Cannabis Decriminalization and the Age of Onset of Cannabis Use

Cervený, J.; van Ours, J.C.; Chomynova, Pavla; Mravcik, Viktor

Link to publication in Tilburg University Research Portal

CANNABIS DECRIMINALIZATION AND THE AGE OF ONSET OF CANNABIS USE

By

Jakub Červený, Pavla Chomynová,
Viktor Mravčik, Jan C. van Ours

27 January, 2015

TILBURG ◆ UNIVERSITY

Cannabis Decriminalization
and the Age of Onset of Cannabis Use

Jakub Červený[*]   Pavla Chomynová[†]
Viktor Mravčík [‡]   Jan C. van Ours[§]

January 27, 2015

Abstract

This paper examines the effect of a change in drugs policy on the age of onset of cannabis use. We use 2012 survey data from the Czech Republic where in 2010 a law was introduced decriminalizing personal possession of small quantities of several illicit drugs, including cannabis. We estimate the effect of the policy change using a mixed proportional hazards framework that models the starting rate of cannabis use, i.e. the transition to first cannabis use. We find that the decriminalization of cannabis did not affect the age of onset of cannabis use.

Keywords: Cannabis, decriminalization, age of onset
JEL-codes: I18, C41

[*]Department of Economics, CentER, Tilburg University, The Netherlands; j.cerveny@uvt.nl

[†]National Monitoring Centre for Drugs and Addiction, the Office of the Government of the Czech Republic; chomynova.pavla@vlada.cz

[‡]National Monitoring Centre for Drugs and Addiction, the Office of the Government of the Czech Republic, Prague, The Czech Republic; Department of Addictology, First Faculty of Medicine, Charles University and General University Hospital, Prague, The Czech Republic; mravcik.viktor@vlada.cz

[§]Corresponding author: Department of Economics, CentER, Tilburg University, The Netherlands; Department of Economics, University of Melbourne, Parkville, Australia; CEPR (London), CESifo (Munich), IZA (Bonn); vanours@uvt.nl.

1   Introduction

Cannabis has been and still is an illegal drug in almost all countries across the world. The main argument for prohibition of cannabis is the potential health risks associated with cannabis use. However, negative health effects of cannabis use are no robust finding. For example, van Ours and Williams (2015) conclude from an overview of the literature that there do not appear to be serious harmful health effects of moderate cannabis use. Only heavy use of individuals who are susceptible to mental health problems may have negative effects on the mental well-being of these individuals. This does not imply that cannabis use is harmless (see also Hall (2015)). The age of onset of cannabis use is important as there is robust evidence that early cannabis use for example reduces educational attainment.

Despite the prohibition policy, cannabis use has increased over the past decades and there is a debate on whether this policy is sensible (see for example Caulkins et al. (2012), Cawley and Ruhm (2011), and Pudney (2010)). The cannabis policy debate is often emotional, with strong views of both proponents and opponents (van Ours (2012)). Those who are in favor of legalization tend to ignore the negative health effects of cannabis use. Those who are against legalization ignore the fact that legal substances such as alcohol and tobacco also have bad health effects (see for example Hall and Lynskey (2009), Nutt et al. (2010) and Taylor et al. (2012)). The debate on legalizing cannabis has gained momentum in recent years. Uruguay and two U.S. states – Colorado and Washington State – have legalized cannabis use, allowing consumption and regulating supply. Other countries have decriminalized the possession of small quantities of cannabis or made assess to cannabis for medical reasons easier.

Whether easier access to cannabis leads to an increase in cannabis use is not clear. Research on the relationship between cannabis policy and cannabis use varies from general comparative cross-country studies to in-depth analysis of differences in cannabis use of individuals who are subject to different policy regimes. Among the general comparative studies is Reinarman et al. (2004) who compare representative samples of experienced cannabis users in decriminalized cannabis Amsterdam and criminalized cannabis San Francisco finding no evidence to support claims that criminalization reduces use or that decriminalization increases use. Reuter and Trautmann (2009) find that the drug policies have limited effects on drug problems. Drug policies seem to be influenced by the drug situation rather than the other way around. A study by the European Monitoring Centre for Drugs and Drug Addiction (2011) explores whether a significant change in prevalence of cannabis use among the population aged 15-34 can be observed after a legislative change regarding cannabis use. Analyzing trend data from countries that changed their cannabis legislation in the past ten years it is concluded that cannabis legislation did not

affect cannabis use.[1]

