effects are due to correlation of unobserved heterogeneity or due to a causal effect one has to account for the possible correlation.

Table 5 shows the parameter estimates if unobserved heterogeneity is allowed to be correlated. As shown, there is a clear correlation between the unobserved components of the starting

rates. It is possible to identify 8 mass points.[14] For females by far the largest group consists of individuals (67.4%) that have a positive starting rate for alcohol, tobacco and cannabis. The second group (15.3%) only has a positive starting rate for alcohol. And, there is a group of 2.9% of the females that consists of abstainers from alcohol, tobacco and cannabis. For males the largest group (49.0%) also consists of individuals that have positive starting rates for alcohol, tobacco and cannabis, but there is also a large group (24.3%) that has positive starting rates for alcohol and tobacco but a zero starting rate for cannabis.

Most of the parameters in Table 5 are very similar to the estimates shown in Table 4. The main exceptions are the effects of alcohol and tobacco on the cannabis starting rates. The effect of alcohol is now significantly negative for both males and females. The effect of tobacco is positive and significant but substantially smaller than before. Now, for smokers the starting rate for cannabis is 30-40% higher than for non-smokers. So, whereas cannabis seems to be a substitute for alcohol, it is complementary to tobacco. Apparently tobacco is a stepping stone for cannabis use while alcohol dampens cannabis use.

4.3 Sensitivity analysis

To investigate the sensitivity of the parameter estimates, a number of additional analyses are performed. First, it was investigated whether introducing more mass points in the distribution of unobserved heterogeneity would improve the estimation results. However, no additional mass points could be identified. Furthermore, it was investigated whether combining age classes of 1 year into age classes of several years to smooth spikes had an effect. Again, the parameter estimates did not change a lot. We also replaced birth year as a continuous variable by dummy

[14]The likelihood ratio test statistics comparing the sum of the loglikelihoods in columns 1,2 and 4 of Table 5 with the loglikelihoods in Table 6 is 239.6 for females and 280.6 for males. This is highly significant since at a 1% level of significance the χ-square statistic for 4 degrees of freedom (4 additional probability parameters) equals 13.3.

variables representing birth cohorts of the 1950s, 1960s, and 1970 onwards. This did not change the basic results. Finally, because education may be endogenous we removed the educational dummies as explanatory variables and re-estimated the model. Again, this did not change the basic results of the analysis.

To give some indication of the size of the effects of personal characteristics on the probability of cannabis use results of simulations using the parameter estimates of Table 5 are shown in Table 6. The first column shows the simulation results for a reference person who has secondary education, is born in 1950, is not confronted with parental cannabis use and never uses alcohol or tobacco. As shown 21.1% of the females with these characteristics have started using cannabis at age 20, 32.2% at age 30, and 33.2% at age 40. The other columns show simulation results if the characteristics are changed one at a time. As shown females with similar characteristics but with parents that used cannabis are much more likely to start using cannabis themselves. Of these females 53.2% has started using cannabis by age 20. Females with lower education are less likely to start using cannabis, while later birth cohorts of females are more likely to use cannabis. As shown of non-drinking and non-smoking females with secondary education and no parents that used cannabis, but born in 1970 37.4% has started using cannabis at age 20. The last three columns of Table 6 show the effect of alcohol and tobacco on cannabis use. Females that start drinking alcohol at age 15 are less likely to start using cannabis, females that start smoking tobacco are more likely to start using cannabis. It is clear that the age of onset of smoking tobacco is also important. Females that start smoking at age 25 at much less likely to start using cannabis than females that start smoking at age 15.

The bottom part of Table 6 shows similar simulation results for males. By and large these results are similar as for females with one exception. By age 40 about 56% of all types of males have started using cannabis. The main influence of the personal characteristics is at a lower

age. After a while all males that are potential cannabis users, i.e. have a positive starting rate for cannabis use do in fact become cannabis users.

5 Conclusions

This paper analyzes information about the use of alcohol, tobacco, and cannabis by prime age individuals living in Amsterdam. By way of exploratory analysis the determinants of current use, recent use, and lifetime use were investigated. It turns out that each of indicators is affected by age, education, marital status, presence of children and parental cannabis. This means that there is correlation in the use of alcohol, tobacco and cannabis working through the observed characteristics of individuals. Furthermore, conditional of the observed characteristics there is also a positive effect of early alcohol use and early tobacco use on cannabis use. This positive effect could come from correlation of unobserved individual characteristics, i.e. through a positive or negative inclination toward drug use.

