This is the authors' final, peer reviewed manuscript published in
Journal of Health Economics 36 (2014) with DOI: 10.1016/j.jhealeco.2014.03.006
(ISSN 0167-6296 print; 1879-1646 online) with the title:
Does liberalizing cannabis laws increase cannabis use?
http://www.sciencedirect.com/science/article/pii/S0167629614000356

Does liberalizing cannabis laws increase cannabis use?

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Does Liberalizing Cannabis Laws Increase Cannabis Use?

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March 2, 2014

Abstract

A key question in the ongoing policy debate over cannabis' legal status is whether liberalizing cannabis laws leads to an increase in cannabis use. This paper provides new evidence on the impact of a specific type of liberalization, decriminalization, on initiation into cannabis use. Our identification strategy exploits variation in the timing of cannabis policy reforms and our estimation framework marries a difference-in-difference approach with a discrete time duration model. Our results reveal evidence of both heterogeneity and dynamics in the response of cannabis uptake to decriminalization. Overall, we find that the impact of decriminalization is concentrated amongst minors, who have a higher rate of uptake in the first five years following its introduction.

Keywords: cannabis initiation; decriminalization; hazard rate; natural experiment

JEL codes: C41, I10, I18

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‡The authors wish to thank Jan van Ours, Asako Ohinata, Matteo Picchio, Stephen Jenkins, participants of the ISSDP conference in Santa Monica (2010) and ASHEcon 2012 for valuable comments. Jamie Fini provided excellent research assistance. We gratefully acknowledge support from the Australian Research Council; grant number DP0770580.

1 Introduction

The legal status of cannabis use is never far from the policy agenda. In 2012, three states in the US held ballot initiatives to legalize the recreational use of cannabis. The initiatives passed in the states of Washington and Colorado but not in Oregon. This followed the narrow defeat of a similar referendum held in California in 2010. In recent years, criminal sanctions for the use of cannabis have been removed in jurisdictions of Europe, the UK and Australia under a policy of decriminalization.[1] The key argument made by those favouring the elimination of criminal sanctions for cannabis use is that criminalization is an expensive and ineffective policy. It is costly both from a societal perspective, requiring significant law enforcement and criminal justice resources, and from the perspective of cannabis users who risk the costs associated with incurring a criminal conviction (Becker et al., 2006; Room et al. 2010). Amongst opponents, the concern is that removing criminal sanctions will increase cannabis use. This is an issue because recent research suggests that potential harms of cannabis use, particularly early initiation into use, may include psychosis, early school leaving, crime and anti-social behaviour (Adda et al., 2013; Moore et al., 2007; Macleod et al., 2004). A critical issue in this debate is whether the removal of criminal penalties for the recreational use of cannabis will increase its use, and if so, by whom and by how much.

The economic theory of crime provides a natural framework for studying the impact of criminal penalties on cannabis use (Becker, 1968). This approach emphasizes the role of the expected cost of punishment associated with committing crime in determining, and deterring, criminal behaviour. Viewed within this framework, the removal of criminal penalties for cannabis use reduces the cost of engaging in this behaviour, and this in turn is predicted to increase participation in cannabis use. Previous research has attempted to establish empirical support for this prediction by studying the impact of cannabis laws on both the extensive and intensive margins of cannabis use. This body of research provides mixed evidence with some studies finding the expected effect while others report no significant impact (Thies and Register, 1993; Pacula, 1998; Saffer and Chaloupka, 1999; Chaloupka et al.,1999a; Cameron and Williams, 2001; Farrelly et al., 2001; Dinardo and Lemieux, 2001;

[1] In 2001, Portugal decriminalized the use of cannabis along with all other drugs. In 2004, Britain reclassified cannabis from a Class B to a Class C drug, which effectively decriminalized it and then reversed the decision in 2008, controversially ignoring the recommendations of its own advisory body.

Williams, 2004; Damrongplasit et al., 2010; Anderson et al., 2011).[2] However, given the potentially addictive nature of cannabis, the standard static approach used in these studies may not be well suited to capturing the potentially dynamic response of cannabis use to changes in cannabis laws.[3]

In this paper, we evaluate the impact of liberalizing cannabis laws on the dynamic decision to start using cannabis. The impact of cannabis policy on the choice to start cannabis use is of interest for at least three reasons. First, this is the margin on which policy is likely to have the greatest impact. This is because, all else being equal, an individual deciding whether to use cannabis for the first time is likely to be more sensitive to its criminal status compared to someone who has been using (and hence engaging in a criminal activty) for some time. Second, the potential social benefit in terms of lifetime harm averted is expected to be larger from preventing an uptake compared to inducing a quit. A third reason for interest in the impact of decriminalization on the uptake decision is that initiation into cannabis use typically occurs in the teenage years and there is mounting evidence that this period of development is particularly vulnerable to the harms associated with cannabis.

Although most cannabis users experience little in the way of adverse consequences from its use, about one in ten become dependent users and the likelihood of this occurring is greater amongst those who start early (Hall, 2009). In addition, there is substantial evidence that early initiation increases the risk of lower educational attainment and mental health problems (Hall and Degenhardt, 2009; Van Ours and Williams, 2009; Moore et al., 2007; Macleod et al., 2004). There is also some evidence that early cannabis use produces cognitive deficits in verbal learning and memory tasks (Solowij et al., 2011; Jacobsen et al., 2004).[4] Given the economic costs associated with these consequences, a policy that delays the uptake of cannabis until the vulnerable period of neural development has passed may be considered desirable even if the policy does not ultimately prevent uptake at a later age. This

[2]Extensive international literature reviews are found in studies Pacula (2010), Room et al. (2010) and Williams (2004).

[3]A further weakness of many of these studies is that the effect of decriminalization is identified from cross-sectional variation in the use of cannabis across decriminalized and non-decriminalized states (Farrelly et al., 2001). More recently, studies based on US data have also been criticized for their systematic misclassification of jurisdictions as decriminalized states (Pacula et al.,2005).

[4]Recent research from developmental neuroscience has sought to find a biological basis for this increased vulnerability of those who start using cannabis at younger ages. It has found that significant "remodelling" of the brain in areas relating to higher cognitive function continues to occur into late adolescence (Lubman et al., 2007). This suggests that early cannabis use adversely affects the developing brain.

paper addresses this issue directly by studying the impact of decriminalization on the age at which cannabis is first used.

Our empirical investigation marries a discrete-time hazard framework to model the uptake of cannabis with a difference-in-difference approach to policy evaluation. In order to identify the causal effect of decriminalization on the transition into cannabis use, we exploit a natural experiment induced by differences in the timing of liberalization of cannabis laws across Australian jurisdictions. Australia provides a useful case study for evaluating the impact of liberalizing cannabis laws both because the form it has chosen for liberalization, decriminalization, is the form typically adopted elsewhere and because Australia has patterns of cannabis use similar to those observed in the US, the UK and Europe. For example, the proportion of the population who have ever used cannabis is 34% in Australia, 31% in England and Wales, 31% in France and 42% in the US. The rate of current use in the population (defined as use in the last year) is 9% in Australia, 8% in England and Wales, 9% in France and 11% in the US (Van Laar, 2011).

In addition to considering the impact of decriminalization on a dimension of cannabis use not previously studied, a further contribution of this research is that it allows for the possibility of heterogenous policy effects. Specifically, we allow the effect of decriminalization to differ for adults and minors, and across the short, medium and long run. Allowing for a heterogenous effect with respect to age is especially important given that uptake most often occurs while legally a minor but decriminalization is a policy that typically applies to adults. Allowing for dynamic policy effects accounts for indirect effects of decriminalization that evolve over time, such as changing societal norms.

Our results reveal the presence of heterogeneity in the response to decriminalization across youth (when legally a minor) and adulthood as well as the presence of dynamics in the effect of decriminalization on initiation into cannabis use. For example, we find that in the five years after its introduction, decriminalization increases early uptake by minors. This is largely attributable to early uptake amongst those who would otherwise have started in adulthood. As a consequence, we find only a small increase in the prevalence of use in the first five years following decriminalization. Once the policy has been in place for more than five years, however, we find no significant effect of decriminalization on initiation into cannabis use during youth or adulthood.

The rest of this paper is laid out as follows. Section two provides background to the current study by reviewing the evolution of the legal environment for cannabis

use in Australia. Section three discusses the data and provides a descriptive analysis. Section four outlines the empirical methodology for identifying the causal effect of decriminalization on initiation into cannabis use. Section five reports the baseline results and an extensive sensitivity analysis. Section six concludes with a discussion of our findings.

2 A Brief History of Cannabis Policy in Australia

Cannabis became a prohibited substance in Australia after the Federal government signed the 1925 Geneva Convention on Opium and Other Drugs.[5] Under prohibition, possession, cultivation, importation, sale and distribution of any amount of cannabis is a criminal offence, with penalties including imprisonment and fines. A number of committees of inquiry have recommended reduced penalties for the personal use of cannabis in order to avoid undesirable and unintended consequences of total prohibition. For example, given the high prevalence of cannabis use, criminalizing this behaviour places a large proportion of the population at risk of incurring a criminal record and the associated costs, such as reduced employment prospects and lower earnings. Further, under total prohibition with criminal penalties, the market for cannabis is a black market, characterized by high prices and profits that induce sellers of hard drugs to also sell cannabis. As a consequence, cannabis users are at increased risk of contact with sellers of these more dangerous substances and are therefore more likely to be offered and use hard drugs.