Another strand of studies on the relationship between cannabis policy and cannabis use focuses on the U.S. in which some states have medical marijuana dispensaries which make access to cannabis easy.[2] The findings in these studies are not uniform. Some studies conclude that easier access to cannabis through the dispensaries has a positive effect on cannabis use while other studies find no effect whatsoever. Pacula et al. (2010) conclude that in states where medical marijuana laws were introduced cannabis use increased. Wall et al. (2011) find that states with medical marijuana laws have higher rates of cannabis use. Chu (2015) concludes that cannabis arrest rates significantly increased after medical marijuana laws were passed. However, Cerdá et al. (2012) concludes that cannabis abuse and cannabis dependence rates among cannabis users are very similar in states with and without medical marijuana laws. Harper et al. (2012) find medical marijuana laws not to have increased cannabis use. Anderson et al. (2012) and Anderson and Rees (2014) also find no evidence that medical marijuana dispensaries increased cannabis use. Finally, Wagenaar et al. (2013) find that neither the prevalence rate nor the frequency of cannabis use seem to have been affected by the dispensaries.

Finally, there are studies on the effect of decriminalization of the possession of small quantities of cannabis. Williams and Bretteville-Jensen (2014) analyze Australian data exploiting variation of the timing of decriminalization over Australian States finding that cannabis decriminalization affected the uptake of cannabis among youngsters in the first five years following the policy change. In the Netherlands consumption of cannabis is quasi-legalized since the mid 1970s. Small quantities of cannabis can be bought in cannabis shops, retail outlets which are referred to as "coffeeshops".[3] Palali and van Ours (2015) find that individuals who grew up within 20 km of a cannabis shop have a lower age of onset.

In our paper we focus on the effects cannabis decriminalization on the age of onset of cannabis use. In the Czech Republic a legislative change was introduced in 2010 decriminalizing cannabis possession. The question we address in our paper is how this policy change affected the uptake of cannabis use. In our analysis we exploit information on the age of onset to model transitions to first cannabis use. For this, we use data from a 2012 survey. We find that the policy change did not affect the age of onset of cannabis use. To investigate the robustness of our findings we also use data from a 2008 survey as a counterfactual analysis finding that indeed the "cannabis policy change that did not happen" did not affect the age of onset of cannabis use.

---

[1]These countries are Italy, UK, Slovakia, Denmark, Finland, Portugal, Bulgaria and Greece.

[2]In the US cannabis is usually referred to as marijuana.

[3]These coffeeshops are subject to strict rules. Some of the fundamental rules are: no sale of hard drugs, no advertising, no sale to youngsters below 18 years of age, no sale above 5 grams per transaction and no more than 500 grams of cannabis on the premises.

Our paper is set-up as follows. In section 2 we give a brief description of cannabis use and cannabis policy in the Czech Republic, in section 3 we describe our data in detail. Section 4 presents the set-up of our empirical analysis. Our parameter estimates are discussed in section 5. Section 6 concludes.

2 Cannabis policy in the Czech Republic

Shortly after the fall of communist regime in 1989, the Czech penal code was revised to remove repressive practices of the previous regime. Illicit drug possession was not a crime from 1990 to 1998. With the development of drug problems during the 1990s, social and political concern argued for a more repressive approach in the Czech drug policy. As a result, the penal code was amended defining the possession of drugs for personal use as a criminal offense and introducing the term "greater than small" quantity as a threshold distinguishing between a criminal offense and an administrative offense. The interpretation of the term "greater than small" was left to judicial practice. The "greater than small" quantity became a focus of debate on illicit drug regulation and prosecution in the Czech Republic (Zabransky (2004), Zeman (2007), Radimecky (2007)).

In 2001, the government decided to differentiate drugs in the penal code according to their health and social risks – initially in three, and finally in two groups – cannabis and other drugs (Zabransky (2004)). Due to a complex re-codification of the old penal code, this decriminalization of cannabis possession was implemented only in January 2010. The new Penal Code includes lower sanctions for unauthorized possession of small quantities of cannabis. At the same time, the new penal code empowered the government to specify the threshold quantities in a Government Decree. Possession of "greater than small" quantities of cannabis could result in a jail sentence of up to one year. For other illicit drugs, the sentence was two years. Trafficking (of drugs) offenses carry stiffer sentences. In addition, the new Penal Code defined standards for cultivation of plants and mushrooms containing narcotic and psychotropic substances for personal use that allowed small-scale cultivation to be treated as a misdemeanor, again distinguishing between cannabis plants with lower punishment and other drugs. Under the new law, possession of less than 15 grams (or five plants) of herbal cannabis and 5 grams of hashish was not considered a criminal offense.[4]

As Csete (2012) remarks, the new cannabis policy aligned the Czech Republic with a growing number of EU countries that effectively decriminalized some cannabis offenses. In July 2013, the Constitutional Court annulled the aforementioned regulation, or, strictly speaking, substantial parts thereof with threshold quantities, as it was found contradic-

---

[4]For other drugs the thresholds were the following: magic mushrooms – 40 pieces, LSD - 5 blotters (small paper pieces), Ecstasy – 4 tablets, methamphetamine – 2 grams, heroin – 1.5 grams, cocaine – 1 gram.

tory to the Constitution of the Czech Republic and the Charter of Fundamental Rights and Freedoms, according to which any criminal offense (and thus also the definition of greater-than-small quantity of a narcotic or psychotropic substances) may only be defined by a law (Mravcik et al. (2013)). As a consequence, the Supreme Court decreased the threshold limit for herbal cannabis from 15 to 10 grams.[5] This decision means *de jure* re-criminalization of cannabis possession in the Czech Republic (see also Mravcik (2015)).

Lifetime prevalence of cannabis use is relatively high in Czech Republic (27.4% in 2012), compared to the European average of 17.6%.[6] Figure 1 shows lifetime prevalence of cannabis use from 2008 to 2012. There is a substantial variation from close to 35% in 2008 to about 25% in 2011. Once an individual has used cannabis, he or she will always be an ever user of cannabis. A change in lifetime prevalence only occurs at the margin, by older individuals leaving the sample because of death or emigration or younger individuals starting to use cannabis. Therefore, lifetime prevalence can only change slowly over time. The fluctuations in Figure 1 are "noise" rather than "signal", most likely introduced by changes in the sampling frame. Figure 1 also shows changes in cannabis use in the last 12 months and last 30 days. These numbers do not show large fluctuations. The prevalence of use in last 12 months is decreasing, falling from 15.3% in 2008 to 9.2% in 2012. Apart from 2008, cannabis use in last 30 days is relatively stable at a level of around 4%.

3   Data

In our analysis we use data from two surveys carried out in the Czech Republic from October to December 2008 and from September to November 2012 by the Czech NMC, the National Monitoring Centre for Drugs and Addiction. The main goals were to provide information on the extent of substance use and attitudes towards psychotropic substances and to determine the extent of selected health risk behaviors associated with illicit drugs in the Czech population. The questionnaires are based on the European Model Questionnaire, a set of standard questions recommended for general population surveys by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). For our paper, we use information on experience with cannabis use and several personal characteristics. To ensure the anonymity of the respondents, the names and addresses were not recorded as is a standard in cross-sectional questionnaire population surveys. The data were collected by means of face-to-face interviews with respondents in randomly selected households using a paper questionnaire (PAPI). Both samples were obtained by multi-stage stratified sampling procedures and are nationally representative for the Czech population aged 15-64 years with regard to gender, age categories, region and level

---

[5]Furthermore, for methamphetamine the threshold limit was reduced from 2 to 1.5 grams.

[6]EMCDDA Statistical Bulletin, based on latest data availability from national surveys.

of education achieved. In the 2008 study, 5613 randomly selected households were approached, with response rate of 80.3%. In the 2012 study, the number of households was 6210 with response rate of eligible households reaching 62%. Most people who declined to be interviewed indicated lack of time or disinterest in the survey as a reason.

Starting to use cannabis is a phenomenon that is highly age related. Individuals most often decide on the use of cannabis when they are in the age range 15 to 25. Individuals who have never used cannabis by age 25 are very unlikely to start using cannabis later on in life (van Ours (2005)). In many countries cannabis use among younger generations is substantially higher than among older generations simply because cannabis was a rare commodity when older generation grew up. For illustrative purposes we use a sample of individuals of age 20 and older and calculated by birth year the probability to have ever used cannabis by age 20. Figure 2 shows the results of these calculations for individuals from birth year 1950 onwards. For individuals in the 2008 sample the last birth year is 1998, for the 2012 sample the last birth year is 2002. Clearly, until birth year 1970 the take-up of cannabis by age 20 was relatively low. From birth year 1970 onwards the take-up of cannabis by age 20 starts increasing. The probabilities in the 2008 sample are somewhat higher than the probabilities in the 2012 sample. Clearly, there are differences in the samples between 2008 and 2012. Whereas in the 2008 sample the probability to have used cannabis by age 20 keeps increasing for younger birth cohorts it levels off in the 2012 sample after birth year 1980.

When studying the effect of a policy change on the uptake of cannabis use, it makes sense to focus on younger generations. In the remainder of our paper we focus in individuals of age 30 or younger at the time of the survey. The appendix provides the definitions of the relevant variables in our analysis and presents descriptive statistics. Our 2012 sample consists of 708 individuals, our 2008 sample has 1673 individuals. As shown, the distribution of the samples according to region are about the same, but there are differences in terms of educational attainment, gender, age and lifetime prevalence of cannabis use. For example, in the 2008 survey 56 percent of the respondents of age 30 and younger indicate to have ever used cannabis while in the 2012 survey this is only 47 percent. In the 2008 survey 7 percent of the respondents has university education while in the 2012 survey this is 17 percent. This can be attributed to a fact that 2008 survey used the data from 2001 national census as a basis for sampling, whereas the 2012 sample used more recent 2011 census. The number of people with university education increased between 2001 and 2011 in Czech Republic, also because the Bachelor degree became more widespread.[7]

In the empirical analysis, we focus on the starting rate of cannabis use. We use the age

---

[7]The Bachelor degree received formal recognition in 1998. Therefore, the number of people with a Bachelor degree was very small in 2001.

of first cannabis use to calculate the starting rate by age, from age 10 onwards, taking into account that some individuals have never used cannabis.[8] Figure 3A plots the evolution of the unconditional starting rate over the age of the individuals. Cannabis use starts at age 13 but only a few percent of the individuals do this at such a young age. There are differences between the starting rates in the samples of 2008 and 2012. The starting rates in 2008 are higher than in 2012. The peak in the starting rates of 2008 is at age 16, while this is age 17 for the sample of 2012. From age 21 onwards the starting rates are very low. Figure 3B shows the related cumulative starting probabilities of cannabis use. Clearly, the cumulative starting probabilities level off after age 20. For the 2008 sample the cumulative starting probability by age 20 is 63%, for the 2012 sample this is 55%.

4 Set-up of the analysis

The focus of our analysis is on the effect of cannabis decriminalization on the uptake of cannabis. Since individuals were asked about the age of their first use of cannabis and also their age at the time of survey, we are able to determine the time-frame in which they might have been affected by the new policy.

To estimate the effect of the policy change, we use a mixed proportional hazard framework which allows the rate of transition from one state to the other to be affected by individual observed and unobserved characteristics as well as the duration of stay in a state (Heckman and Singer (1984)). In our case the state of origin is the state in which individuals have never used cannabis while the state of destination is the state in which individuals have used cannabis. The transition rate is equivalent to the starting rate of cannabis use. The duration of stay in the first state is equivalent to the age of the individual from age 10 onwards. Thus, the starting rate for cannabis use at age t conditional on observed characteristics x, effect of policy t_p and unobserved characteristics u, the model is specified as follows:

$$\theta(t \mid x, t_p, u) = \lambda(t) \, \exp(x'\beta + \delta I(t > t_p) + u) \tag{1}$$

where $\lambda(t)$ represents individual age dependence. The parameter δ describes how the hazard rate shifts at the moment when the new law was introduced in the year 2010 and thus measures the effect of policy change on the uptake of cannabis. Age dependence is flexibly modeled using step function:

$$\lambda(t) = \exp\left(\sum_k \lambda_k I_k(t)\right) \tag{2}$$

---

[8]For these individuals we assume that the duration until cannabis use is right-censored at their current age.

where $k(=1,...,K)$ is a subscript for age-intervals and $I_k(t)$ are time-varying dummy variables for subsequent age-intervals. We assume that individuals are being exposed to cannabis from age 10 onwards. Subsequent age intervals are annually specified from age 15 to age 20, and the last interval refers to ages over 21. We estimate a constant and normalize $\lambda_0 = 0$. The conditional density function for the completed durations of non-use can be written as:

$$f(t \mid x, t_p, u) = \theta(t \mid x, t_p, u) \exp\left(-\int_0^t \theta(s \mid x, t_p, u)\, ds\right) \tag{3}$$

We assume that the random effects u come from a discrete distribution G with two points of support (u_1, u_2), representing two groups of individuals.[9] The associated probabilities are denoted as follows: $\Pr(u = u_1) = p_1$, $\Pr(u = u_2 - u_1) = p_2$, where p_j $(j = 1, 2)$ is assumed to have a multinomial logistic distribution:

$$p_n = \frac{\exp(\alpha_n)}{\sum_n \exp(\alpha_n)}, \; n = 1, 2 \tag{4}$$

with α_1 normalized to zero. We remove the unobserved heterogeneity distribution through integration:

$$f(t \mid x, t_p) = \int_u f(t \mid x, t_p, u)\, dG(u) \tag{5}$$

In the estimation we take into account that we do not know the birthday of the individual nor the exact day at which an individual started using cannabis. So, if a male indicated to have used cannabis for the first time at age 17, this could be at his 17th birthday or the day before he turned 18. The resulting log-likelihood function equals:

$$\mathcal{L} = \sum_{i=1}^N \log\left\{d_i(F(t+1) - F(t)) + (1 - d_i)F(t+1)\right\} \tag{6}$$

where K denotes dataset consisting of $i = 1,...,N$ individuals, d_i denotes an indicator whether an individual started using cannabis and F is the distribution function related to f. The likelihood function is optimized over all unknown parameters.

To check the robustness of our findings we also estimate the same model on 2008 data. By way of counterfactual analysis we introduced in 2006 a "policy change that did not occur". This is about three years before the survey, similar to the 2010 policy change that occurred about three years before the 2012 survey.

---

[9]We investigated whether we could identify a third mass-points but were unable to do so.

5 Parameter Estimates

5.1 Baseline estimates

Table 1 reports the parameter estimates. Column (1) shows the estimates based on the 2012 data, column (2) presents the results of the counterfactual analysis based on the 2008 data. The top row of the table shows the effect of the decriminalization law on the starting rate of cannabis use. The effect is small and insignificant in 2012. In the counterfactual analysis the "effect" is bigger but still not different from zero at conventional level of significance. The remainder of Table 1 shows how personal characteristics including the region in which people live affect the uptake of cannabis use. There are differences in the parameter estimates between 2012 and 2008. With respect to for example the effect of education, in 2008 individuals with a university degree have the lowest starting rate of cannabis use while in 2012 this is for individuals with a vocational education. Men have a higher take-up rate than women have in 2012, i.e. if they start consuming cannabis men do this earlier than women. However, this is not the case in 2008. Birth cohort has a positive effect in 2008 indicating that more recent cohorts have a higher starting rate. But, this is not the case in 2012. The differences in the effect of birth year were also illustrated in Figure 2. There are no differences between regions in 2012 while there are some differences in 2008. However, the differences in 2008 are only significant at the 10%-level. Finally, there is clear age dependence in the starting rate while unobserved heterogeneity is present. In both samples, we find that the distribution of unobserved heterogeneity in the starting rates can be described by a discrete distribution with two points of support. There is one type of individuals that has a substantial lower starting rate than the other type. This implies that some individuals with a very low starting rate will never start using cannabis. The distribution of the types is different for the two surveys. In 2012 74 percent has a very low starting rate, in 2008 this is 45 percent.

5.2 Sensitivity analysis

The main conclusion from Table 1 is that there is no significant effect of the decriminalization policy on the starting rate of cannabis use. To investigate the robustness of this finding we provide a range of sensitivity analysis of which the main results – the parameter estimates of δ – are shown in Table 2. For reasons of comparison panel a repeats the main parameter estimates of Table 1. In panel b we restrict the effect of the policy change to age up to and including 25. For the 2012 sample the parameter estimate of δ increases but it is still insignificantly different from zero. For the 2008 sample the parameter estimate hardly changes, but it is now different from zero at a 10% level of significance. In panel c we restrict the policy effect to be equal to zero. The loglikelihood for the 2012

estimates does not change, while a comparison between the 2008 loglikelihoods in panels a and c shows that we cannot reject the hypothesis that there is no treatment effect.[10]

In panels d and e the samples are split-up according to gender. Again we find that neither for the actual policy change in the 2012 sample nor for the counterfactual policy change in the 2008 sample there is a significant effect on the age of onset of cannabis use. Apparently the policy change that decriminalized cannabis use in 2012 did not affect the uptake of cannabis.

5.3 How to explain our findings

To explain our findings in the previous sections of the paper, we exploit two opinion questions related to cannabis use. One potential explanation of why the age of onset was not affected by the decriminalization policy is that potential consumers may have found the access to cannabis as easy as before. In both 2008 and 2012 surveys respondents were asked the question "How difficult do you think it would be to obtain cannabis within next 24 hours?". We analyze the response to this question by individuals who indicated that they used cannabis within last year of the respective survey. The answers are summarized in Table 3. Before the policy change, in 2008, 92.5% of the respondents indicated that it was relatively easy or very easy to obtain cannabis within 24 hours. After the policy change, this was 92.3%. The only difference is that the percentage of respondents indicating that it is very easy to obtain cannabis is higher in 2012, while the percentage indicating it is relatively easy is smaller. Nevertheless, there is not much difference in difficulty of obtaining cannabis before and after the policy change.[11]

To further explore the differences between 2008 and 2012, we estimate an ordered probit model on the joint dataset. This model is specified as:

$$y_i^* = x_i'\zeta + d_{2012}\lambda + \epsilon_i \qquad (7)$$

where y_i^* represents the underlying latent variable, x is a vector of observed individual characteristics, d_{2012} represents dummy variable indicating 2012 survey, ζ is a vector of parameters, λ is the parameter of main interest capturing the policy effect and ϵ_i

---

[10]The Likelihood-Ratio statistic is equal to 1.6 which is not significantly different from zero. Note that the 10%-level critical value of the χ^2 distribution with 1 degree of freedom is 2.7.

[11]χ^2-test with 4 degrees of freedom equals to 6.3, with associated p-value of 0.17, confirming that there is no difference between 2008 and 2012.

represents the error term. The observed categories are:

$$
y_i = \begin{cases}
= 1 & \text{if } y_i^* \leq 0 \\
= 2 & \text{if } \gamma_{1,i} < y_i^* \leq \gamma_{2,i} \\
= 3 & \text{if } \gamma_{2,i} < y_i^* \leq \gamma_{3,i} \\
= 4 & \text{if } \gamma_{3,i} < y_i^* \leq \gamma_{4,i} \\
= 5 & \text{if } \gamma_{4,i} < y_i^*
\end{cases} \tag{8}
$$

where the γ's are the four threshold parameters. The results are summarized in Table 4. The parameter of main interest λ is statistically insignificant, confirming that cannabis users did not find it easier to obtain cannabis after the policy change. [12]

We also examined the perception of the risk of being caught by the police when obtaining cannabis. In both surveys respondents were asked a question "Have you felt threatened last time when you obtained cannabis?". There is not much difference in response. Only 7% of cannabis users felt threatened by the police before the decriminalization law was introduced. After the introduction of the law this number was 7.5%.[13]

6   Conclusions

Cannabis policy is changing across the world varying from legalization in Uruguay and in two U.S. states to decriminalization in many other countries. In 2010 as part of a broader drugs decriminalization policy, the Czech Republic decriminalized the possession of small quantities of cannabis. We examine the effect of this change in the Czech drug policy on the age of onset of cannabis use. We estimate the effect of the policy change using a mixed proportional hazards framework that models the transition to cannabis use and allows us to distinguish between the effect of observed and unobserved personal characteristics as well as the effect of the drugs policy change. Starting to use cannabis is a phenomenon that usually occurs in a small age range from 15 to 25. Individuals who have not used cannabis when they are in their mid-twenties are very unlikely to do so later on in life. Therefore, we focus on a sample of individuals up to age 30 and find that the policy change did not affect the age of onset of cannabis use. To investigate the robustness of our findings we performed among others a counterfactual analysis on 2008 data in which we introduced a "policy change that did not happen". Also for this counterfactual policy change we find no effects on the age of onset.

---

[12]The Likelihood-Ratio statistic comparing the full model with the restricted model with $\lambda = 0$ is equal to 2.9 with 1 degree of freedom, which is significant at 10% level.

[13]The χ^2-test statistic with 1 degree of freedom is equal to 0.02, with associated p-value of 0.87, confirming that there is no difference between 2008 and 2012.

We can only speculate on why there is no effect. Perhaps the policy change did not increase supply of cannabis. From an additional analysis we find that cannabis consumers found it as easy to access cannabis after the decriminalization as they did before the policy change. Perhaps the risk of being caught with a small quantity of cannabis was not high before the policy change. For this we also find some evidence. So, the decriminalization changed the law but not the perceived risks related to cannabis use. Finally, whether or not an individual starts using cannabis is not only opportunity driven. Some individuals will never start using cannabis. Apparently, the decriminalization did not persuade the abstainers to start using cannabis. All in all, the lack of evidence of an effect of cannabis decriminalization on the age of onset of cannabis is a fortunate finding for those who worry about negative health effects related to early onset of cannabis use.

References

Anderson, D. M., B. Hansen, and D. I. Rees (2012). Medical marijuana laws and teen marijuana use. *IZA Discussion Paper No. 6592*.

Anderson, D. M. and D. I. Rees (2014). The legalization of recreational marijuana: How likely is the worst-case scenario? *Journal of Policy Analysis and Management 33*, 221–232.

Caulkins, J., A. Hawken, B. Kilmer, and M. Kleiman (2012). *Marijuana Legalization: What Everyone Needs to Know.* Oxford, U.K.: Oxford University Press.

Cawley, J. and C. J. Ruhm (2011). The economics of risky health behaviors. In T. G. M. Mark V. Pauly and P. P. Barros (Eds.), *Handbook of Health Economics*, Volume 2 of *Handbook of Health Economics*, pp. 95 – 199. Elsevier.

Cerdá, M., M. Wall, K. M. Keyes, S. Galea, and D. Hasin (2012). Medical marijuana laws in 50 states: Investigating the relationship between state legalization of medical marijuana and marijuana use, abuse and dependence. *Drug and Alcohol Dependence 120*, 22–27.

Chu, Y. L. (2015). Do medical marijuana laws increase hard drug use? *Journal of Law and Economics*, forthcoming.

Csete, J. (2012). A balancing act: Policymaking on illicit drugs in the Czech Republic. Technical report, Open Society Foundations, New York.

European Monitoring Centre for Drugs and Drug Addiction (2011). The state of the drugs problem in Europe 2011. Annual report, Publications Office of the European Union, Luxembourg.

Hall, W. (2015). What has research over the past two decades revealed about the adverse effects of recreational cannabis use? *Addiction 110*, 19–35.

Hall, W. and M. Lynskey (2009). The challenges in developing a rational cannabis policy. *Current Opinion in Psychiatry 22*, 258–262.

Harper, S., E. C. Strumpf, and J. S. Kaufman (2012). Do medical marijuana laws increase marijuana use? replication study and extension. *Annals of Epidemiology 22*, 207–212.

Heckman, J. and B. Singer (1984). A method for minimizing the impact of distributional assumptions in econometric models for duration data. *Econometrica 52*(2), 271–320.

Mravcik, V. (2015). (De)criminilisation of possession of drugs for personal use - case study from the Czech Republic. *International Journal of Drug Policy*, forthcoming.

Mravcik, V., P. Chomynova, K. Grohmannova, V. Necas, L. Grolmusova, L. Kissova, B. Nechanska, B. Sopko, H. Fidesova, J. Vopravil, and L. Jurystova (2013). The Czech Republic drug situation in 2012. Annual report, Urad vlady CR.

Nutt, D., L. King, and L. Phillips (2010). Drug harms in the UK: a multicriteria decision analysis. *Lancet 376*, 1558–65.

Pacula, R. L., B. Kilmery, M. Grossman, and F. J. Chaloupka (2010). Risks and prices: The role of user sanctions in marijuana markets. *The B.E. Journal of Economic Analysis and Policy 10(1)*, 1–38.

Palali, A. and J. C. van Ours (2015). Distance to cannabis-shops and age of onset of cannabis use. *Health Economics*, forthcoming.

Pudney, S. (2010). Drugs policy – What should we do about cannabis? *Economic Policy 61*, 165–211.

Radimecky, J. (2007). Rhetoric versus practice in Czech drug policy. *Journal of Drug Issues 37*, 11–44.

Reinarman, C., P. Cohen, and H. Kaal (2004). The limited relevance of drug policy: cannabis in Amsterdam and in San Francisco. *American Journal of Public Health 94*, 836–42.

Reuter, P. and F. Trautmann (2009). A report on global illicit drugs markets 1998-2007. Technical report, RAND.

Taylor, M., K. Mackay, J. Murphy, A. Mcintosh, C. Mcintosh, S. Anderson, and K. Welch (2012). Quantifying the RR of harm to self and others from substance misuse: results from a survey of clinical experts across Scotland. *BMJ Open 2*(4), 1=7.

van Ours, J. C. (2005). Dynamics in the use of drugs. *Health Economics 15*(12), 1283–1294.

van Ours, J. C. (2012). The long and winding road to cannabis legalization. *Addiction 107*, 872–873.

van Ours, J. C. and J. Williams (2015). Cannabis use and its effects on health, education and labor market success. *Journal of Economic Surveys*, forthcoming.

Wagenaar, A. C., S. D. Lynne-Landsman, and M. D. Livingston (2013). Effects of state medical marijuana laws on adolescent marijuana use. *American Journal of Public Health 103*, 1500–1506.

Wall, M. M., E. Poh, M. Cerda, K. M. Keyes, S. Galea, and D. S. Hasin (2011). Adolescent marijuana use from 2002 to 2008: higher in States with medical marijuana laws, cause still unclear. *Annals of Epidemiology 21*, 714–716.

Williams, J. and A. L. Bretteville-Jensen (2014). Does liberalizing cannabis laws increase cannabis use? *Journal of Health Economics 36*, 20 – 32.

Zabransky, T. (2004). Czech drug laws as an arena of drug policy battle. *Journal of Drug Issues 34*, 661–686.

Zeman, P. (2007). Legislation and practice concering prosecution of drug offenses in the Czech Republic. *Journal of Drug Issues 37*, 45–72.

Appendix: Definition & descriptives of variables

Cannabis: Have you ever tried cannabis (marijuana or hashish)? If so, indicate at what age did you try cannabis for first time.

Cannabis opinions: How difficult do you think it would be to obtain cannabis within next 24 hours? Impossible, very difficult, relatively difficult, relatively easy, very easy, don't know (only 2012 survey) – When you obtained cannabis last time, have you felt threatened while doing it? By a police, by a seller/dealer, by a side that did not take part in transaction, other threats, did not feel any threat.

Education: Dummy variables: *Secondary:* