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CANNABIS PROCES AND DYNAMICS OF CANNABIS USE

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Cannabis prices and dynamics of cannabis use

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Abstract

This paper uses duration models and self-reported cannabis histories from young Australians to study the dynamics of cannabis use. We find that low cannabis prices are associated with early initiation into cannabis use. While the decision to quit does not appear to be directly influenced by price, we find that the younger an individual is when they start using cannabis the less likely they are to quit. Therefore, low cannabis prices lead to early use and because of that they lead to a low quit rate and hence a longer duration of use.

Keywords: cannabis use; cannabis prices; age of initiation

JEL codes: C41, D12, I19

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1 Introduction

That initiation into cannabis use typically occurs during the mid to late teens is well established. In recent years, however, initiation into use has been occurring at earlier ages in countries such as the U.S. and Australia.[1] This raises questions about the cause of the greater up-take of cannabis use amongst youth and the consequences of early initiation into cannabis use. However, very little is known about the determinants of up-take of cannabis or the impact of the age of onset. This paper attempts to shed light on these issues by investigating the determinants of initiation into cannabis use and the decision to quit among young Australians. Of particular interest is the way in which the price of cannabis affects these decisions.

The illicit nature of cannabis makes it difficult to obtain reliable information about its use. Consequently, previous research on the price responsiveness of demand for cannabis has focused on the participation decision (see Williams et al. (2004), DeSimone and Farrelly (2003) and Pacula et al. (2001) for studies using U.S. data and Cameron and Williams (2001), Williams (2004) and Zhao and Harris (2004) for studies based on Australian data).[2] A shortcoming of this approach is that it fails to distinguish between people who are deciding to start using cannabis and those who are deciding to quit. There are good reasons, however, to analyze these decisions separately. For example, for a potentially addictive substance such as cannabis, it may be easier to avoid starting use than it is to quit. If this is the case, then policies that aim to reduce the up-take of cannabis are more likely to be effective at reducing

[1]In the U.S the annual number of cannabis initiates for the under 18 age group increased between 1990 and 1995 (Substance Abuse and Mental Health Services Administration (2004)). See Figure 1 for evidence of a decline in the age of initiation in cannabis use for Australia.

[2]Due to the paucity of data on the price of cannabis, most studies on the demand for cannabis use its criminal status as a measure of the full cost of consumption. See for example Saffer and Chaloupka, (1999) and Farrelly et al. (2001).

its use and the associated harm than policies that target the quitting decision.[3]

In this paper, duration models are used to study the decision to start and quit cannabis use. To do so, we take advantage of self-reported information on individual cannabis histories collected as part of the 1998 Australian National Drug Strategy's Household Survey. By matching information on the price of cannabis to each year an individual is at risk of starting or quitting use, we are able to model their dynamic response to changes in the cost of cannabis. The analysis is limited to people aged 14 to 22 at the time of the 1998 survey, covering initiations and quits from ages 12 to 22. This age range is particularly well suited to studying initiation into cannabis use (Hall and Pacula (2003)) and we therefore focus on the up-take decision.

The benefits of understanding starting and quitting use of an addictive substance are not unique to cannabis and have been raised in the literature on tobacco (Douglas and Harihan (1994), Douglas (1998), Lopez Nicholas (2002), Forster and Jones (2001/03), DeCicca, Kenkel and Mathios (2002), Kidd and Hopkins (2004)).[4] In this literature, duration models are used to study the transitions from non-smoker to smoker, and from smoker to non-smoker. Key empirical regularities describing these transitions are also apparent in the dynamics of cannabis use. For example, most people start using tobacco and cannabis as teenagers, very few people take up use later in life, and a substantial proportion of people never use either drug.[5] For

[3]Pudney (2004) and Van Ours (2003) use duration analysis to study cannabis use. Pudney (2004) models initiation into cannabis use and subsequent consumption. Van Ours (2003) models initiation into cannabis use and its impact on initiation into cocaine use. However, due to a lack of price information, neither paper examine the impact of prices on these decisions.

[4]Starting rates for alcohol, tobacco, cannabis, and cocaine are analyzed in Van Ours (2003, 2004).

[5]It is noteworthy that starting rates are high in the teenage years and low by the mid-twenties for both cigarettes and cannabis. The rational addiction model predicts that the starting rate of use should be high when the cost of using an addictive substance is low. Since the health costs (such as developing respiratory diseases) of smoking either tobacco or cannabis accumulate

this reason, the duration models used to study transitions in smoking are also useful for studying transitions in cannabis use.

As noted by Douglas (1998), duration models offer several advantages over participation models. For example, unlike models of participation, duration models can distinguish between an increased flow into use and decreased flow out of use. They can also account for the duration of the habit, whereas participation models cannot. Finally, price elasticities from participation models are difficult to interpret since they are not the same as the elasticity of starting, nor the elasticity of quitting. If based on a sample of youth, participation elasticities are more likely to capture starting behavior, whereas those based on older samples are more likely to reflect quitting behavior. Duration models avoid this type of bias.

To study the decisions to start and quit cannabis use, we estimate mixed proportional hazard models and split population models. We examine the robustness of our results to the age group examined and assumptions about the distribution of unobserved heterogeneity. We also investigate whether the unobserved heterogeneity in the starting and quitting decisions are correlated. The central findings of this study are that lower cannabis prices are associated with early initiation into cannabis use, and that early initiation into cannabis use is associated with a longer duration of use. Therefore, lower cannabis prices are associated with greater harm directly through their impact on the age of initiation and indirectly through the duration of use.

over time, one might consider that costs are lower at older ages because the health consequences are felt for fewer time periods. However, the health costs occur many years after initiation, and discounting these costs over time provides an explanation as to why costs may be viewed as low by youth (Douglas and Hariharan, 1994).

2 Cannabis use in Australia

Cannabis is the mostly widely used illicit drug in Australia. Over one third of the population over the age of 14 have used it at some point in their life. The average age at which Australians first use cannabis is 18.8 years. Table 1 draws on data from the 1998 National Drug Strategy's Household Survey to provide information on lifetime and more recent use of cannabis in Australia, by age group and gender. It shows that over 45% of 14-19 year olds have used cannabis in their life-time, compared to 64% of 20-29 year olds, 57% of 30-39 year olds, and 21% of those aged forty or older. Use in the last 12 months, last month and last week follow a similar pattern. For each category of recent past use, prevalence increases from the 14-19 year age group to the 20-29 year age group and falls thereafter. For example, 9% of 14-19 year olds have used in the last week, compared to 13% of 20-29 year olds, 7% of 30-39 year olds, and 1% of those aged at least forty. Table 1 also shows that the prevalence of life-time and more recent use of cannabis are higher among men than women.

The legal environment surrounding cannabis use varies across Australia's eight states and territories. South Australia was the first to adopt this system, introducing it in 1987. The Australian Capital Territory followed suit in 1992, the Northern Territory in 1997, and Western Australia in 2004. Under this system, it is still an offence to use, possess, or grow cannabis for personal use, but (for small quantities) the offence is expiable by payment of a fine with no conviction recorded if the fine is paid. Strictly speaking, this system is called prohibition with civil penalties.

Where decriminalization has not been legislated, most states have reduced penalties for minor cannabis offences.[6] Cannabis cautioning programs have been intro-

[6]The exception is Queensland, which has adopted the Police Diversion Program. Under the

duced in Victoria, Tasmania, and New South Wales. These programs do not require legislative changes and are based on a change to policy that allows police officers to exercise discretion in the use of a caution (rather than an arrest) for possession of small amounts of cannabis for personal use.

3 Data

This research combines individual level data on cannabis histories from the 1998 Australian National Drug Strategy's Household Survey (NDSHS) with state level information on the price of cannabis. The NDSHS is designed to provide data on the extent of drug use by the non-institutionalized civilian population aged fourteen years and older in Australia. In addition to the 1998 wave of the NDSHS, the survey was also conducted in 1985, 1988, 1991, 1993, 1995 and 2001. However, only the 1998 wave enquired about the age respondents first used and last used cannabis and for this reason our analysis is based on this survey only.

3.1 Cannabis Use

In addition to asking respondents whether they have used cannabis in their lifetime, whether they have used it in the past 12 months, and how frequently they have used it, the 1998 wave of the NDSHS asks individuals the age at which they first used cannabis and the age at which they last used cannabis. We use information on the age they first used cannabis to model the probability of starting use. In order to identify when respondents quit use, we combine the age that they report last using cannabis with information on whether they no longer use (which is a

Program, eligible offenders charged with possession of 50 grams or less of cannabis will be required to admit guilt and agree to undertake a drug assessment or brief intervention that includes an education program.

potential response to the frequency of use question). Because information about the respondent's age at the time of survey is also collected, we are able to translate the age each individual started and quit using cannabis into calendar time. This is important as it allows us to match state level cannabis price data to individuals at the time they are facing starting and quitting decisions.

Since the focus of this research is on determining the impact of the price of cannabis on the decision to start and stop using cannabis, we are limited in the ages for which we can study these decisions by the availability of the price data. We have price data for the period 1988-1998. Assuming individuals are at risk of initiation into cannabis use from age 12, our analysis is restricted to studying individuals who were no older than 12 years old in 1988. This corresponds to the sample of respondents aged 14-22 in 1998. There are 2157 observations (with non-missing values for the control variables) for this age group, of which 1068 (50%) reported that they had used cannabis at some point prior to survey. From the group of people who had used cannabis, 398 (37%) reported that they had quit use prior to the date of survey and 670 reported that they were still using (see appendix A for details).

As with previous research studying transitions in cigarette smoking using cross-sectional data, this study is subject to several potential measurement error problems. First, using retrospective information about when individuals start and quit cannabis use poses the potential problem of recall error. If people make errors in the age they report starting and quitting cannabis use, the parameter estimates are likely to be biased. A related issue is that although respondents may have "quit" using cannabis several times, only the most recent quit is recorded. True panel data (rather than the pseudo panel we construct using the retrospective information) is required to address these problems. However, no such data exists for Australia. We explored the issue of recall bias by rescaling the duration variable for starting and quitting to calendar years. This allowed us to check for "heaping" on years that end with five or zero, for example. Our analysis suggests that this is not a significant issue in our sample. This is not surprising as we are dealing with young respondents and so the calendar time elapsed between the start of use and the survey date is limited.

Another potential source of measurement error arises because the price data are matched to each individual's state of residence at the time of survey. Our objective in doing so is to capture the average price faced by individuals when they are making starting and quitting decisions. Since we only observe where people live at the time they are interviewed, we assume people do not change their state of residence between age 14 and the time of the survey. Although making this assumption is less than a perfect solution, it seems a reasonable approximation because there is very little interstate migration in Australia. For example, for the most populous states of New South Wales and Victoria, annual interstate arrivals represent between 1.1% and 1.6% of the states population in any given year over the period 1988-1998, while departures represent 1.4% to 2.1%. Nonetheless, to the extent that the assumption that individuals in our sample do not move state is incorrect, the effect of this measurement error problem is most likely to bias the coefficients on the price of cannabis towards zero.

A final measurement issue is that the questions concerning the dynamics of cannabis use are phrased in terms of the age of first (last) use and not in terms of the calendar year of first (last) use. Consequently, the year of birth is combined with the information about age of first use to calculate the calendar year in which first use occurred (and information about year of last year use to calculate the calendar year in which last use occurred). This may create a bias in the calculation of the relevant cannabis prices.

Table 2 reports information about the sample used in the analysis. The mean age of initiation into cannabis use amongst 14-22 year olds is 15 years. By the age of 12, only about 3% of the sample had used cannabis.[7] Initiation into cannabis use increases dramatically over the teenage years, with 19% of the sample having used cannabis by the age of 15, 45% by the age of 18, and 51% by the age of 21. Table 2 also shows that a large proportion of those who use cannabis do so for a short period of time. For example, 15% of those who have used cannabis quit within 2 years of initiation. After 6 years, only 45% of those who started are still using cannabis.

Figures 1-4 give more detailed information about the dynamics of cannabis use. In addition to the 14-22 year old age group, these figures also provide information on 23-32 year olds, 32-42 year olds and 43-52 year olds. The purpose of doing so is to show how these dynamics have changed over time. Figure 1 shows the starting rate of cannabis use, defined as the probability of starting use at a particular age conditional on not having started up to that age. In calculating age-specific starting rates, those who have not started to use cannabis at the time of survey are considered to have a duration until use that is right censored. As can be seen in Figure 1, the hazard of starting cannabis use peaks at younger ages for more recent cohorts. For example, for the 14-22 year old age cohort, the starting rate increases from age 12, reaching a maximum at age 15 and then drop off dramatically after age 17. By contrast, the hazard of starting cannabis use continues to rise until the age of 18 for the 33-42 year old age group, declining more gradually through to the age of

[7] The 4 individuals who reported using cannabis before the age of 12 are recoded as starting at age 12.

23. The age-specific starting rates are used to calculate the survival functions (the probability of not using until at least age T), which are shown in Figure 2. Figure 2 reiterates the earlier age of initiation of more recent cohorts already commented upon.[8] It also shows that the prevalence of cannabis use by age 20 is around 51% in 14-22 year old cohort compared to 37% for the 33-42 year old cohort.

Figure 3 shows the quit rate, defined as the probability of ceasing to use cannabis at a particular duration of use, given that the individual has not stopped up until that duration. If an individual is still using cannabis at the time of survey, their duration of use is considered to be right censored. As shown in Figure 3, the quit rate for cannabis use is very high in the first year of use, although it has fallen from around 30% in the oldest cohort to around 15% in the youngest cohort. For all but the youngest cohort, the quit rate is fairly stable at between 7% and 5% thereafter. However, for the 14-22 year old age cohort, the quit rate remains at around 10% for 2-6 years of use. Because of the youth of this cohort, we observe very few quits at durations greater than six years. The quit rates are used to calculate the survival functions, which are shown in Figure 4. As can be seen in Figure 4, the lower quit rates after the first year of use among the 14-22 year old age group is offset by the higher quit rates in subsequent years (compared to older cohorts). After about 5 years of use around 40% of cannabis users from all cohorts except the 23-32 year olds have quit using cannabis. For the 23-32 year old age group, only about 33% have quit after 5 years of use.

[8] This observation is consistent with Darke et. al (2000) who report that an increasing proportion of young people have tried cannabis, with 32% of 14-19 year olds from the 1985 NDSHS having tried cannabis compared to 41% from the 1995 NDSHS and 45% from the 1998 NDSHS.

3.2 Price of Cannabis

This research uses state level information on the monetary price of cannabis from the Australian Illicit Drug Reports (AIDR) and Drug Intelligence Reports (AIDR's predecessor) prepared by the Australian Bureau of Criminal Intelligence. These prices are recorded by police during undercover purchases (Australian Illicit Drug Report). The price data differentiate purchases by quality and weight, with states reporting prices for one or more of the following types of purchases: 1) a gram of high-quality cannabis, 2) a pound of high-quality cannabis, 3) a gram of low-quality cannabis or 4) a pound of low-quality cannabis. In terms of the following analysis, the ideal data would include a complete set of prices for each state and year for at least one of these price series. However, because there are no uniform reporting requirements, some states report a particular series while other states report a different price series. Missing observations for a reported series is also a problem. These issues are overcome by constructing a predicted (CPI deflated) price of a gram of high-quality cannabis from a regression model where price is based on quality of cannabis (high/low), size of purchase (pound/gram), state where purchase occurred, year of purchase, interactions of state and year of purchase and the jail sentence for possession of one kilogram of cannabis with intent to sell (measured in years). Further details on the construction of the predicted price of cannabis can be found in Williams (2004).

Figure 5 graphs the (CPI deflated) predicted price of cannabis for each state and territory over the period 1988-1998. Variation in the price of cannabis is apparent across states and across time. There are two main sources for this variation: comparative advantage (due to climate, geography or legislation) and technological innovation. Prior to the mid 1990's, cultivation of cannabis in Australia took place in large outdoor plantations, generally located in National Parks or on crown land. Due to a combination of climate and availability of remote locations (making detection difficult), Queensland, Western Australia, South Australia and Tasmania were the primary producers of cannabis, exporting to states such as New South Wales, Victoria and the Northern Territory.[9] South Australia had a further advantage in the production of cannabis in the form of its legislation governing cannabis. The legislation permitted each individual in a household to grow up to 10 cannabis plants, with the offense expiable by a fine of $150.[10]

From the mid 1990's onwards, there has been an increasing trend towards hydroponically grown cannabis. This trend started in states such as New South Wales, Victoria and the Australian Capital Territory, which had no comparative advantage in the outdoor crops. As opposed to outdoor cultivation, hydroponic crops are easily concealed from authorities and can therefore be grown in houses in metropolitan areas. They can also be grown year round and have the further advantage that the plant types cultivated hydroponically produce more potent cannabis.[11] By the late 1990's hydroponically grown cannabis was the dominant mode of cannabis produc-

[9] In NSW, the supply of cannabis was adversely affected by drought and eradication programs. In Victoria, a lack of suitably remote locations made outdoor cultivation too risky.

[10] This lead to the formation of cannabis syndicates. These syndicates operated by franchising cannabis growing operations to households. The households would typically grow between 8 and 10 plants for the syndicate in return for a share of the profits. The syndicates would transport (by car) cannabis to markets on other states, primarily NSW and Victoria.

[11] The syndicates in South Australia were quick to realize the commercial advantage of moving to the hydroponic crops. Given the long standing concern over the cannabis syndicates in South Australia, legislative changes were made in attempt to reduce the opportunity for them by reducing the number of plants that an individual could grow under the expiation scheme from 10 to 3. However, due to the increased profitability of the hydroponic cannabis, these syndicates continue to operate and to export to other states and territories. After recruiting home owners or people to rent houses to be crop sitters, the syndicate provides equipment to grow the hydroponic cannabis, specialist plant doctors to provide advice when pants were not producing and electricians to by-pass electricity meters. Similar arrangements are also common in Victoria.

tion.

4 Starting rates

4.1 Mixed proportional hazard model

Our analysis of initiation into cannabis use begins with the mixed proportional hazard (MPH) model, assuming a flexible baseline hazard. This type of model is often used in the analysis of exit rates out of unemployment (see Van den Berg (2001) for a recent overview). The rate at which individuals start using cannabis is assumed to depend upon their observed characteristics, the elapsed duration of time they are exposed to potential use and unobserved characteristics. Potential exposure to cannabis use is assumed to occur from the age of 12.

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

$$\theta(t \mid x, v) = \lambda(t) \exp(x'\beta + \gamma ln(p_t) + v) \tag{1}$$

where $\lambda(t)$ represents individual age dependence, p_t is the cannabis price at age t, β is a vector of parameters, and γ is the price elasticity of the starting rate. The unobserved components (random effects) are assumed to follow a discrete distribution with two points of support v^a and v^b

$$Pr(v = v^a) = q \quad Pr(v = v^b) = 1 - q \tag{2}$$

in which q has a logit specification with $q = \frac{e^\alpha}{1+e^\alpha}$. We assume that some of the youngsters will never use cannabis and therefore have a zero starting rate for cannabis: $v^b = -\infty$.

[12]Omitting the subscript for the individual

We model flexible age dependence by using a step function:

$$\lambda(t) = \exp(\Sigma\lambda_k I_k(t)) \tag{3}$$

where k (= 1,..,N) is a subscript for age-intervals and $I_k(t)$ are time-varying dummy variables that are one in subsequent age-intervals. We distinguish 9 age intervals: 12, 13, 14, 15, 16, 17, 18, 19, ≥20. Because a constant term is also estimated, λ_1 is normalized to 0.

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

$$f(t \mid x, v) = \theta(t \mid x, v) \exp(-\int_0^t \theta(s \mid x, v) ds) \tag{4}$$

and we remove the unobserved components by taking expectations:

$$f(t \mid x) = E_v[f(t \mid x, v)] = q.f(t \mid x, v = v^a) + (1 - q).f(t \mid x, v = v^b) \tag{5}$$

In the estimation we assume individuals that do not start using cannabis at age 22 have right-censored durations of non-use.

The observable characteristics that we control for are gender (an indicator for male), nationality (an indicator for Australian born), and education (an indicator for dropping out of school with 10 years of education or less) which is used as a proxy for ability. These characteristics are assumed to be known at the time an individual first faces the decision to start cannabis use. The education variable we use does not fulfill this requirement if, at the time an individual has to decide whether to initiate cannabis use, he is uncertain as to whether he will drop out of school before completing 10^{th} grade. There is also the possibility of reverse causality in which case cannabis use may result in dropping out of school. We ignore this possibility and assume that our educational variable represents ability and that this ability is known to the individual from the time he first faces the decision to use cannabis.[13]

The parameters of the model are estimated using maximum likelihood and presented in Table 3. As shown in the first column of Table 3, we find no significant difference in starting rates between males and females. Individuals that drop out of the education system at grade 10 and native born Australians have higher starting rates than their counterparts. Furthermore, as individuals grow older they are more likely to start using cannabis. The parameter α has a value of 0.46, which indicates that conditional on the observed characteristics 61% of the sample of 14-22 year olds have a positive cannabis starting rate while the remaining 39% will never start using cannabis. The results in column 1 of Table 3 also show that cannabis prices have a negative effect on the cannabis starting rates. The price elasticity is estimated to be -0.48.

As previously discussed, the variation in the price of cannabis reflects variation over time and across states. If the inter-state variation is correlated with unobserved state level characteristics, the estimated effect of cannabis prices on the starting rate will be biased. To address this we include a set of state fixed effects in the model. The results from doing so are contained in column 2 of Table 3. An LR test finds that the state fixed effects are jointly insignificant in the starting rate model and the parameter estimates are very similar to those obtained when the fixed effects are omitted.[14] The estimated price elasticity is equal to -0.55 when state fixed effects are included in the model for the starting rate for cannabis use.

[13]As a sensitivity analysis we excluded the educational variable but this does not affect our main results.

[14]The LR test statistic equals 5.4 compared to a the critical value (for a χ^2 with 7 degrees of freedom at the 5% level of significance) of 14.7.

The third column of Table 3 shows what happens if the effect of the price of cannabis is ignored. Most of the parameter estimates are robust to omitting the price variable. However, an LR test confirms that the price of cannabis has a significant effect on the cannabis starting rate.[15]

4.2 Split population model

To account for the fact that a large proportion of people never start smoking, research on the dynamics of cigarette use typically use a split population (SP) model (see for example Douglas and Hariharan (1994) and Kidd and Hopkins (2004)). The SP model differs only slightly from the MPH model. While both models specify the probability of being a potential user as a binary choice, the SP model allows the outcome to depend on time-invariant personal characteristics.[16]

To demonstrate that the differences between the MPH model and the SP model are not large, Table 4 presents parameter estimates for a SP model.[17] This model is similar to the MPH model of equation (5) except for the probability q is now specified as a function of gender, education, and nationality.

$$q = \frac{e^{\alpha_0 + x'\delta}}{1 + e^{\alpha_0 + x'\delta}} \tag{6}$$

As with Table 3, the first column in Table 4 reports the results for a model that excludes state level fixed effects, the second column reports the results when state fixed effects are included and the model reported in the third column includes state fixed effects but excludes price from the model. The top half of the table reports

[15]The LR test statistic equals 7.0, whereas the critical value for a $\chi^2$with 1 degree of freedom at the 5% level of significance is 3.8.

[16]A second difference between the two models is that a functional form is typically imposed on the age dependence in the SP mode. This leads to some inflexibility in the baseline starting rate.

[17]For reasons of comparison with the MPH model we specify the binary choice in the SP model as a logit instead of a probit as is usually done.

results for the hazard of starting cannabis use for potential users and the bottom half of the table reports results for the probability of being a potential cannabis user. Almost all the parameter estimates for the hazard of starting cannabis use for potential users in the first column of Table 4 are the same as those reported in Table 3, including the estimated price elasticity. The probability of being a potential cannabis user does not differ by gender. Native born Australians have a higher probability of being a potential cannabis user. An LR test comparing the MPH model with the SP model indicates that education has a significant effect on the probability of being a potential cannabis user leading to the conclusion that the SP model is the preferred model.

The second column of Table 4 shows that introducing state fixed effects in both the starting rate and the probability of being a potential cannabis user has little impact on the parameter estimates except for the price elasticity, which is now estimated to be -0.53.[18] The third column of Table 4 shows the parameter estimates if we constrain the effect of the price of cannabis to be zero. As with the MPH model, an LR test finds that price has a significant effect on the starting rate.[19]

5 Quit rates

As with the decision to start cannabis use, our analysis of the decision to quit use begins with the mixed proportional hazard model. In this model, the quit rate at time t conditional on the observed characteristics z and the unobserved

[18]The LR test statistic for testing the joint significance of the state fixed effects is 26.4, compared to the critical value of 23.7 (for a chi-squared with14 degrees of freedom at the 5% level of significance) leading to the conclusion that state fixed effects matter.

[19]The LR test statistic equals 6.2 compared to the critical value for a $\chi^2$with 1 degree of freedom at the 5% level of significance of 3.8.

characteristics u is specified as

$$\theta^s(t \mid z, u) = \lambda^s(t) \exp(z'\beta^s + \gamma^s ln(p_t) + u) \tag{7}$$

where z contains the age the individual started using cannabis in addition to the variables contained in x. Furthermore, λ^s(t) represents duration dependence, which is specified as

$$\lambda^s(t) = \exp(\Sigma\lambda^s_m I_m(t)) \tag{8}$$

where m (= 1,..,N) is a subscript for duration intervals and $I_m(t)$ are time-varying dummy variables that are one in subsequent duration intervals. We distinguish 5 duration intervals, specified in years: 1, 2, 3, 4, $\geq$5. Because a constant term is also estimated, λ^s_1 is normalized to 0. As before, the unobserved components are assumed to follow a discrete distribution with two points of support, where the distribution has a logit specification. Just as some individuals may be of a type that never starts using cannabis, there may be a group of cannabis users who will never quit. Therefore, one of the quit rates is assumed to be equal to zero.

The parameter estimates of the MPH model are contained in columns 1-3 of Table 5. The model reported in the first column omits state fixed effects, the second column reports results when state fixed effects are included, and the third column reports results when state fixed effects are included but price is omitted. The parameter estimates in the first column of Table 5 show that while there is no evidence that gender or education affects the quit rate from cannabis use, Australian born cannabis users are more likely to quit than foreign born users. The age of initiation is found to have a positive effect indicating that individuals who start to consume cannabis at a younger age are less likely to quit use. The parameter estimate for α_0 implies that about half of the individuals that started using cannabis never quit.[20] It also appears that the quit rate is substantially higher after one year of use than after two years of use. This reflects the fact that many individuals stop using cannabis within a year of starting and is consistent with Donnelly and Hall (1994) who report a relatively high degree of experimentation in cannabis use in Australia. Beyond two years of use, the quit rate increases with the duration of use. Finally, the cannabis price seems to have a significant negative effect on the quit rate. The second column of Table 5 shows that the most of the coefficient estimates are robust to the inclusion of state fixed effects. The exception is the coefficient on the indicator for being male, which is now significantly negative.

Taken at face value, the negative estimate for the coefficient on price suggests that higher cannabis prices are associated with fewer quits. This implausible result is due to the limitations of our data. Our sample does not contain many quits because it consists of young individuals who have only recently started using cannabis. Therefore, most of the quits from cannabis use occur from 1995 onwards. In the period since 1995, cannabis prices declined in most states creating a spurious calendar time correlation between quit rates and cannabis prices.

Although data limitations make it difficult to get useful estimates of the impact of price on the decision to quit cannabis use, it may be the case that price has no effect on the quit rate. A substantial proportion of those who start using cannabis do so for only a short while. If, as shown in Table 3 and 4, up-take of cannabis is associated with lower prices and prices have been falling, it is difficult to see why so many users stop after such a short time. The third column of Table 5 shows that the

[20]Note that we can only follow cannabis users for a limited period of time. If there is a group that has a small quit rate it is likely that we estimate the quit rate for this group to be equal to zero.

parameter estimates are robust to imposing the constraint that price has no effect on the quit rate.

The fourth column of Table 5 presents the results for the SP model. These estimates show that males are less likely to be in the group of potential quitters than females. In other words, male cannabis users are more likely to be in the group of permanent cannabis users.

6 Other age groups

The focus of this paper is on people born between 1976 and 1984 (aged 14-22 years old at the time of survey) because we can observe how they respond to changes in the price of cannabis. In this section we investigate the sensitivity of our results to limiting our analysis to this age range by estimating models for start and quit rates for older age groups. Specifically, we estimate models for individuals born in the periods 1966 to 1975 (aged 23-32 at the time of survey), 1956 to 1965 (aged 33-42 at the time of survey), and 1946 to 1955 (aged 43-52 at the time of survey). For these three groups we present MPH model and SP model estimates for starting rates and quit rates.[21] Due to a lack of information on cannabis prices we have to ignore the price effects for these age groups.

Table 6 reports the parameter estimates of the models for the hazard of starting cannabis use. Based on the MPH model, 65% of the 23-32 year old sample are potential cannabis users. Among the potential users of cannabis in this age group males, the low skilled and native born Australians have higher starting rates than their female, more highly educated, foreign born counterparts. The results are similar for the SP model. In addition, the SP model results reveal that males and

[21]State fixed effects are included in all models presented in this section.

native born Australians are more likely to be in the group of potential cannabis users than females and those born overseas. Estimates of the MPH model for 33-42 year olds indicate that 55% of this age group are potential users of cannabis. The results are otherwise similar to those for the 23-32 year old age group. Overall, with the exception of the gender effect, the parameter estimates for the 23-32 year olds and the 33-42 year olds are in agreement with those for the 14-22 year olds. About 36% of the 43-52 year olds are potential cannabis users. The results for this age group differ from the younger cohorts in that, among potential users of cannabis, the low skilled are less likely to start using cannabis and less likely to be a potential cannabis user.[22]

A comparison of the parameter estimates for the starting rates across different age cohorts reveals the way cannabis use has penetrated the Australian population over time. It shows that the probability of being a potential cannabis user has increased over time, whereas the differences in cannabis use dynamics between males and females have become smaller. Among the oldest cohort, high skilled individuals are more likely to use cannabis but over time, this has been reversed and high skilled individuals are now more likely to use. Comparing the estimates for the different cohorts we conclude that there is no indication that restricting sample to the youngest age category leads to biased parameter estimates of the starting rate.

Table 7 provides parameter estimates for the MPH model and SP model of the hazard of quitting cannabis use. The differences between the MPH-estimates and the PH-estimates are small since none of the explanatory variables have a significant effect on the probability of being a potential cannabis quitter in the SP models

[22] For this age group, there are too few individuals who start using cannabis at a young age to identify separately the impact of being 13 and 14 years old on the hazard of starting cannabis use.

models for most age groups. On average 67% of the 23-32 year old age group are potential quitters, 80% of the 33-42 year old age group are potential quitters and 84% of the 43-52 year old age group are potential quitters. For all cohorts males are less likely to quit cannabis use than females and the starting age has a positive effect on the quit rate. There is clear negative duration dependence in the quit rate, with the first year quit rate substantially higher than the quit rate in subsequent years of use. Results for the SP model for the 43-52 year old age group indicates that the starting age has a negative effect on the probability of being a potential quitter. That is, the later individuals started using cannabis the more likely they are to be in the group of non-quitters. Comparing the estimates for the older cohorts with those for the 14-22 year old age group, we conclude that our main finding, that the age of initiation into cannabis use has a negative effect on the quit rate, is robust to the age group considered.

7 Sensitivity analysis

In this section we discuss the robustness of our results to the assumptions about the distribution of unobserved heterogeneity in the MPH models, whether the unobserved components of the start and quit rates in the MPH model are correlated and the way that the age of onset affects the quit rate. We also give a sense of the quantitative impact of variables on the start and quit rates.

In the MPH models of starting and quitting cannabis use we assumed the distribution of unobserved heterogeneity to be discrete with two points of support. In order to assess the impact of this assumption, we tried to expand the number of points of support to three but could not find a third point. We also investigated whether the unobserved heterogeneity components of the start rate and quit rate are correlated but found no evidence of this. Finally, we investigated whether there is a non-linear relationship between the age of onset and the quit rate. For example, the age of onset may be a significant determinant of the quit rate up to a particular age but not beyond that age. We examined this issue by adding dummy variables for each age of onset between 13 and 17, and a dummy variable for age of onset beyond 17 (a total of 6 dummy variables) to the MPH-specification of Table 5 column 4. The loglikelihood of the resultant model dropped to 1135.0 and an LR-test found that the dummy variables for age of onset are jointly insignificant.[23] We also examined this issue for the SP specification reported in column 5 of Table 5 and found that age of onset has a linear effect on both the probability of being a potential quitter and the quit rate.[24]

Because of the non-linearity of the models estimated in this paper, it is difficult to get a sense of the size of the effect of explanatory variables on the starting rate and the quit rate. To illustrate these effects we used the parameter estimates of the SP model of the start rate presented in column 2 of Table 4 and the quit rate presented in column 5 of Table 5 to calculate cumulative starting rates and quit rates. We did this for two different types of individuals. Type 1 is male, Australian born with a maximum education of 10 years. Type 2 is female, foreign born with more than 10 years of education. To illustrate the effect of the price of cannabis we calculate cumulative starting rates for each type when the price is 20 dollars per

[23]The LR test of the joint significance of the age of onset dummy variables is 6.4 whereas the critical value for a χ^2 with 6 degrees of freedom at the 5% level of significance is 12.59. The LR-test for the significance of the linear term is 9.2 compared to the critical value for a χ^2 with 1 degree of freedom at the 5% level of significance of 3.8.

[24]The LR test of the joint significance of the age of onset dummy variables is 20.0 whereas the critical value for χ^2 a with 12 degrees of freedom at the 5% level of significance is 21.03. The LR-test for the significance of the linear term is 12.0 compared to the critical value for a χ^2 with 1 degree of freedom at the 5% level of significance of 3.8.

gram and 40 dollars per gram.

Table 8 shows the results of the calculations. Type 1 individuals have a substantially higher cannabis starting rate than type 2 individuals, with 64% of type 1 individuals having a positive starting rate compared to 47% of type 2 individuals. For both types, irrespective of the cannabis price the cumulative starting rate reaches the maximum at age 18 implying that all individuals with a positive starting rate have started using cannabis by that age. Higher cannabis prices are associated with lower starting rates at each age. For example, if faced with a price of 20 dollars per gram about 51% of 14 year olds start using cannabis, compared to 42% when the price is 40 dollars per gram. The third column of Table 8 shows the way that the age of onset affects the quit rate amongst those who have used for a duration of five years. If individuals of type 1 start using cannabis at age 12, 88% are still using cannabis five years later. However, if they start at age 17, 72% are still using after five years. So the older individual are when they start using cannabis, the more likely they are to use for a shorter duration. For type 2 individuals the starting rates and quit rates are lower but the general pattern is the same: a low price leads to an early age of onset, an early age of onset leads to a low quit rate. Combining these two observations, it is clear that the cannabis price has an indirect effect on the quit rate: a high cannabis price leads to an older age of onset, and this older age of onset leads to a high quit rate. In short, high cannabis prices lead to low durations of cannabis use.

8 Discussion

Previous research on participation in cannabis use provides useful evidence that cannabis demand is price responsive but is limited in its ability to inform policy makers as to how best minimize the harm associated with cannabis use. This is because studies of participation are uninformative as to whether price has a greater impact on the initiation or quitting decision.

In order to investigate these aspects of cannabis use, we estimate mixed proportional hazard models and split population models of initiation into cannabis use for Australians aged 14-22 years old. While the split population model emerged as the preferred model, the results are remarkably consistent with those obtained from the mixed proportional hazard model. Overall, conditional on the observed characteristics about 60% of the sample of 14-22 year olds are estimated to be potential users of cannabis. Australian born respondents are more likely than their foreign born counterparts to be in this group. The results also indicate that initiation into cannabis use is price responsive, with the estimated price elasticity falling in the range of -0.47 to -0.55. We find no significant difference between males and females in terms of either their likelihood of being potential users or their hazard of starting cannabis use for this age group. However, we do find that among potential users, the less educated and the Australian born are more likely to use cannabis.

We also study the decision to quit cannabis consumption using mixed proportional hazard models and split population models. Due to the relative youth of our sample and the consequent recentness of their initiation into cannabis use, most of the quits we observe occur in the last few years of the sample. Unfortunately, there does not appear to be sufficient variation in the price data observed over this time frame to obtain reliable estimates of the price responsiveness of the quitting decision. We feel, however, that it is unlikely that there is a strong price effect on the quitting decision. Nonetheless, we do uncover important policy relevant results with regard to quits. We find that, just as some individuals will never start using cannabis, around half of those who do start using never quit and that males are more likely to be in the group of permanent users. Among those who are potential quitters, however, we find that individuals who start using cannabis at a younger age are less likely to quit.

This research makes several significant contributions to understanding the dynamics of cannabis use. First, we find that price has a stronger effect on the up-take decision that the quitting decision. Since the decision to quit is impacted by considerations that do not affect up-take, such as the users current level of addictive stock, our finding that contemporaneous prices have a larger impact on the current period decision to start using cannabis than the decision to stop using cannabis is consistent with the rational addiction model. It also sheds light on the empirical results of Williams (2004), who finds participation in cannabis use by young people is more price responsive than participation by older people. Taken together with the results from the current study, it is likely that the participation elasticity for the younger age group largely reflects the price sensitive up-take decision, whereas participation by the older age group reflects both up-take and quitting decisions.

The second contribution of this research comes from the finding that those who initiate cannabis use earlier in life are likely to use the drug for longer. As harm accumulates over time, a longer duration is likely to be associated with greater harm. Similarly, Pudney (2004) finds that early onset of cannabis use raises subsequent rates of consumption substantially. Both studies imply that policies that aim to delay or prevent the onset of cannabis use are likely to be more effective at minimizing harm associated with use compared to policies which encourage current users to quit.

Finally, taken together, the results from this research suggest that in addition to its direct effect on initiation into cannabis use, the price of cannabis has an indirect effect on the quit rate. Specifically, low cannabis prices lead to early cannabis use and early initiation into cannabis use is associated with a low quit rate. Therefore, lower cannabis prices are associated with greater harm directly through their impact on age of initiation and indirectly through the duration of use.

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Appendix A. Definition of variables

Male: indicator for respondent is male (reference category is female)

Australian born: indicator for the respondent was born in Australian

Age: age of individual at time of survey; minimum age = 14, maximum age = 22.

Education ≤ 10: dropping out after 10 years of education

The characteristics of the samples used in the analysis of starting rates (Sample 1) and quit rates (Sample 2) are as follows:

	Sample 1	Sample 2
Male	0.46	0.46
Australian born	0.87	0.90
Education ≤ 10	0.15	0.19
Age	18.1	18.8
Price	31.8	32.6
Regions		
NT	0.06	0.08
ACT	0.13	0.13
NSW	0.14	0.12
QLD	0.23	0.25
VIC	0.16	0.14
SA	0.09	0.10
TAS	0.10	0.10
WA	0.08	0.09
N	2157	1068

Sample 1 contains 1068 completed durations and 1089 right-censored durations; Sample 2 contains 398 completed durations and 670 right-censored durations. All variables are dummy variables except for the cannabis price, which has a minimum of 21.9 and a maximum of 41.9 (dollars per gram of high-quality cannabis; prices 1989-90).

Table 1 Prevalence of cannabis use by age and gender

	Age group				Gender		
Period	14-19	20-29	30-39	40+	Males	Females	Total
In lifetime	45.2	63.9	56.7	21.4	43.8	34.6	39.1
In the last 12 months	35.1	36.9	20.3	6.2	21.4	14.5	17.9
In the last month	14.0	16.8	8.7	2.1	10.1	4.9	7.5
In the last week	9.1	12.6	6.7	1.4	7.6	3.3	5.4

Table 2 Dynamics of cannabis use amongst 14-22 year olds

	Males	Females	Total
Mean Age of Onset	15.4	15.4	15.4
Prob. to have used (%)			
At age 12	3.1	3.0	3.0
At age 15	17.7	19.6	18.7
At age 18	45.6	44.7	45.1
At age 21	51.4	51.2	51.3
Prob. of remaining user (%)			
After 2 years	85.3	83.8	84.5
After 4 years	71.3	65.9	68.4
After 6 years	61.4	50.1	55.5

Table 3 Parameter estimates starting rates cannabis; mixed proportional hazard model

	(1)	(2)	(3)
Male	0.05 (0.8)	0.05 (0.9)	0.05 (0.9)
Education $\leq$ 10	0.34 (3.2)*	0.33 (4.7)*	0.33 (4.7)*
Australian born	0.36 (3.2)*	0.36 (3.0)*	0.36 (3.0)*
Cannabis price	-0.48 (3.7)*	-0.55 (3.1)*	0 (-)
Age 13	0.94 (6.4)*	0.94 (6.5)*	0.92 (6.3)*
Age 14	1.36 (9.7)*	1.36 (9.7)*	1.34 (9.6)*
Age 15	1.85 (13.5)*	1.85 (13.5)*	1.83 (13.4)*
Age 16	2.33 (17.1)*	2.34 (17.2)*	2.32 (17.0)*
Age 17	2.89 (21.1)*	2.90 (21.1)*	2.88 (21.1)*
Age 18	2.77 (18.0)*	2.78 (17.9)*	2.76 (17.8)*
Age 19	3.13 (19.2)*	3.14 (19.2)*	3.16 (19.2)*
Age $\geq$20	4.47 (27.0)*	4.44 (25.6)*	4.47 (25.8)*
α_0	0.46 (8.5)*	0.46 (8.4)*	0.49 (8.8)*
Territories [a)]	no	yes	yes
-Loglikelihood	3169.7	3167.0	3170.5

[a)] 7 territories fixed effects

Note: The estimates are based on 2157 observations; absolute t-statistics in parentheses, a * indicates that the coefficient is different from zero at a 5% level of significance.

Table 4 Parameter estimates starting rates cannabis; split population model

	(1)	(2)	(3)
Male	0.05 (0.8)	0.05 (0.8)	0.05 (0.8)
Education $\leq$ 10	0.34 (4.9)*	0.36 (4.9)*	0.36 (4.9)*
Australian born	0.18 (1.7)*	0.17 (1.4)	0.16 (1.3)
Cannabis price	-0.47 (3.6)*	-0.53 (2.9)*	0 (-)
Age 13	0.94 (6.4)*	0.94 (6.4)*	0.92 (6.3)*
Age 14	1.36 (9.7)*	1.36 (9.7)*	1.34 (9.6)*
Age 15	1.85 (13.4)*	1.86 (13.5)*	1.83 (13.3)*
Age 16	2.33 (17.1)*	2.34 (17.1)*	2.32 (17.0)*
Age 17	2.89 (21.2)*	2.91 (21.1)*	2.89 (21.1)*
Age 18	2.78 (18.0)*	2.79 (18.0)*	2.77 (17.8)*
Age 19	3.15 (19.3)*	3.16 (19.3)*	3.18 (19.4)*
Age $\geq$20	4.48 (27.0)*	4.46 (25.6)*	4.48 (25.7)*
α_0	-0.14 (0.9)	-	-
Male	0.01 (0.1)	0.03 (0.2)	0.03 (0.3)
Education $\leq$ 10	0.06 (0.5)	0.00 (0.0)	-0.01 (0.1)
Australian born	0.66 (4.3)*	0.66 (4.1)*	0.67 (4.2)*
Territories [a)]	no	yes	yes
-Loglikelihood	3161.1	3147.9	3151.0

[a)] 7 territories fixed effects; these are included in the hazard as well as the probability; therefore in the model with territories fixed effects no constant (α_0) is reported.

Note: The estimates are based on 2157 observations; absolute t-statistics in parentheses, a * indicates that the coefficient is different from zero at a 5% level of significance.

Table 5 Parameter estimates quit rates

	(1)	(2)	(3)	(4)
Male	-0.13 (1.3)	-0.20 (2.0)*	-0.15 (0.5)	-0.00 (0.0)
Education $\leq$ 10	-0.00 (0.0)	0.03 (0.2)	-0.03 (0.2)	-0.04 (0.4)
Australian born	0.50 (2.8)*	0.38 (2.0)*	0.53 (2.9)*	0.50 (2.5)*
Starting age	0.42 (16.5)*	0.40 (16.1)*	0.43 (16.9)*	0.41 (14.9)*
Cannabis price	-0.57 (2.7)*	-1.51(4.7)*	0 (-)	0 (-)
Year 2	-0.25 (2.7)*	-0.21 (1.8)	-0.24 (2.0)*	-0.25 (2.1)*
Year 3	0.20(1.6)	0.28 (2.2)*	0.23 (1.8)	0.23 (1.8)
Year 4	0.43 (2.9)*	0.54 (3.6)*	0.50 (3.3)*	0.51 (3.3)
Year $\geq$5	1.14 (6.2)*	1.31 (7.6)*	1.21 (6.7)*	1.25 (7.1)*
α_0	-0.11 (1.5)	-0.15 (2.0)*	-0.11 (1.4)	-
Male	-	-	-	-0.45 (2.9)*
Education $\leq$ 10	-	-	-	0.09 (0.5)
Australian born	-	-	-	0.06 (0.2)
Starting age	-	-	-	0.06 (1.5)
Territories [a)]	no	yes	yes	yes
-Loglikelihood	1145.2	1132.1	1138.2	1128.4

[a)] 7 territories fixed effects; in the SP-model these are included in the hazard as well as the probability; therefore in the model with territories fixed effects no constant (α_0) is reported.

Note: The estimates are based on 1068 observations; absolute t-statistics in parentheses, a * indicates that the coefficient is different from zero at a 5% level of significance.

Table 6 Parameter estimates starting rates; other age groups

	Age 23-32		Age 33-42		Age 43-52	
	MPH	SP	MPH	SP	MPH	SP
	(1)	(2)	(3)	(4)	(5)	(6)
Male	0.21 (4.1)*	0.18 (3.5)*	0.29 (5.0)*	0.25 (4.6)*	0.60 (4.3)*	0.38 (3.0)*
Education $\leq$ 10	0.29 (5.2)*	0.28 (5.1)*	0.13 (2.1)*	0.13 (1.7)	-0.92 (4.8)*	-0.30 (1.8)
Australian born	0.22 (2.5)*	0.11 (1.3)	0.20 (2.6)*	0.14 (1.9)	0.21 (1.3)	0.23 (1.5)
Age 13	0.34 (1.3)	0.34 (1.3)	0.84 (2.3)*	0.84 (2.3)*	-	-
Age 14	1.52 (6.8)*	1.52 (6.8)*	1.37 (4.1)*	1.37 (4.0)*	-	-
Age 15	2.12 (9.8)*	2.12 (9.8)*	2.21 (7.0)*	2.21 (6.9)*	1.35 (1.9)	1.35 (1.9)
Age 16	2.93 (14.2)*	2.93 (14.2)*	2.83 (9.1)*	2.83 (9.1)*	2.51 (4.4)*	2.51 (4.3)*
Age 17	2.94 (14.0)*	2.94 (14.0)*	3.18 (10.3)*	3.18 (10.3)*	3.17 (5.8)*	3.17 (5.7)*
Age 18	3.46 (16.6)*	3.46 (16.6)*	3.93 (12.9)*	3.93 (12.9)*	3.82 (7.1)*	3.82 (7.0)*
Age 19	3.24 (15.2)*	3.24 (15.2)*	3.37 (10.8)*	3.37 (10.8)*	3.64 (6.7)*	3.64 (6.6)*
Age $\geq$ 20	3.12 (14.9)*	3.12 (15.0)*	3.31 (10.8)*	3.35 (11.0)*	3.46 (6.6)*	3.59 (6.8)*
α_0	0.60 (13.4)*	-	0.19 (4.4)*	-	-0.58 (6.9)*	-
Male	-	0.33 (3.7)*	-	0.45 (5.0)*	-	0.70 (4.6)*
Education $\leq$ 10	-	0.08 (0.8)	-	0.02 (0.2)	-	-0.64 (3.7)*
Australian born	-	0.59 (4.8)*	-	0.60 (5.6)*	-	0.00 (0.0)
-Logl.	5048.6	5022.9	4808.8	4763.3	1456.4	1430.8
N	2402		2321		919	

Note: All estimates include territories fixed effects; absolute t-statistics in parentheses, a * indicates that the coefficient is different from zero at a 5% level of significance.

Table 7 Parameter estimates quit rates; other age groups

	Age 23-32		Age 33-42		Age 43-52	
	MPH	SP	MPH	SP	MPH	SP
	(1)	(2)	(3)	(4)	(5)	(6)
Male	-0.55 (6.8)*	-0.42 (4.7)*	-0.35 (4.5)*	-0.22 (2.6)*	-0.20 (1.5)	-0.28 (2.1)*
Education $\leq$ 10	-0.04 (0.5)	0.03 (0.3)	0.13 (1.6)	0.19 (2.3)*	0.15 (1.0)	0.32 (2.2)*
Australian born	0.07 (0.6)	0.13 (1.1)	0.39 (3.9)*	0.34 (2.9)*	0.06 (0.3)	0.13 (0.9)
Starting age	0.24 (25.6)*	0.24 (24.5)*	0.16 (23.3)*	0.16 (20.5)*	0.09 (10.0)*	0.11 (11.6)*
Year 2	-1.01 (8.7)*	-1.01 (8.7)*	-1.19 (10.1)*	-1.18 (10.0)*	-1.77 (6.1)*	-1.78 (5.9)*
Year 3	-0.92 (7.5)*	-0.91 (7.4)*	-1.00 (8.4)*	-1.00 (8.2)*	-1.12 (4.9)*	-1.13 (4.9)*
Year 4	-0.90 (6.8)*	-0.89 (6.7)*	-1.36 (9.2)*	-1.35 (9.0)*	-2.11 (5.6)*	-2.14 (5.6)*
Year 5	-0.75 (5.6)*	-0.73 (5.5)*	-1.30 (8.4)*	-1.28 (8.2)*	-1.38 (5.0)*	-1.43 (5.1)*
Year 6	-0.65 (4.6)*	-0.61 (4.3)*	-1.05 (7.0)*	-1.04 (6.8)*	-1.45 (4.8)*	-1.51 (4.9)*
Year 7	-0.66 (4.0)*	-0.60 (3.7)*	-1.44 (7.6)*	-1.43 (7.5)*	-2.17 (4.7)*	-2.24 (4.9)*
Year 8	-0.69 (3.9)*	-0.63 (3.5)*	-1.20 (9.6)*	-1.18 (6.6)*	-1.90 (4.6)*	-1.99 (4.7)*
Year 9	-0.45 (2.5)*	-0.37 (2.0)*	-0.96 (5.7)*	-0.94 (5.4)*	-1.15 (3.8)*	-1.28 (4.2)*
Year $\geq$10	0.05 (0.3)	0.17 (1.0)	-1.20 (9.6)*	-1.16 (7.3)*	-1.80 (8.1)*	-2.07 (10.9)*
α_0	0.72 (7.6)*	-	1.37 (10.9)*	-	1.64 (6.4)*	-
Male	-	-0.29 (1.8)	-	-0.37 (1.8)	-	-0.04 (0.0)
Education $\leq$ 10	-	-0.03 (0.2)	-	0.16 (1.6)	-	-1.13 (1.3)
Australian born	-	-0.17 (0.7)	-	-0.23 (1.1)	-	-2.24 (1.6)
Starting age	-	0.02 (0.7)	-	0.01 (0.3)	-	-0.18 (2.5)*
-Logl.	2645.3	2623.6	2654.1	2649.3	697.0	688.8
N	1518		1253		299	

Note: All estimates include territories fixed effects; absolute t-statistics in parentheses, a * indicates that the coefficient is different from zero at a 5% level of significance.

Table 8 Cumulative starting probabilities and cumulative probabilities to use 5 years after initiation; results of calculations

	Type 1			Type 2		
	Start		Quit	Start		Quit
Age	p=20	p=40		p=20	p=40	
12	5.4	3.8	88.4	2.3	1.6	89.6
13	30.6	23.2	84.6	14.5	10.6	85.6
14	50.7	42.4	80.4	27.6	21.3	80.9
15	61.5	57.1	76.5	39.3‘	33.5	75.8
16	63.6	61.6	73.6	43.8	39.4	71.0
17	64.2	63.6	72.0	46.2	43.8	67.4
18	64.3	64.3	71.4	47.3	47.2	65.4
19	64.3	64.3	71.3	47.3	47.2	64.6

Type 1: Male, Australian born, Education ≤ 10.

Type 2: Female, non-Australian born, Education > 10.

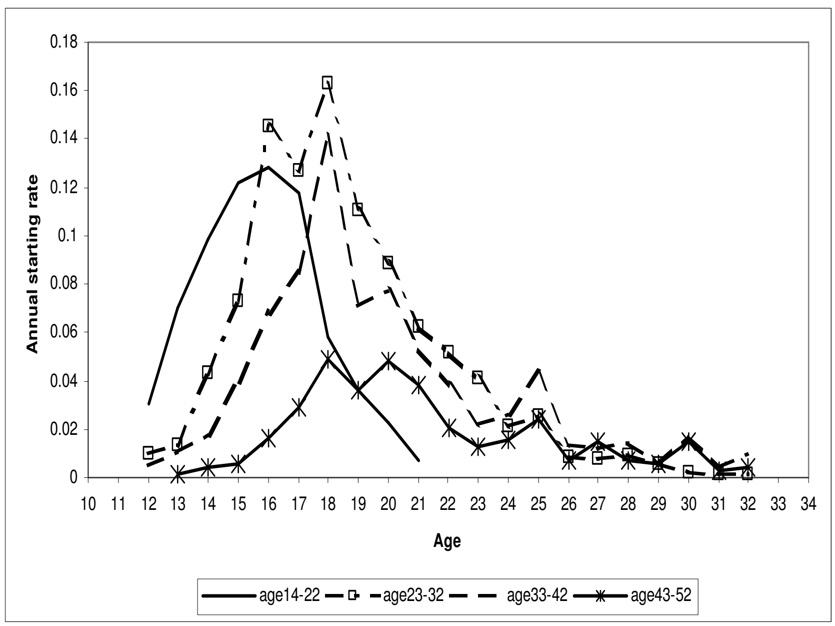

Figure 1: Annual starting rates cannabis use; four age groups

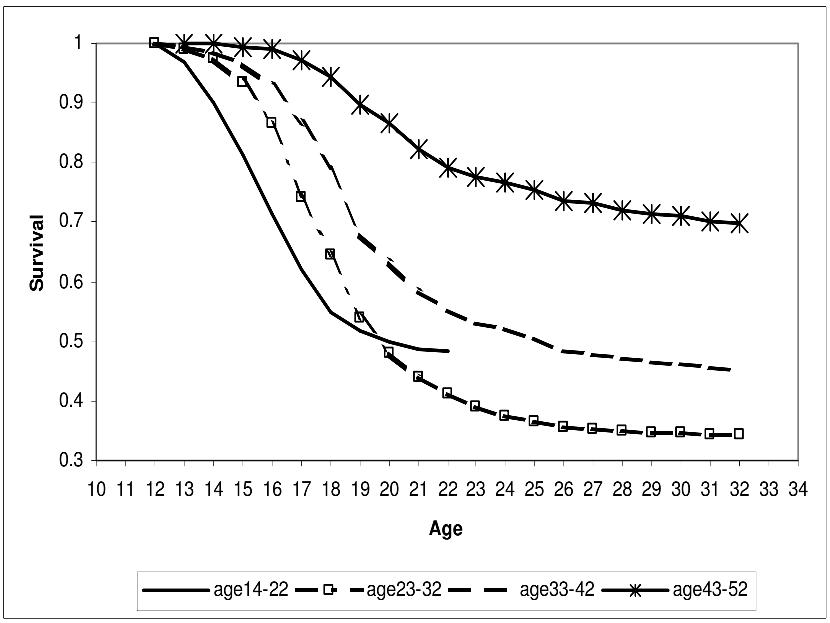

Figure 2: Survival functions non cannabis use; four age groups

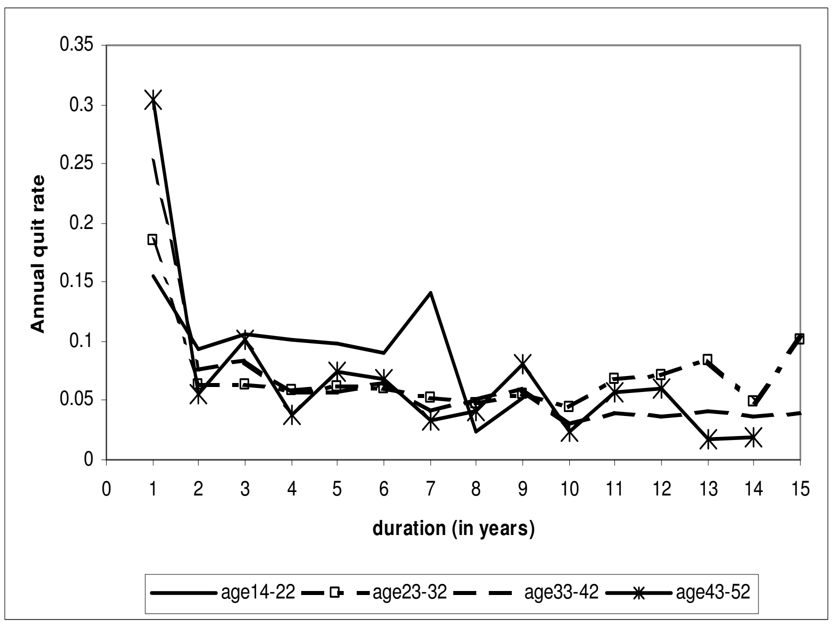

Figure 3: Annual quit rates cannabis use; four age groups

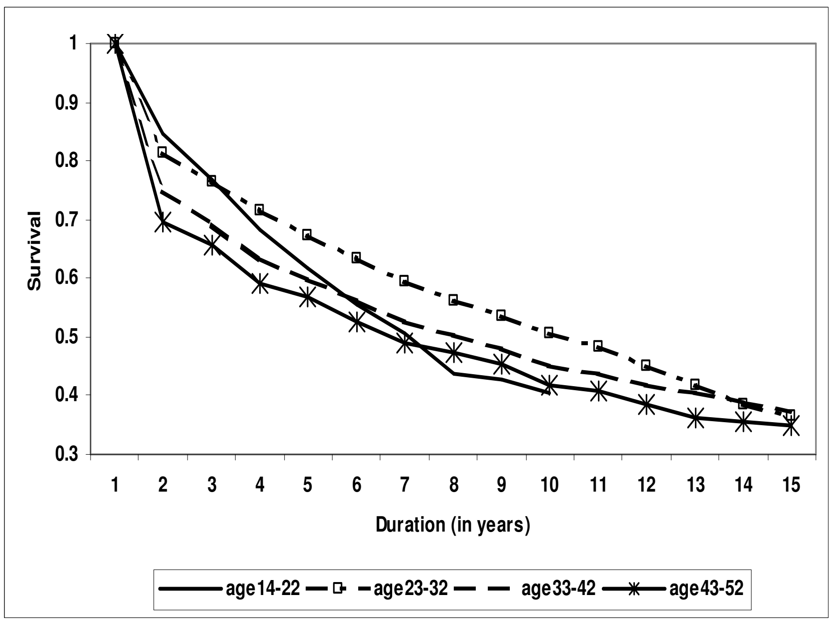

Figure 4: Survival functions cannabis use; four age groups

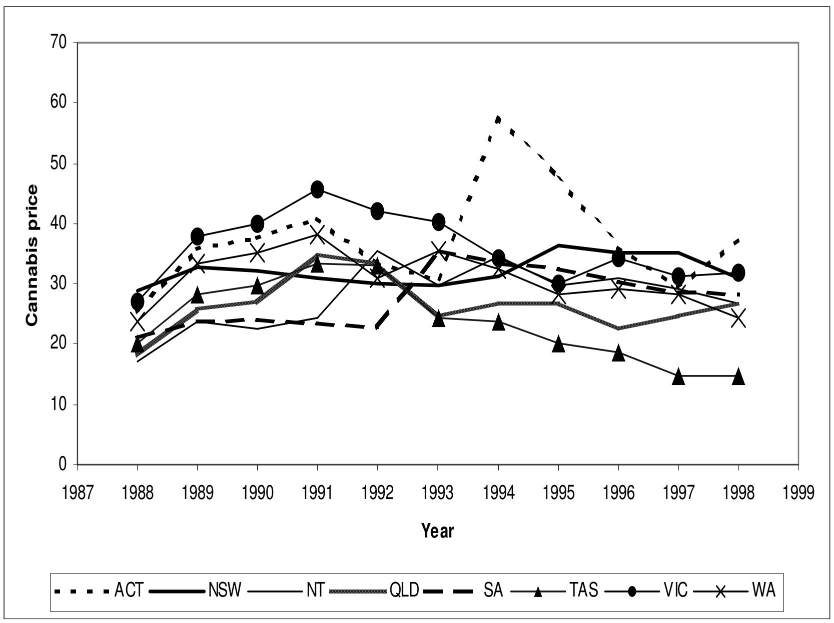

Figure 5: Cannabis prices; 1988-98