The concern over separating cannabis markets from harder drug markets, in particular, has led several Australian state legislators to decriminalize simple cannabis offences.[6] The first state to do so was South Australia (SA). The 1979 report of the South Australian Royal Commission into the Non-Medical Use of Drugs provided the basis for South Australia's form of decriminalization. However it was not until 1987, after an extended and intense period of community and political debate, that the Cannabis Expiation Notice System Act (CEN) was finally legislated. Under the CEN system, it is still an offence to use, possess, or grow cannabis for personal use, but (for small quantities) the offence is punishable by payment of a fine, with no criminal conviction recorded (if the fine is paid). In the Australian Capital Territory

[5] This section draws on Hall (2008).

[6] For the purpose of this study, decriminalization is defined as the removal of the criminal status and all criminal sanctions for the use of cannabis. Under decriminalization, the personal use of cannabis remains illegal but is a civil offence.

(ACT), legalization of simple cannabis offences was recommended in 1991 by the Select Committee on HIV, Illegal Drugs and Prostitution in its Report on Marijuana and Other Illegal Drugs. In 1992 (and contrary to the the committee's recommendation to legalize simple cannabis offences), a system of decriminalization similar to South Australia's CEN scheme was introduced. Queensland's (QLD) Criminal Justice Commission also recommended a system similar to the CEN system in their 1994 report, but the recommendation was rejected by that state's government.

In the wake of the emergence of differing state level approaches to cannabis, the Federal government established a National Task Force on Cannabis charged with developing recommendations for a national cannabis policy. In its 1993 report to the Ministerial Council on Drug Strategy, the Task Force recommended that civil penalties should replace criminal penalties for simple cannabis offences (such as personal use or possession of cannabis).The Ministerial Council made no formal response to the Task Force's report. The only jurisdiction to respond to the recommendations was the Northern Territory. Legislation introducing decriminalization using a model similar to South Australia's CEN was passed in the Northern Territory (NT) in 1995. The recommendations of Victoria's (VIC) 1996 Drug Advisory Council and New South Wales' (NSW) 1999 Drug Summit to remove criminal penalties for simple cannabis offences were rejected by their respective state governments. By the late 1990's, after more than two decades of state level political momentum, the push for decriminalization appeared to have come to an end. One more state was to move to liberalize cannabis laws, however. In Western Australia (WA), following the election of a new state government in 2001, a Community Drug Summit's recommendation to decriminalize the possession and cultivation of small amounts of cannabis was accepted. In 2004, the Western Australian government passed legislation decriminalizing simple cannabis offences.[7]

In summary, the Australian legal environment surrounding cannabis use has undergone significant changes over the last few decades. While there was momentum to decriminalize simple cannabis offences in the eighties and nineties, the political processes invoked to bring about legislative change varied by state, as did the outcomes of these processes. Importantly for this research, in addition to the uncertainty about whether decriminalization would be adopted, there was also a large amount of variability in the time it took for this outcome to be decided and successfully legislated.[8]

[7]Decriminalization in Western Australia was repealed in 2011.

[8]There are some differences across states in terms of the implementation of decriminalization.

3 Data

This research uses individual level data on the age at which cannabis is first used from the Australian National Drug Strategy Household Survey (NDSHS). The NDSHS is a cross-sectional survey designed to provide data on awareness, attitudes and behavior relating to licit and illicit drug use by the non-institutionalized civilian population in Australia. For this study we pool 1998, 2001, 2004, 2007 and 2010 waves of NDSHS. We limit our sample to individuals aged 20-40 years of age at the time of survey. The lower and upper age limits are chosen in order to minimize the potential issues of censoring and recall error, respectively, with respect to age at first use.

Information on the decision to start using cannabis is provided retrospectively by responses to the question "What age were you when you first used marijuana/cannabis?". This question was asked of everyone who reported having ever used cannabis. Using this information on age at first use, we are able to form individual histories by assuming that sample members are at risk of uptake from the age of 12.[9] The estimation sample is therefore comprised of 39,087 individuals aged 20-40 at the time of survey for whom we have constructed histories on cannabis uptake from the age of 12 years. Importantly, this sample spans the calendar time period 1970-2010, covering the introduction of decriminalization in all four of the decriminalizing states and territories.

Sample means for the data used in our analysis are reported in Table 1. We report this information for the full sample and for subsamples based on whether the respondent lives in a state that decriminalizes cannabis use during the observation period (SA, ACT, NT, WA) or a state that does not introduce decriminalization during the observation period (NSW, VIC, QLD, TAS). For brevity we will refer to observations on individuals living in a state that decriminalizes as the "treatment" group and observations on individuals living in a state that does not decriminalize

In South Australia and the Northern Territory, decriminalization applies only to individuals aged 18 years and older. It applies to those aged 17 and older in Western Australia and to adults and minors in the Australian Capital Territory.

[9] To illustrate, suppose a person reports first using cannabis at age 17. We then know that they did not start using cannabis for ages up to and including 16. From this information we form an indicator for the uptake of cannabis which takes on the value of zero for all ages up to and including 16 and takes the value of one at the age of 17, when use is reported to first occur. The respondent is represented in the sample used for estimation from the age that they are first at risk of cannabis use, which we assume to be 12 years old, until the age at which use is reported to have first occurred. Those who have never used cannabis are represented in the data up until the age at interview.

as the "control" group. Table 1 shows that 57% of individuals in our sample of 20–40 year olds have used cannabis in their lifetime. Amongst those who have ever used cannabis, the average age of initiation is 17.5 years. Males account for 41% of the sample and the average age at survey is 30.9 years. Approximately 31% of the sample have a low level of educational attainment (no more than a 10th grade education). The majority of survey respondents live in a capital city (68%) and are born in Australia (79%). Just 2% of those surveyed are of Aboriginal descent. In terms of birth cohorts, around 1% of the sample were born in the 1950's, 30% were born in the 1960's, 49% were born in the 1970's and 20% were born in the 1980's. A comparison between the treatment group (individuals living in a state that introduces decriminalization) and the control group (individuals living in a state that does not introduce decriminalization) reveals that the two samples differ significantly in terms of lifetime prevalence of cannabis use, with 63% of those in the treatment group having ever used cannabis compared with 55% of those in the control group. In terms of other observed characteristics, the control and treatment groups appear to be similar with the exception that members of the treatment group are more likely to live in a capital city compared to members of the control group (78% compared to 65%).

3.1 Descriptive Analysis

Figure 1 shows the hazard rate and survival functions for starting cannabis use for treatment and controls groups separately. The top panel graphs the hazard rate, which is the transition rate from non-use to use for each particular year of age, conditional on not having used up until 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. Inspection of the top panel of Figure 1 shows that the hazard of starting cannabis use for treatment and control groups each have peaks at ages 16 and 18 and that uptake is rare after the age of 25 in each group. Figure 1 also shows that the rate of uptake in treatment and control groups diverge up until the age of 18 years, with transition rates into cannabis use higher in the treatment group. The hazard rates then begin to converge from the age of 18.[10] The lower panel in Figure 1 graphs the survival functions for treatment and control groups. The survival function is the probability of not using cannabis until at least age T. It shows that, in the control group, 63% of individuals have

[10]Decriminalization generally applies to adults, defined as aged 18 and older.

not used cannabis by age 18 compared to 53% in the treatment sample. By age 40, 45% of the control group have not used cannabis compared to 36% in the treatment group.

It is unclear from the descriptive analysis above the extent to which these differences are attributable to decriminalization and the extent to which they reflect observed and unobserved characteristics that differ between states that do decriminalize cannabis use and those that do not. To address this issue, the analysis that follows adapts the difference-in-difference framework to a hazard rate analysis of cannabis uptake.

4 Empirical Methods

4.1 Identification

For the purpose of identifying the causal effect of decriminalization on the uptake of cannabis, the Australian experience offers two great strengths: (1) variation in the timing of the introduction of the policy across the country's states and territories, and (2) unpredictability about if an when the policy will be introduced.

Decriminalization was introduced into half of the country's states and territories at different points in time over the period 1987 to 2004. As half the jurisdictions introduced decriminalization and the other half did not, jurisdiction of residence becomes the basis for allocating individuals to treatment and control groups. As discussed above, a simple comparison of treatment and control groups confounds the effect of decriminalization with (observed and) unobserved jurisdiction specific characteristics that determine cannabis use. In order to account for this, we compare the change in the rate of uptake before and after decriminalization in the treatment states to the change in the rate of uptake in the control group that occurs over the same period. By focusing on the uptake decision, our approach leverages the difference in timing of the policy change because it transforms survey data collected over the period 1998-2010 to observations spanning the period 1970-2010, covering all policy changes.

In the "difference-in-difference" framework, identification of the causal effect of a policy on the outcome of interest relies on the assumption that the policy is exogenous with respect to the outcome. One may be concerned that this condition is not satisfied in studying the impact of decriminalization on cannabis uptake if states with higher levels of cannabis use face greater pressure to decriminalize. This

issue is less of a concern once state and year fixed effects are controlled for (Cohen and Einav, 2003). Moreover, in the duration framework, it is the timing of the introduction of decriminalization that matters. Since decriminalization requires the passage of legislation, which is a political process, whether and when legislation is passed will depend on many factors that are unlikely to be related to cannabis use (Levitt 1996; Cohen and Einav, 2003). Indeed, as discussed above, there has been considerable variability across states and territories as to whether recommendations to decriminalize have been accepted and, where they have been accepted, substantial variability in the length of time it has taken to pass legislation decriminalizing cannabis use. This evidence suggests that the timing of the introduction of legislation related to cannabis' legal status is a complex, long and uncertain process that can be plausibly considered exogenous to an individual's decision to start using cannabis. Accounting for state and year fixed effects in the model for initiation into cannabis use strengthens the plausibility of the exogeneity assumption.

A further threat to the reliable estimation of the causal effect of decriminalization on the rate of uptake of cannabis is that of measurement error. There are two potential sources of measurement error that we are concerned about. The first is reporting error. For example, since the age at which cannabis is first used is retrospectively reported, there is the possibility that errors are made in accurately remembering this information.[11] Other potential sources of reporting error are a lack of honesty in responses to the questionnaire due to the presence of others, or ignoring experimentation in the reporting drug use. We investigate these issues in the sensitivity analyses reported in Section 5.2.

The second potential source of measurement error that we are concerned about arises because we must match state level policy information to the respondent's state of residence at each age that the respondent is at risk of starting cannabis use. As we only observe respondents' state of residence at the time of survey, we assume they have not moved across state borders. Although making this assumption is less than a perfect solution, it seems a reasonable approximation because there is very little interstate migration in Australia in general.[12] Perhaps more relevant in the context of this paper, there is very little interstate mobility for the purposes of attending

[11]We note however, that given the relative youth of the sample (20-40 years old at the time of survey) recall error is not expected to have a large impact on our results.

[12]For example, for the 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 1988-2007, while departures represent 1.2% to 2.1% (Australian Bureau of Statistics catalogue no. 3105.0.65.001 - Australian Historical Population Statistics, 2008.)

higher education, with around 90% of students attending university in their home state. This is because in Australia, the higher education sector is fairly homogenous across states and so there is little incentive to attend an institution out of state. In Section 5.2 we provide evidence that the inter-state mobility that does occur among students commencing higher education is unrelated to the decriminalization of cannabis. Nonetheless, to the extent that there is random measurement error in the state policy variables because some individuals in our sample have moved state, the effect of this problem is most likely to bias the coefficients on the policy variables towards zero.

4.2 The Empirical Model for Initiation into Cannabis Use

In the discrete time setting, the hazard of person i starting cannabis use at age j, h_{ij}, is defined as:

$$h_{ij} = h(j \mid x_{ij}) = P(T_i = j \mid T_i \geq j, x_{ij}) \tag{1}$$

where x_{ij} is a vector of observed covariates. This hazard function characterizes the probability that person i starts cannabis use at age j given that they have not started use at age $j-1$. In order to operationalize this model, a functional form must be specified for the hazard function, h. We use the complementary log-log hazard rate (cloglog), which is the discrete time representation of the continuous time proportional hazard model.[13] Assuming the cloglog functional form, the hazard rate for cannabis uptake by individual i at age j conditional on x_{ij} is given by:

$$h_{ij} = 1 - exp(-exp(\theta(j) + \beta' x_{ij} + \gamma decrim_{ij})) \tag{2}$$

or equivalently, as:

$$log(-log(1 - h_{ij})) = \theta(j) + \beta' x_{ij} + \gamma decrim_{ij} \tag{3}$$

where $\theta(j)$ captures the duration dependence attributed to differences in length of exposure to the risk of cannabis use prior to uptake and *decrim* is an indicator equal to one for ages at which the respondent resides in a state for which cannabis use is decriminalized. We model the duration dependence flexibly using a piecewise

[13] In effect, it estimates a continuous time proportional hazard model using data that is grouped into discrete intervals.

constant specification based on age dummies. The vector of observed covariates, x_{ij} contains individual characteristics (gender, an indicator for dropping out of school with a 10^{th} grade education or less, Australian born, Aboriginality, living in a capital city, and year surveyed), state level time varying characteristics (the unemployment rate to proxy for the opportunity cost of time), a set of time invariant indicators for state of residence (to account for unobserved time invariant state specific factors that impact on cannabis uptake and that are potentially correlated with state level cannabis policies), year fixed effects (to account for common shocks that may impact on cannabis uptake), and state specific time trends (to allow for differences in uptake trends across states).[14]

Following Jenkins (2005), the log likelihood function for the sample is given by:

$$log\ell = \sum_{i=1}^{n}\sum_{k=1}^{j} y_{ik} log\left(\frac{h_{ik}}{1-h_{ik}}\right) + \sum_{i=1}^{n}\sum_{k=1}^{j} log(1-h_{ik}) \tag{4}$$

where the binary indicator $y_{ik} = 1$ if individual i makes the transition to cannabis use at age k and $y_{ik} = 0$ otherwise and we assume that h_{ik} has the complementary log-log functional form. Note that the first term represents observations with completed durations until uptake while the second term represents observations for which the duration until uptake is censored at the time of survey. This expression can be simplified to:

$$log\ell = \sum_{i=1}^{n}\sum_{k=1}^{j} [y_{ik} log h_{ik} + (1-y_{ik}) log(1-h_{ik})]. \tag{5}$$

The key parameter of interest in this model is the coefficient on *decrim*, γ. In the usual linear difference-in-difference setting, the *decrim* variable is the interaction between the indicator for being in the treatment group and the indicator for the post treatment period. Its coefficient is interpreted as the impact of treatment

[14]The individual level characteristics are time invariant and assumed to be known at the time an individual first faces the decision of whether to initiate cannabis use. In the case of the education variable, this requires the assumption that education represents ability and that this ability is known to the individual from the time he first faces the decision to use cannabis. The education variable will not fulfill this requirement if, at the time an individual decides to start using cannabis, he is uncertain as to whether he will drop out of school before completing 10^{th} grade or, if there exist unobserved characteristics that impact both educational attainment and cannabis use. See for example, Heckman, Stixrud and Urzua (2006) who allow latent cognitive and noncognitive skills to determine education and cannabis use.

as measured by the difference in the outcomes pre and post intervention between the treatment and control group. In the proportional hazard model, interpretation of the (exponentiated) coefficients is in terms of hazard ratios and the analog to the linear model's difference-in-difference is the ratio of (hazard) ratios.[15] In the proportional hazard model, the impact of treatment (decriminalization) is the percentage increase in the hazard of cannabis uptake when a treatment state changes from criminalization to decriminalization, relative to the change that occurs over the same calender time period in a control state. This is measured by $(exp(\gamma)-1)*100$.

The specification above assumes that everyone exposed to decriminalization is impacted the same way. However, this need not be the case. For example, amongst those who would have started cannabis use under the criminal regime, the reduced lifetime costs associated with decriminalization may lead some to start cannabis use at a younger age. If so, an increase in uptake during youth would then be closely matched by a decrease in uptake during adulthood. In effect, the age distribution of uptake would shift to the left. In addition, the reduced lifetime costs implied by decriminalization could also lead to a net increase in the number of users. In order to investigate the potentially differential effect of cannabis policies during youth ($<$ 18 years) and adulthood ($\geq$ 18 years), we include an interaction term between the indicator for decriminalization and an indicator equal to one for ages 12-17. We focus on the difference between youth and adulthood because, while decriminalization typically applies to adults, uptake typically happens in youth and this age-group is of particular interest from a policy perspective .

Finally, as discussed by Wolfers (2006) a policy change may have different short, medium and long term effects. For example, decriminalization could lead to a change in social norms – especially amongst youth – whereby the novelty of decriminalization makes cannabis fashionable (at least temporarily). If this is the case, then the impact of decriminalization is expected to change with the length of time that the policy has been in place. We explore the potential for dynamic policy effects in a sensitivity analysis.

[15] Specifically, the (exponentiated) coefficient on the *decrim* indicator in the proportional hazard model, γ captures the policy impact as measured by the ratio of the hazard ratio of post to pre policy intervention, for treatment and control groups.

5 Results

5.1 Baseline Results

Table 2 contains coefficient estimates from maximum likelihood estimation of four progressively richer specifications of the discrete time hazard model for the uptake of cannabis use. In addition to the control variables listed in the table, all specifications also include 16 indicators for duration dependence in the baseline hazard (14 indicators for ages 12 years old through to 25 years old, an indicator for 26-30 years old, and an indicator for 31-35 years old, with 36-40 years old as the omitted category) and a full set of calendar year dummies. Specifications 2 – 4 progressively add the following covariates: state fixed effects, state specific time trends, and interaction terms between the policy variable and an indicator for being a minor in terms of the law (age less than 18). All standard errors are clustered at the state level.

The first column reports results for a specification which is similar in spirit to the typical approach found in the literature, where the effect of decriminalization is identified from cross-sectional variation across decriminalized and non-decriminalized states.[16] The estimates from this specification suggest that decriminalization has a positive effect on cannabis uptake and that this effect is statistically different from zero at the 5% level of significance. On the basis of these estimates, living in a regime in which cannabis use has been decriminalized is associated with a 12% $(exp(0.115)-1)*100$ increase in the rate of uptake compared to an otherwise similar individual living in a regime in which cannabis has not been decriminalized.[17]

We address the issue of unobserved heterogeneity that is correlated with cannabis policy by including state level fixed effects. The results from doing so are reported in column 2 of Table 2. A test of the null hypothesis that the set of state indictors are jointly zero is rejected with p-value smaller than 1%, providing strong evidence of time invariant differences across states in the (hazard) rate of cannabis uptake. The coefficients on the state indicators show differences in uptake relative to an individual living in the comparison state, NSW. NSW is a state that does not introduce decriminalization and therefore, people living in this state belong to the

[16] Specifically, it fails to account for unobserved time invariant state level heterogeneity that may be correlated with a state's tendency to decriminalize cannabis.

[17] The magnitude of this effect is similar to that found by Damrongplasit et al. (2010) who do not account for state fixed effects in their study of the impact of decriminalization on participation in past year cannabis use.

control group. As can be seen from Table 2, people living in states which belong to the treatment group (states which do introduce decriminalization during the observation period) have significantly higher transition rates into cannabis use, ranging from 25-50% higher, compared to individuals living in NSW. In contrast, the coefficients on indicators for living in the states which belong to the control group are small and generally significantly negative, indicating baseline hazards that are no higher than in NSW.[18] As can be seen, once we account for these state level differences, there is no evidence that decriminalization affects cannabis uptake.

Specification 3 allows for state specific time trends, in addition to state and calendar year fixed effects, in the hazard for the uptake of cannabis. The state specific time trends are found to be jointly significant (p-value < 0.001). As can be seen from the results reported in column 4 of Table 2, after accounting for state specific time trends, the coefficient on decriminalization becomes positive, although it remains insignificant at conventional levels.

A possible explanation for why we fail to detect a statistically significant impact of decriminalization on cannabis uptake once time invariant unobserved differences across states are accounted for is that the model is mispecified in assuming that decriminalization affects everyone in the same way. As discussed above, since uptake typically occurs by the age of 18, individuals may be more responsive to a change in the policy environment while legally a minor. In order to investigate this, we augment the model reported in column 3 with an interaction term between the policy variable and an indicator equal to one for the ages at which the respondent is a minor (aged less than eighteen). The results from estimating this specification are reported in column 4 of Table 2. We find that minors who live in a decriminalized policy regime have a hazard rate of uptake that is 12% higher than an otherwise similar minor living in a policy regime in which cannabis use is a criminal offence (p-value < 0.10).[19] The negative coefficient on the indicator for decriminalization indicates that compared to an otherwise similar adult living in a strictly criminal policy regime, living in a decriminalized regime reduces the rate of initiation into cannabis by 11%.

In order to get a better sense of the impact of decriminalization on cannabis uptake, we use the coefficient estimates reported in column 4 of Table 2 to predict hazard and survival functions before and after the introduction of decriminal-

[18]The exception is QLD, which has a baseline hazard 3% higher than NSW.

[19]To find the effect of decriminalization for minors, we exponentiate the sum of the coefficient on decriminalization and the interaction term and subtract one from this quantity.

ization. The predicted hazard and survival functions are for an Australian born, non-Aboriginal male who lives in a capital city, who has more than a low level of education and lives in the decriminalizing state of South Australia in 2010, facing the unemployment rate for that state and year. The results are graphed in Figure 2. A comparison of the hazard functions for this treated state pre and post treatment shows that the effect of introducing decriminalization is to shift the hazard function for initiation into cannabis use to the left. As a consequence of decriminalization, the spike in the uptake of cannabis occurs at age 16 rather than at age 18. Inspection of the survival functions reveals that by the age of 40, there is no difference in survival rates across the two scenarios, with 46% predicted to use cannabis by age 40 amongst those living in the state before and after decriminalization is introduced. However, there are differences at earlier ages. For example, the proportion of those aged 15 and younger who have used cannabis is 15% after decriminalization is introduced compared to 14% before decriminalization is introduced. Among the population aged 16 and younger, the proportions are 25% and 23% respectively. This suggests that: (1) decriminalization leads to uptake at an earlier age than would otherwise occur under criminalization, and (2) decriminalization does not affect whether an individual ever uses cannabis.

As a point of comparison, we consider survey responses regarding the use of cannabis if it were legal. Each of the five waves of the NDSHS used in our analysis ask all survey respondents about their cannabis use if it were legal to use. Figure 3 graphs the proportion of respondents of each age who have never used cannabis and who would be induced into cannabis use by legalization.[20] It shows that the impact of legalization in terms of new use is concentrated amongst those who are less than 18 at the time they are surveyed. This provides qualitative support for our finding that decriminalization shifts uptake to younger ages.

Turning to the results for the individual level control variables, we see from Table 2 that being male, having low educational attainment and being born in Australia have a positive and statistically significant influence on cannabis uptake. These effects are stable across specifications. Also, being of Aboriginal descent increases the hazard of cannabis uptake but only in models that exclude state fixed effects. The coefficients on the year of survey indicators (survey 2001, 2004, 2007 and 2010 with 1998 as the comparison category) are statistically significant and negative.

[20]That is, for each age from 12 to 40, the number who report that they had not used cannabis in their lifetime but if it were legal, they would try it or use it more than they currently do divided by the total number of respondents for that age.

Living in a capital city and the state specific unemployment rate are found to have no statistically significant effect on initiation into cannabis use.

5.2 Sensitivity analysis

To investigate the robustness of our findings we performed a range of sensitivity analyses. These include examining issues related to recall error, inter-state mobility, differences across cohorts, accounting for the cannabis policy environment for minors, and examining differences across gender. We also explore the potential for dynamic policy effects by allowing the impact of decriminalization to vary by the length of time the policy has been in place. Table 3 reports the coefficient estimates for the key policy variables from these sensitivity analyses. Finally, we explore the robustness of our results by using a placebo test, where we examine the impact of decriminalization on the uptake of cigarettes. The results of this analysis are reported in Table 4.

This study uses retrospective information about when individuals first started to use cannabis and this poses the potential problem of recall error. If respondents make errors in the age they report first using cannabis, the parameter estimates for the starting rate are likely to be biased. In order to investigate this issue, we include the respondent's age at survey as an additional control variable in the model. If there exists a systematic misreporting in the form of forward telescoping for example, then distant events are perceived as more recent and we would expect a negative coefficient on the age at survey variable. Although not reported in the table, we find a positive and statistically insignificant coefficient on age at survey (p-value=0.40), suggesting that forward telescoping is not a serious issue in these data. As shown in Table 3, the sign, magnitude and significance of the coefficient on the policy variable and its interaction term are unaffected by the inclusion of the proxy for recall error.

Reporting errors may also arise for other reasons. For example, survey respondents may not truthfully answer questions on sensitive issues such as illicit drug use if others are present in the room while they are completing the survey, or if they ignore experimentation in their reporting of drug use. Issues of truthfulness are more likely to arise when surveys are administered by personal interview. While personal interview is amongst the survey methods used in the 1998 and 2001 waves of the NDSHS, it accounts for just 5% of the total number of surveys completed over the five waves utilized in our analysis. Around 85% of completed surveys were

conducted using self-completion questionnaires, with around 10% conducted using computer assisted telephone interviewing (CATI).

While the use of self-completion and CATI survey methods maximizes the likelihood of privacy when answering the survey questionnaire, and hence illiciting truthful responses, the survey includes two questions which allow us to directly examine this issue. Respondents are asked whether anyone else was present when they were completing the survey, and if so, whether their presence affected the honesty with which they completed the questionnaire. As can be seen from Table 1, 35% of the sample report the presence of another person when they were completing the questionnaire, and 2% report the presence of another impacted on the honesty with which they completed the questionnaire. Column 2 of Table 3 reports the results from a sensitivity analyses in which we directly account for the presence of others and whether honestly in answering the questionnaire is affected by the presence of others in the model. We find that those who completed the questionnaire in the presence of others, but whose honestly is unaffected by their presence, are more likely to report initiating into cannabis use at any age compared to someone who completed the questionnaire without others present. However, the transition rate into cannabis use is lower amongst those for whom someone else was present and their presence affected the respondents honestly.[21] Nonetheless, our findings and conclusions regarding the impact of decriminalization are robust to accounting for these factors. This is unsurprising since Table 1 shows no differences in either the likelihood of others being present, or of it affecting the respondents honesty, across treatment and control states.

The data do not permit us to examine the impact of errors in reporting age of first use that occur if experimentation is ignored in reporting behavior. There is some evidence that this may be less of an issue with cannabis uptake compared to alcohol, tobacco and other drug use, and for adults reporting age of first use compared to children(Johnson and Mott, 2001).[22] In terms of our analysis, we are particularly concerned as to whether the occurrence of this kind of error in reporting of age at first use differs between states that decriminalize and those that do not. We are not aware of any study that has examined the effect of a policy change on

[21]The full set of results are available upon request.

[22]Johnson and Mott (2001) examine the stability of reporting behavior over time using panel data from the US. By employing a test-retest method they find that i)adults report age of first use more consistently than children; ii) age of first use for cannabis is reported more consistently than for alcohol, tobacco and other drugs; iii) Calculated intraclass correlation coefficient (ICC) of age of first use of cannabis is rated excellent (ICC¿0.75) on a reliability scale.

reporting behavior, so it is unclear a-priori whether, and to what extent, this is a problem for this study. If however, reporting bias does not differ across treatment and control groups, it should not affect our main conclusions.

The potential impact of measurement error in matching state policies to individuals at each age they are at risk of cannabis uptake due to mobility is also a concern, particularly if there is differential mobility related to cannabis laws. In order to investigate this, we obtained state level data on commencing students at higher education institutions over the period 1992–2009.[23] We constructed a measure of mobility into state s, defined the proportion of commencing students in state s and year t who are from out of state. We then examined whether cannabis laws are a determinant of mobility into state s by regressing the measure of mobility on an indicator for decriminalization as well as state and year fixed effects.[24] The point estimate on the decriminalization indicator from this regression is negative and statistically insignificant with a p-value of 0.398. This suggests that, to the extent that commencing students relocate inter-state, the relocation decision is unrelated to cannabis laws. It therefore seems reasonable to consider measurement error due to inter-state mobility to be random. As a consequence, our estimates provide a magnitudinal lower bound on the impact of decriminalization on the uptake of cannabis.

We also examine the robustness of the results to accounting for differences in the uptake of cannabis across different birth cohorts. To do so, we include a set of indicators for being born in the 1950's, the 1960's, the 1970's, with being born in the 1980's as the comparison category. We find that the indicators for birth cohort are jointly significant ($p < 0.01$). As shown in the results reported in column 3 of Table 3, accounting for birth cohort does reduce the estimated impact of decriminalization. It does not, however, alter our qualitative findings.

Column 4 of Table 3 examines whether the differing policy effects uncovered for adults and minors reflect genuine heterogenous effects or are due to a confounding with unobserved differences in the uptake of minors and adults across states. To examine this issue, we introduce interaction terms between state indicators and the indicator for ages at which the respondent is legally a minor (age < 18) into the

[23]The first year that data is available is 1992. Data are from the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (various years), "Students: Selected Higher Education Statistics," Commencing students by state of permanent home residence and state of institution of study. These data were accessed from: http://innovation.gov.au/highereducation/HigherEducationStatistics/StatisticsPublications).

[24]These results are not reported in Table 3 but are available upon request.

hazard model. While these interaction terms are found to be jointly significant, including them has little impact on the coefficients of interest. This suggests that our findings do not reflect differences across states in terms of the structure of age dependence.

We next investigate whether the responsiveness of minors to decriminalization is in fact attributable to a generally more liberal cannabis policy stance coinciding with decriminalization. We explore this issue by accounting for the cannabis policy that applies to minors. This issue may have relevance given that all states (other than the ACT, where decriminalisation applies to both adults and minors) have introduced diversion schemes for minors over the period under analysis.[25] Specifically, we introduce an indicator equal to one for ages at which the respondent lives in a state with a diversion program for minors in place and an interaction term between the diversion for minors indicator and an indicator for being an adult (that is, over the age of 17). These additional terms are found to be individually and jointly insignificant (p-value=0.31). As shown in column 5 of Table 3, after accounting for cannabis policies covering minors and adults our main findings remain unchanged. We find that decriminalization shifts uptake to earlier ages with the rate of cannabis uptake in youth increasing (p-value < 0.05) and the rate of uptake in adulthood decreasing.

In columns 6 and 7 we investigate whether there are differences across gender in the impact of decriminalization on initiation into cannabis use. Column 6 of Table 3 reports estimates for the baseline model reported in column 4 of Table 2 based on the subsample of males, while column 7 reports results based on the subsample of females. A likelihood ratio test leads us to reject the null hypothesis of common coefficients for males and females (p-value < 0.00). However, as can be seen from the estimates reported in the table, the differences across gender do not appear to be driven by a differential impact of decriminalization on cannabis uptake.

The final set of coefficient estimates reported in Table 3 is from estimating a model that allows for dynamic policy effects. As noted by Wolfers (2006), a potential problem with the difference-in-difference approach arises if a policy shock

[25]Unlike decriminalization, diversion programs do not require legislative changes. Often, they are based on a change to police guidelines. Under diversion programs, on admitting to the offense, the individual is issued a caution (also known as an offense notice). A copy of that notice is also served to the minor's parent/guardian. Depending on the jurisdiction, the diversionary mechanism is typically a fine, but may be attendance at a drug assessment and treatment program, or receipt of educational information. If the offender complies with the diversion mechanism, no criminal charges are laid. Diversion programs were introduced for minors in Victoria in 1977, in WA in 1992, in SA and QLD in 1994, NSW in 1998, in TAS in 2000 and in NT in 2001.

has dynamic effects.[26] This is because the state specific trends that are included to account for different pre-existing trends may pick up the dynamic effects of the policy. To address this issue, we follow Wolfers (2006) and modify our model by replacing the indicator for decriminalization with indicators for the length of time the policy has been in place. Specifically, we include indicators for the first two years of decriminalization (0-2), for years three to five, six to eight and nine or more years after the introduction of decriminalization. We allow the effects of duration since decriminalization to differ between adults and minors through the use of interaction terms. The key parameter estimates are reported in column 8 of Table 3. The results indicate that the negative effect of decriminalization on uptake in adulthood is only statistically significant for the 3-5 years following its introduction. After that, decriminalization has no significant effect on uptake during the adult years. In contrast, the impact of decriminalization while a minor is significant 0-2 years after its introduction (p-value=0.09) and 3-5 years after its introduction (p-value=0.09). The impact of decriminalization while a minor is not statistically significant 6-8 years after the policy is introduced (p-value=0.39) or nine or more years after its introduction (p-value=0.21).[27]

Overall, these results suggest differing short and long run effects following the introduction of decriminalization. In order to get a better sense of the dynamic effect of decriminalization on the uptake of cannabis, Figure 4 graphs the predicted hazard and survival functions based on the coefficient estimates in column 8 of Table 3. It shows that the short term impact of decriminalization is largely to shift uptake to earlier ages amongst those who would otherwise start using cannabis in adulthood. The net effect of decriminalization on the proportion of the population who will ever use cannabis does produce a slight increase in use from 48.1% to 48.2% after 1-2 years, and to 48.7% after 3-5 years. However, in the longer term, this increase in uptake is not sustained and we find no significant impact of decriminalization on uptake (during youth or adulthood).[28]

Our final robustness check is a falsification test. In particular, we examine the

[26]For example, a policy of decriminalization may have larger effects when first introduced than in the longer term due to pent up demand. Alternatively, after the introduction of decriminalization, norms may evolve which are more accepting of cannabis use leading to larger long run effects than short run effects.

[27]This lack of statistical significance may reflect a lack of variation in the data rather than a genuine null effect as most observations in the latter categories are contributed by South Australia.

[28]Note that we do not graph the predicted hazard or survival rates when decriminalization has been in effect for more than 5 years since the impact of decriminalization is not significant for adults or minors in this case.

relationship between decriminalization and initiation into cigarette use. Changes in the legal regime governing cannabis use should not directly impact on the uptake of cigarette use. Evidence of a significant effect suggests that our results are picking up other changes that occurred around the same time as the introduction of decriminalization that impacted on cigarette use and cannabis use. In other words, the estimated effect of decriminalization would then be spurious. Table 4 reports results for age at initiation into cigarette use using the same specifications reported in Table 2. As can be seen from Table 4, with the exception of specification 2 (which include state fixed effects but does not account for state specific time trends in cigarette uptake) in which decriminalization has a significantly negative coefficient, the policy variables are individually and jointly insignificant. This suggests that our findings with respect to the effect of decriminalization on cannabis uptake are not spurious. Rather, they represent genuine causal effects of the policy.

6 Discussion

Cannabis users account for 80% of the 200 million illicit drug users in the world (UNODC, World Drug Report, 2010). In countries such as the US, the UK and Australia, over 30% of the population have used cannabis and they have done so despite it being illegal. There has been much concern about the economic and social costs of maintaining harsh criminal sanctions for its use. These concerns have culminated in the decriminalization of cannabis use in many jurisdictions and more recently, in the legalization of cannabis use in two jurisdictions of the US. Nonetheless, the question of whether liberalization of cannabis laws increases the use of cannabis remains open and hotly debated.

In order to shed light on this issue, this paper investigates the causal impact of decriminalization on the uptake of cannabis. To do so, we exploit the natural experiment provided by the exogenous variation in the timing of the introduction of decriminalization across Australian states and territories. Our empirical framework marries the difference-in-difference approach to evaluating the impact of a policy change with a discrete time hazard model for the transition into cannabis use. We allow for both heterogenous and dynamic treatment effects in the hazard setting.

Our empirical findings underline the importance of accounting for both heterogenous treatment effects and dynamics in evaluating the impact of policy changes. Specifically, we show that imposing a homogenous treatment effect of decriminalization leads to the conclusion that decriminalization has no significant effect on uptake.

However, this "average" effect masked a shift in the timing of uptake from adulthood to the juvenile years. We also find that decriminalization has different effects in the short and long run. In the short run (up to five years following its introduction), we find that individuals who would have started using cannabis in adulthood under criminalization respond to decriminalization by initiating at younger ages. We also find a small net increase in uptake in this period. After the policy has been in place for greater than five years however, we find no significant effect of decriminalization on initiation into cannabis use in either youth or the adult years.

While we undertake a wide range of sensitivity analyses to demonstrate the robustness of our findings, several caveats remain. First, our analysis is based on the assumption that respondents have lived in their current state of residence since the time they were first at risk of using cannabis. While we find no evidence of a systematic relationship between mobility among commencing university students and state cannabis laws, to the extent mobility across states induces random measurement error, we are likely to underestimate the impact of cannabis policy on the age at first use. Second, there is the potential for measurement error due to experimentation being ignored in reporting age at first use. Although we are not able to examine this issue with our data, we note that to the extent that this measurement error does not differ across states that decriminalize and those that do not, it should not affect our main findings. Finally, this analysis is based on Australian household survey data. While prevalence of lifetime and recent use statistics indicates similar patterns of cannabis use in Australia and countries such as the US, the UK and Europe, it is nonetheless important to verify the findings of this research using data from other countries before any strong policy conclusions can be drawn.

So, what does this study reveal about the effect of decriminalization on the uptake of cannabis? While we find no evidence of any long run effect, we do find that for the first five years following decriminalization, those who start using cannabis tend to do so at an earlier age than would otherwise have been the case. There is also a small net increase in the proportion of the population who ever use cannabis in the first five years after the introduction of decriminalization. A net increase is in line with some previous studies of decriminalization like Damrongplasit et al. (2010); Saffer and Chaloupka; (1999); Chaloupka et al. (1999a); Chaloupka et al. (1999b), while it is contrary to results reported in studies like Anderson et al (2012); Williams (2004); Dinardo and Lemieux (2001); Pacula (1998) and Thies and Register (1993). We are the first to study dynamic effects of the policy change, however, and our results suggest that the increase in cannabis uptake will not last beyond the

first few years following its introduction. The magnitude of the estimated effect of decriminalization is also much smaller than the assumed effect on cannabis use from legalizing the drug, for which the price effect and the non-price effect seem to suggest a substantial increase (Caulkins et al 2012; Pacula 2010; MacCoun 2010).

While the overall impact of decriminalization on the population prevalence of cannabis use is temporary and small, the finding that uptake shifts to earlier ages under decriminalization is still a significant concern since a growing literature points to several specific adverse outcomes that are causally related to early uptake. There is evidence that early cannabis initiation increases the risk of dependence (Hall, 2009); lower educational attainment (Hall and Degenhardt, 2009; Van Ours and Williams, 2009); mental health problems (Degenhardt et al., 2013; Moore et al., 2007; Macleod et al., 2004); and deficits in verbal learning and memory tasks (Solowij et al., 2011; Jacobsen et al., 2004). Earlier initiation and a small net increase in uptake are unintended adverse consequences of the decriminalization which can, and should, be addressed when designing a liberalized cannabis policy environment.

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Table 1: Sample Means

	Full Sample	Treatment Sample	Control Sample
ever use cannabis	0.57	0.63	0.55
start age	17.51	17.30	17.60
male	0.41	0.43	0.40
age at survey	30.88	31.03	30.81
low education	0.31	0.32	0.31
Australian born	0.79	0.79	0.80
Aboriginal	0.02	0.03	0.02
Lives in a capital city	0.68	0.78	0.65
survey_yr01	0.24	0.23	0.25
survey_yr04	0.24	0.23	0.25
survey_yr07	0.18	0.18	0.18
survey_yr10	0.20	0.19	0.21
cohort1950	0.01	0.01	0.01
cohort1960	0.30	0.32	0.29
cohort1970	0.49	0.48	0.49
cohort1980	0.20	0.19	0.20
someone present	0.35	0.36	0.34
affected honesty	0.02	0.02	0.02
VIC	0.21	0.00	0.29
QLD	0.21	0.00	0.30
WA	0.10	0.35	0.00
SA	0.08	0.27	0.00
TAS	0.05	0.00	0.06
ACT	0.05	0.19	0.00
NT	0.05	0.19	0.00
N	39087	11088	27999

Note: The Treatment group consists of individuals residing in the decriminalizing states (SA, ACT, NT or WA) and the Control group consists of individuals living in the non-decriminalizing states (NSW, VIC, QLD or TAS) at the time of survey.

Table 2: Hazard Model for Cannabis Uptake

	(1)	(2)	(3)	(4)
decriminalized	0.115**	-0.0905	0.00928	-0.116***
	(0.0572)	(0.0661)	(0.0395)	(0.0303)
decrim*age < 18				0.225***
				(0.0690)
control states				
VIC		-0.0770***	-0.599***	-0.596***
		(0.00455)	(0.0251)	(0.0248)
QLD		0.0314**	-0.356***	-0.356***
		(0.0148)	(0.00757)	(0.00760)
TAS		-0.0675**	-0.841***	-0.842***
		(0.0315)	(0.0130)	(0.0129)
treatment states				
WA		0.306***	-0.0734***	-0.0867***
		(0.00404)	(0.00862)	(0.00682)
SA		0.219***	0.0816***	0.0526***
		(0.0595)	(0.0116)	(0.0107)
ACT		0.250***	-0.0492	-0.0726**
		(0.0181)	(0.0382)	(0.0363)
NT		0.410***	0.413***	0.391***
		(0.0167)	(0.0298)	(0.0255)
individual characteristics				
male	0.190***	0.190***	0.190***	0.190***
	(0.00824)	(0.00838)	(0.00859)	(0.00858)
low education	0.287***	0.286***	0.289***	0.288***
	(0.0248)	(0.0218)	(0.0214)	(0.0215)
Australian born	0.481***	0.493***	0.493***	0.493***
	(0.0808)	(0.0813)	(0.0819)	(0.0821)
Aboriginal	0.119***	0.0489	0.0496	0.0497
	(0.0386)	(0.0575)	(0.0579)	(0.0578)
lives in a capital city	0.0254	0.0227	0.0242	0.0237
	(0.0340)	(0.0351)	(0.0352)	(0.0352)
other controls				
survey_yr01	-0.162***	-0.151***	-0.158***	-0.159***
	(0.0356)	(0.0216)	(0.0250)	(0.0251)
survey_yr04	-0.176***	-0.151***	-0.158***	-0.158***
	(0.0250)	(0.0161)	(0.0213)	(0.0217)
survey_yr07	-0.226***	-0.203***	-0.208***	-0.208***
	(0.0301)	(0.0255)	(0.0252)	(0.0256)
survey_yr10	-0.228***	-0.203***	-0.209***	-0.209***
	(0.0274)	(0.0319)	(0.0314)	(0.0314)
ur_person	-0.0138	0.0232*	-0.00137	-0.000681
	(0.0230)	(0.0128)	(0.00870)	(0.00877)
state time trends	NO	NO	YES	YES

Note: The table reports coefficient estimates and standard errors in parentheses; standard errors are clustered at the state level; ***, **, * indicates significance at a 1% 5% or 10% level respectively.
Although not reported, all models include calendar year fixed effects. Duration dependence is modeled using 16 age indicators (single year indicators for ages 12-25, an indicator for 26-30, an indicator for 31-35) with an indicator for 35-40 as the omitted category.

Table 3: Sensitivity Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
decrim	-0.116***	-0.124***	-0.0941***	-0.172***	-0.112***	-0.0872**	-0.131***	
	(0.0302)	(0.0277)	(0.0347)	(0.0202)	(0.0306)	(0.0339)	(0.0405)	
decrim*age < 18	0.225***	0.228***	0.187***	0.337***	0.232***	0.205**	0.248***	
	(0.0690)	(0.0685)	(0.0632)	(0.0684)	(0.0734)	(0.0835)	(0.0717)	
decriminalized 0-2 yrs								-0.0874
								(0.0613)
decriminalized 3 - 5yrs								-0.115*
								(0.0658)
decriminalized 6-8 yrs								-0.0828
								(0.112)
decriminalized 9 years								-0.00344
								(0.238)
< 18 *decriminalized 0-2 yrs								0.201*
								(0.104)
< 18*decriminalized 3 - 5yrs								0.271***
								(0.0681)
< 18 *decriminalized 6-8 yrs								0.184**
								(0.0745)
< 18 * decriminalized 9 years								0.244***
								(0.0600)
include age at survey	YES	NO	NO	NO	NO	NO	NO	NO
Include presence of others, honesty	NO	YES	NO	NO	NO	NO	NO	NO
include cohort dummy	NO	NO	YES	NO	NO	NO	NO	NO
include state ¡18 interactions	NO	NO	NO	YES	NO	NO	NO	NO
include polices for minors	NO	NO	NO	NO	YES	NO	NO	NO
males only	NO	NO	NO	NO	NO	YES	NO	NO
females only	NO	NO	NO	NO	NO	NO	YES	NO

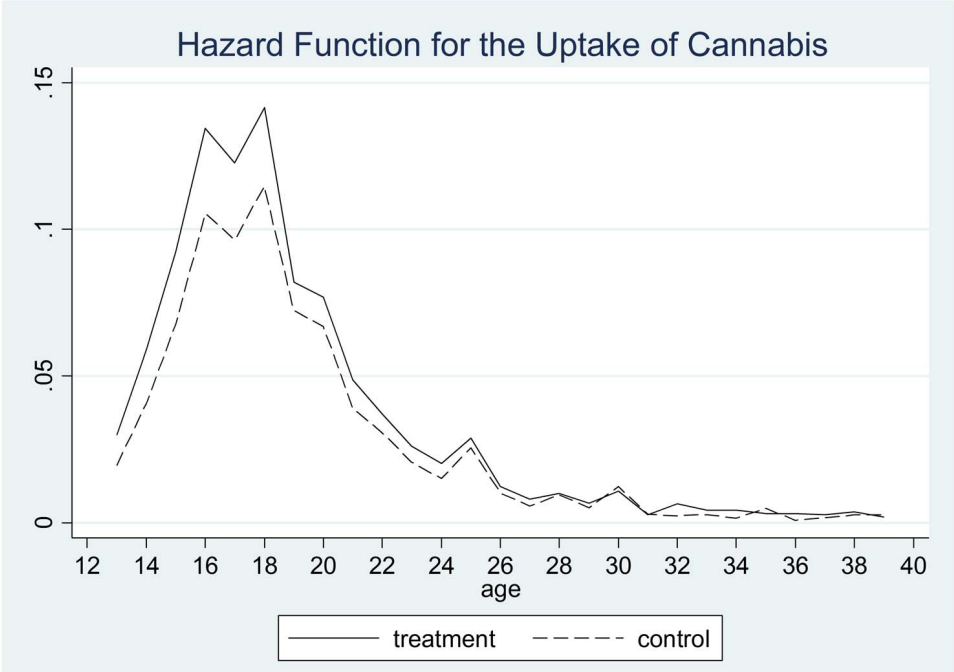
Note: The table reports coefficient estimates and standard errors in parentheses; standard errors are clustered at the state level; ***, **, * indicates significance at the 1% 5% or 10% level respectively. Controls are the same as included on column 4 of Table 2.

Table 4: Hazard Model for Cigarette Uptake

	(1)	(2)	(3)	(4)
decriminalized	-0.0260	-0.119***	0.00672	-0.0331
	(0.0371)	(0.0382)	(0.0458)	(0.118)
decrim*age < 18				0.0535
				(0.113)
control states				
VIC		0.123***	0.187***	0.187***
		(0.00314)	(0.0165)	(0.0165)
QLD		0.0814***	0.125***	0.125***
		(0.00706)	(0.0160)	(0.0160)
TAS		0.0481***	0.0124	0.0121
		(0.0147)	(0.0181)	(0.0180)
treatment states				
WA		0.137***	0.282***	0.280***
		(0.00278)	(0.0146)	(0.0162)
SA		0.152***	0.389***	0.385***
		(0.0279)	(0.0202)	(0.0262)
ACT		0.225***	0.352***	0.348***
		(0.0150)	(0.0260)	(0.0317)
NT		0.200***	0.487***	0.483***
		(0.00906)	(0.0267)	(0.0325)
individual characteristics				
male	0.0400***	0.0376***	0.0371***	0.0371***
	(0.00805)	(0.00791)	(0.00759)	(0.00758)
low education	0.419***	0.424***	0.424***	0.424***
	(0.00821)	(0.00802)	(0.00821)	(0.00825)
Australian born	0.381***	0.378***	0.378***	0.378***
	(0.0601)	(0.0597)	(0.0597)	(0.0597)
Aboriginal	0.0379	0.0230	0.0238	0.0237
	(0.0666)	(0.0778)	(0.0775)	(0.0775)
lives in a capital city	-0.0585***	-0.0685***	-0.0679***	-0.0680***
	(0.0153)	(0.0126)	(0.0128)	(0.0128)
other controls				
survey_yr01	-0.000850	0.0177	0.0197	0.0197
	(0.0331)	(0.0233)	(0.0227)	(0.0227)
survey_yr04	0.00297	0.0210	0.0226	0.0227
	(0.0319)	(0.0229)	(0.0226)	(0.0227)
survey_yr07	-0.328***	-0.312***	-0.309***	-0.309***
	(0.0248)	(0.0247)	(0.0243)	(0.0244)
survey_yr10	-0.282***	-0.263***	-0.261***	-0.262***
	(0.0257)	(0.0190)	(0.0189)	(0.0186)
ur_person	0.00259	0.0192**	0.0164*	0.0165*
	(0.00714)	(0.00885)	(0.00878)	(0.00880)
state time trends	NO	NO	YES	YES

Note: The table reports coefficient estimates and standard errors in parentheses; standard errors are clustered at the state level; ***, **, * indicates significance at a 1% 5% or 10% level respectively. Controls are the same as included on column 4 of Table 2.

Figure 1:


Hazard Function for the Uptake of Cannabis
0
.05
.1
.15
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
age
treatment
control

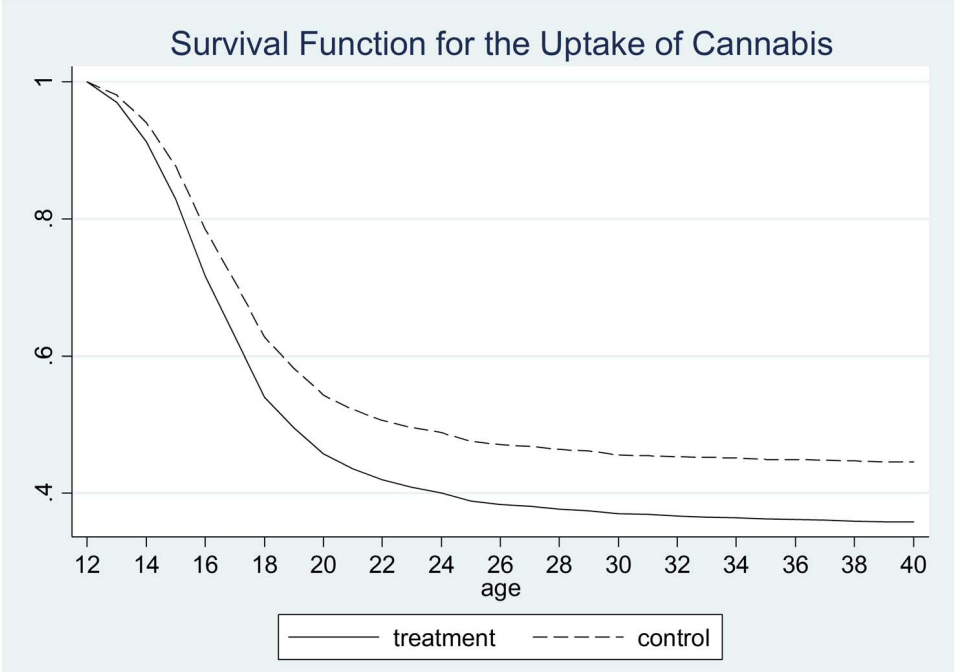
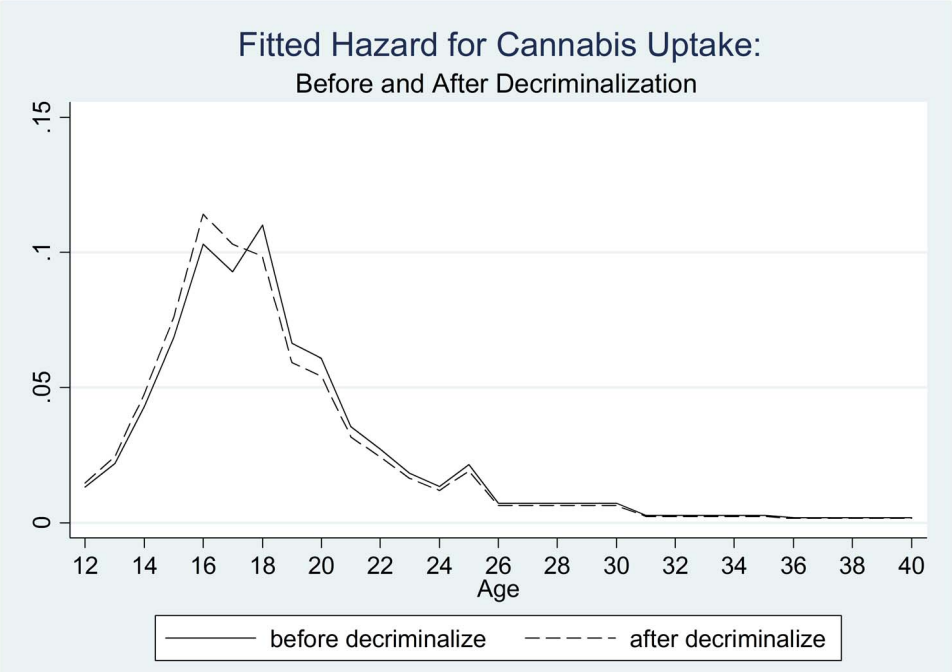

Survival Function for the Uptake of Cannabis
.4
.6
.8
1
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
age
treatment
control

Figure 2:


Fitted Hazard for Cannabis Uptake:
Before and After Decriminalization
0
.05
.1
.15
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Age
before decriminalize
after decriminalize

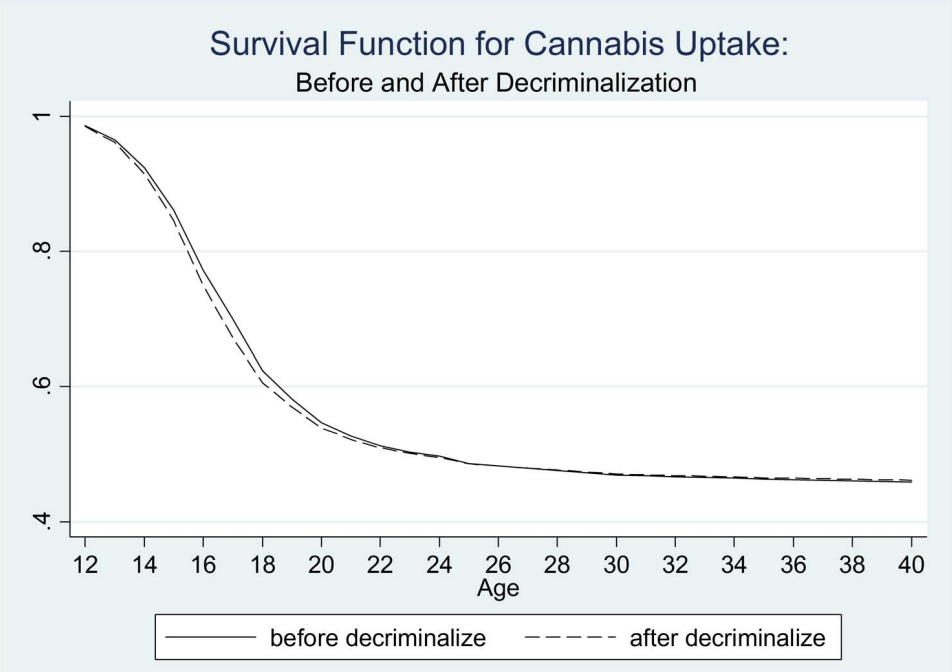

Survival Function for Cannabis Uptake:
Before and After Decriminalization
.4
.6
.8
1
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Age
before decriminalize
after decriminalize

Figure 3:

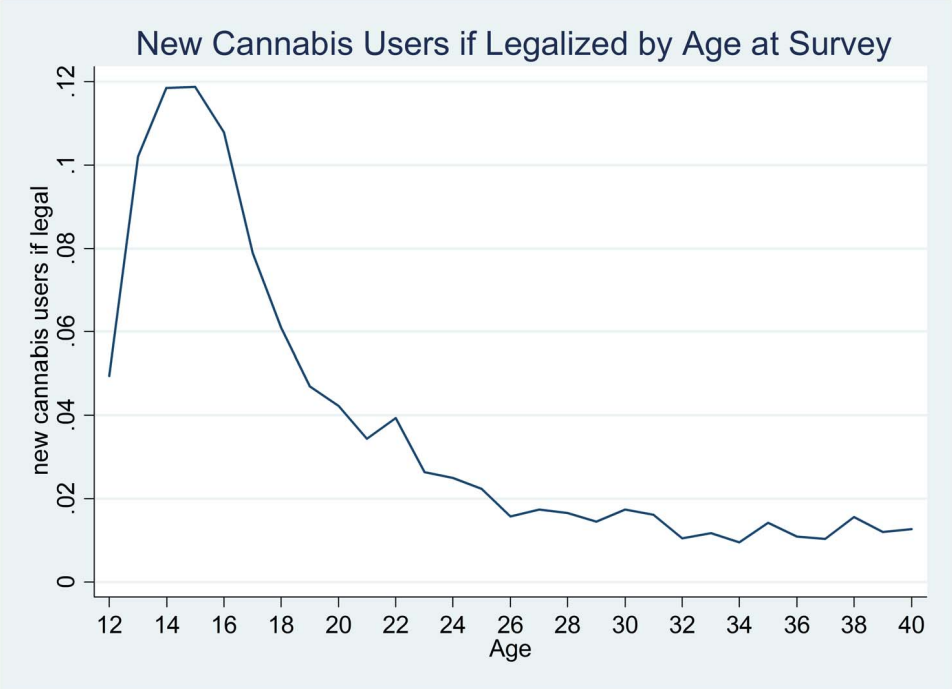
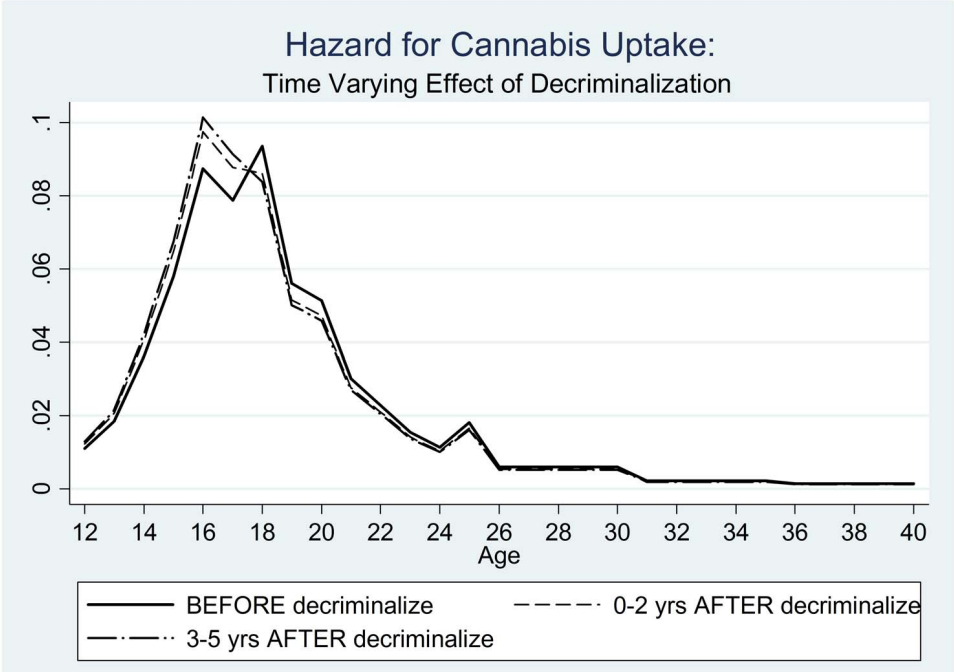
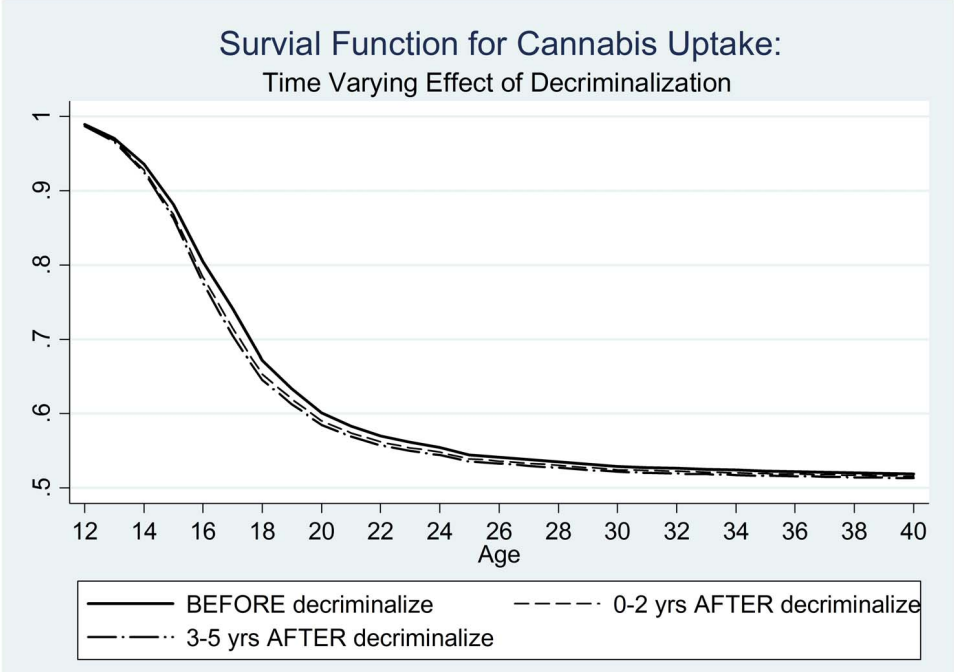

New Cannabis Users if Legalized by Age at Survey
new cannabis users if legal
0
.02
.04
.06
.08
.1
.12
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Age

Figure 4:


Hazard for Cannabis Uptake:
Time Varying Effect of Decriminalization
0
.02
.04
.06
.08
.1
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Age
BEFORE decriminalize
0-2 yrs AFTER decriminalize
3-5 yrs AFTER decriminalize


Survial Function for Cannabis Uptake:
Time Varying Effect of Decriminalization
.5
.6
.7
.8
.9
1
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Age
BEFORE decriminalize
0-2 yrs AFTER decriminalize
3-5 yrs AFTER decriminalize