To investigate this possibility in more detail starting rates for alcohol use, tobacco use, and cannabis use are analyzed. It appears that adoption of alcohol and tobacco usually occurs up to an age of 20 while adoption of cannabis usually occurs up to an age of 25. If an individual did not use drugs up to that age then (s)he is very unlikely to do so at a later age. Furthermore, it is clear that a large share of the population uses alcohol, tobacco or cannabis at a particular stage of their life. Nevertheless, since current and recent use are substantially below lifetime use there is not a lot of addiction involved. Apparently, a high share of individuals that uses a particular drug can stop using that drug. If the ratio of current or recent use to lifetime use would be used as an indicator of addictiveness alcohol would be the most addictive and cannabis would be the least addictive with tobacco having an intermediate position. Starting rates turn out to be affected by age, education, birth year, and parental cannabis use. Furthermore, the

starting rate for cannabis use is higher for smokers and lower for individuals have started using alcohol.

The policy implications from the analysis of the starting rates are clear. Since alcohol and cannabis are substitutes while tobacco and cannabis are complements policies that stimulate the use of alcohol and policies that will reduce smoking will reduce cannabis use. However, policies that stimulate alcohol use will not have a wide impact since almost every individual uses alcohol sooner or later. Therefore, policies aimed at reducing cannabis use can better exploit the complementarity between tobacco and cannabis. For those that worry about cannabis use it is reassuring to know that policy measures that reduce smoking will also reduce cannabis use. Furthermore, the analysis shows that policy measures should focus on young individuals; if not to prevent them from starting to smoke, then to increase the age of onset of smoking. It is clear that individuals that start smoking at a higher age are less likely to start using cannabis than individuals that start smoking very young.

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Appendix A. Data

CEDRO, the Center for Drug Research of the University of Amsterdam has collected data on drug use in 1994, 1997 and 2001 (see Abraham et al. (2003) for a detailed description). There are some differences between these surveys, but the information used in this paper is collected consistent through time. The data on drug use are based on self-reported information, which is the norm for analyses of drug consumption. The survey population is defined as all persons in the Municipal Population Registry of Amsterdam.

In 1994 two interview methods were used, a written and a computer assisted version (using laptop computers where the interviewer directly typed in the answers). The sample was randomly subdivided into two equal sized samples. It turns out that the interview method did not affect the answers to the questions. The 1997 survey was fully computer assisted. The 2001 survey was based on a mixture of methods. Respondents could choose between a paper questionnaire, a computer assisted face-to-face interview, an interview per telephone, via their own computer on the Internet or on a floppy disk (by mail). The non-response in 1994 was 49.2%, in 1997 48.1%, and in 2001 60%.

The available data refer to all inhabitants of Amsterdam of 12 years and older. As indicated in the main text the sample is reduced according to a number of criteria. First, only individuals who were between age 26 and 50 at the time of the survey are considered. Furthermore, the sample concerns individuals born in the Netherlands with a Dutch nationality. After removing observations with incomplete information about the use of alcohol, tobacco and cannabis the sample contain 2307 females and 2060 males. Tables 1 and 2 present the drug use characteristics of these individuals. In the empirical analysis information is used about individual characteristics like age, education, marital status, presence of children, parental cannabis use. After removing individuals with missing information about these characteristics the net sample

contains 2227 females and 1970 males. The results of empirical analysis presented in Tables 3-6 are based on these net samples.

Appendix B. Variables

In the analysis the following variables are used:

- Age: Age of individuals at the time of the survey.
- Secondary education: Dummy variable with a value of 1 if the individual attended secondary general or vocational education, and a value of 0 otherwise. Secondary education refers to intermediate vocational or secondary general education.
- Higher education: Dummy variable with a value of 1 if the individual attended higher vocational or academic education, and a value of 0 otherwise. Since there are two dummy variables for education the overall reference group consists of individuals with basic or primary education.
- Single: Dummy variable with a value of 1 if the individual is living alone and a value of 0 if the individual is part of a multi-person household.
- Children: Dummy variable with a value of 1 if the individual has children and a value of 0 otherwise.
- Year 1997 (year 2001): Dummy variable with a value of 1 if the individual participated in the survey of 1997 (2001) and a value of 0 otherwise.
- Birth year: Year of birth, calculated as (year of survey − age − 1950)/10

- Cannabis use parents: Dummy variable with a value of 1 if one or both parents have ever used cannabis and a value of 0 otherwise
- Past use of cannabis (alcohol, tobacco): Dummy variable with a value of 1 if life time prevalence cannabis (alcohol, tobacco) = 1 and a value of 0 otherwise
- Recent use of cannabis (alcohol, tobacco): Dummy variable with a value of 1 if last year prevalence cannabis (alcohol, tobacco) = 1 and a value of 0 otherwise
- Lifetime use of cannabis (alcohol, tobacco): Dummy variable with a value of 1 if lifetime prevalence year prevalence cannabis (alcohol, tobacco) = 1 and a value of 0 otherwise
- Early use of alcohol (tobacco): Dummy variable with a value of 1 if age of onset for alcohol (tobacco) use was below 16.

Table 1 Use of alcohol, tobacco and cannabis[a)]

a. Averages

	Alcohol	Tobacco	Cannabis
Females			
Lifetime use	95.6	77.3	47.7
Recent use	90.0	53.1	10.5
Current use	81.1	46.8	6.2
Males			
Lifetime use	98.1	77.3	57.8
Recent use	94.3	55.0	20.8
Current use	90.5	49.0	12.8

b. Distinguished by parental cannabis use

	Parental cannabis use			No parental cannabis use		
	Alcohol	Tobacco	Cannabis	Alcohol	Tobacco	Cannabis
Females						
Lifetime use	98.3	89.5	88.3	95.4	76.3	44.3
Recent use	92.3	67.4	29.8	89.8	51.8	8.9
Current use	87.8	61.9	23.8	80.5	45.5	4.7
Males						
Lifetime use	100.0	84.4	91.2	97.9	76.8	55.2
Recent use	98.6	68.2	50.0	93.9	54.0	18.5
Current use	97.2	59.5	35.1	90.0	48.2	11.1

[a)] Sample of 2307 females and 2060 males age 26-50; 181 females and 148 males have parents that used cannabis; recent use = last year prevalence, current use = last month prevalence

Table 2 Combinations of recent drug use[a)] (%)

Alcohol	Tobacco	Cannabis	Females	Males
Yes	Yes	Yes	9.6	17.1
Yes	Yes	No	39.5	35.8
Yes	No	Yes	0.7	3.0
Yes	No	No	40.2	38.4
No	Yes	Yes	0.4	0.3
No	Yes	No	3.6	1.8
No	No	Yes	0.0	0.2
No	No	No	6.0	3.4
		Total	100.0	100.0

[a)] Sample of 2307 females and 2060 males age 26-50; 181 females and 148 males have parents that used cannabis; recent use = last year prevalence

Table 3 Parameter estimates logits recent drug use[a)]

	Females			Males		
	Alcohol	Tobacco	Cannabis	Alcohol	Tobacco	Cannabis
Year 1997	0.40 (2.2)	-0.03 (0.3)	0.54 (3.0)	-0.33 (1.4)	0.06 (0.5)	0.06 (0.4)
Year 2001	0.11 (0.7)	-0.20 (1.9)	0.23 (1.3)	-0.04 (0.2)	-0.23 (2.1)	-0.04 (0.3)
Age	0.02 (1.5)	-0.00 (1.6)	-0.04 (3.3)	-0.01 (0.6)	-0.01 (1.7)	-0.03 (3.2)
Sec education	0.57 (3.1)	-0.44 (3.5)	0.14 (0.6)	0.36 (1.6)	-0.10 (0.7)	0.32 (1.9)
Higher education	1.38 (7.5)	-0.66 (5.8)	0.09 (0.5)	1.50 (5.9)	-0.28 (2.3)	-0.05 (0.3)
Single	0.27 (1.7)	0.64 (6.8)	0.67 (4.2)	-0.02 (0.1)	0.21 (2.0)	0.77 (6.0)
Children	-0.29 (1.9)	-0.33 (3.5)	-0.72 (3.8)	0.25 (1.1)	-0.25 (2.2)	-0.72 (4.1)
Cannabis parents	0.23 (0.7)	0.65 (3.7)	1.23 (6.1)	1.52 (2.1)	0.46 (2.3)	1.26 (6.3)
Number of users	2000	1173	224	1854	1072	402

[a)] 2227 females and 1970 males; absolute t-values in parentheses

Table 4 Estimation results independent starting rates[a)]

	Alcohol	Tobacco	Cannabis	Cannabis
Females				
Year 1997	-0.08 (1.0)	-0.08 (1.1)	0.27 (3.0)	0.19 (2.3)
Year 2001	-0.05 (0.7)	0.03 (0.4)	0.07 (0.7)	0.03 (0.3)
Sec. education	0.38 (5.0)	-0.35 (4.0)	0.78 (6.6)	0.83 (7.7)
Higher education	0.72 (9.9)	-0.52 (6.8)	1.04 (9.8)	1.14 (11.7)
Birth year	0.35 (8.7)	0.10 (2.4)	0.21 (3.7)	0.24 (4.1)
Cannabis parents	0.43 (3.3)	0.16 (1.3)	1.60 (12.5)	1.34 (13.2)
$\delta_{alcohol}$	–	–	–	0.04 (0.4)
$\delta_{tobacco}$	–	–	–	1.10 (14.7)
α	2.49 (30.0)	1.15(23.1)	0.86 (20.7)	1.07(9.2)
-Loglikelihood	4849.6	5151.5	4048.9	3933.5
Males				
Year 1997	-0.02 (0.3)	-0.07 (1.0)	-0.16 (1.8)	0.20 (1.7)
Year 2001	-0.16 (2.2)	-0.08 (1.0)	-0.24 (2.5)	0.05 (0.4)
Sec. education	0.19 (2.5)	-0.20 (2.2)	0.09 (0.7)	0.47 (3.5)
Higher education	0.40 (5.6)	-0.43 (5.2)	-0.03 (0.3)	0.50 (4.3)
Birth year	0.31 (7.7)	0.05 (1.3)	0.34 (6.1)	0.38 (4.2)
Cannabis parents	0.39 (2.6)	0.15 (1.4)	0.63 (4.7)	1.18 (6.5)
$\delta_{alcohol}$	–	–	–	-0.07 (0.6)
$\delta_{tobacco}$	–	–	–	0.86 (11.0)
α	2.98 (28.4)	1.11(21.2)	0.55 (48.8)	0.76 (11.5)
-Loglikelihood	4059.9	4716.9	4099.4	4055.5

[a)] 2227 females and 1970 males; all estimates contains age-specific dummy variables; absolute t-values in parentheses

Probabilities positive starting rate (%)

	Alcohol	Tobacco	Cannabis	Cannabis
Females	92.4	76.0	70.2	74.5
Males	95.2	75.2	63.4	68.1

Table 5 Parameter estimates correlated starting rates[a)]

	Females			Males		
	Alcohol	Tobacco	Cannabis	Alcohol	Tobacco	Cannabis
Year 1997	-0.08 (0.5)	-0.08 (1.1)	0.17 (1.9)	-0.02 (0.3)	-0.15 (1.6)	-0.15 (1.6)
Year 2001	-0.05 (0.7)	0.03 (0.4)	-0.00 (0.0)	-0.16 (2.2)	-0.08 (1.1)	-0.26 (2.3)
Sec. education	0.38 (5.0)	-0.35 (4.0)	0.89 (6.8)	0.19 (2.5)	-0.20 (2.2)	0.18 (0.6)
Higher education	0.71 (10.0)	-0.52 (6.8)	1.19 (9.7)	0.40 (5.6)	-0.43 (5.3)	0.09 (0.3)
Birth year	0.35 (8.7)	0.10 (2.4)	0.37 (3.4)	0.31 (7.7)	0.05 (1.3)	0.41 (2.3)
Cannabis parents	0.43 (3.3)	0.16(1.3)	1.32 (6.6)	0.39 (2.6)	0.15 (1.3)	0.68 (4.8)
$\delta_{alcohol}$	-	-	-0.25 (2.4)	-	-	-0.24 (2.2)
$\delta_{tobacco}$	-	-	0.35 (3.4)	-	-	0.34 (4.2)
α_1		3.14 (17.0)			2.92 (19.8)	
α_2		-0.29 (1.0)			-1.06 (3.9)	
α_3		0.61 (2.6)			0.76 (4.3)	
α_4		-2.15 (3.8)			-2.15 (5.0)	
α_5		0.39 (0.2)			2.22 (13.8)	
α_6		-0.26 (1.0)			-1.01 (3.7)	
α_7		1.66 (11.3)			1.81 (12.0)	
-Loglikelihood		13814.8			12692.0	

Probabilities	Alcohol	Tobacco	Cannabis	Females	Males
p_1	+	+	+	67.1	49.0
p_2	0	+	+	2.2	0.9
p_3	+	0	+	5.4	5.7
p_4	0	0	+	0.3	0.3
p_5	+	+	0	4.3	24.3
p_6	0	+	0	2.3	1.0
p_7	+	0	0	15.5	16.2
p_8	0	0	0	2.9	2.6

[a)] See footnote Table 4

Table 6 Simulation results; cannabis use (%)[a)]

Females Age	Reference person	Cannabis parents	Low education	Born 1970	Alcohol age 15	Tobacco age 15	Tobacco age 25
20	21.1	53.2	9.5	37.4	17.2	27.7	21.1
30	32.3	65.9	15.5	51.9	26.8	41.0	34.0
40	33.2	66.7	16.1	53.0	27.6	42.1	35.2

Males Age	Reference person	Cannabis parents	Low education	Born 1970	Alcohol age 15	Tobacco age 15	Tobacco age 25
20	36.5	48.9	32.9	51.0	31.8	43.1	36.5
30	53.3	55.8	51.9	55.9	51.3	55.2	54.6
40	55.3	55.9	54.4	55.9	54.0	55.8	55.6

[a)]Reference person: Secondary education, born in 1950, no parental cannabis use, no use of alcohol or tobacco

Figure 1a Starting rates females

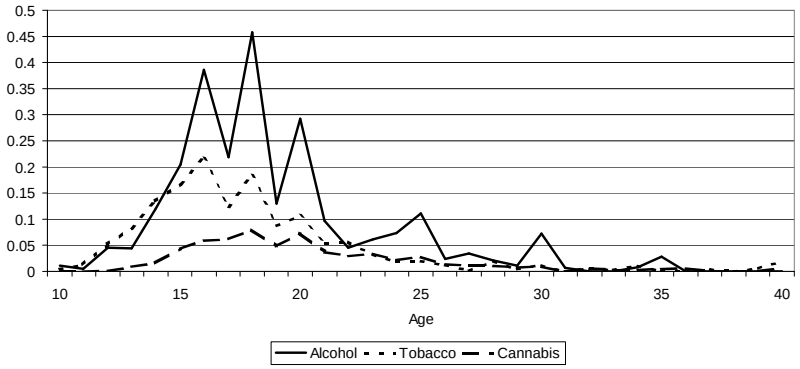

Figure 1b Starting rates males

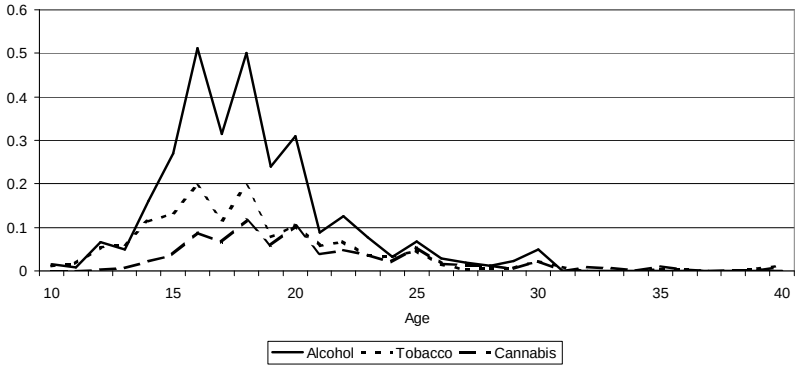

Figure 2a Cumulative starting probabilities females (%)

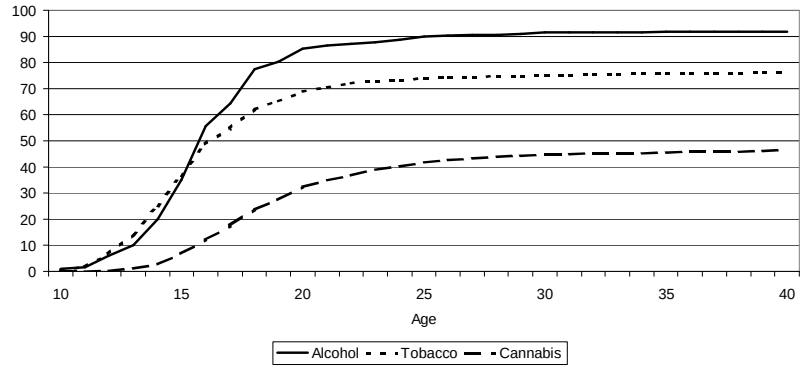

Figure 2b Cumulative starting probabilities males (%)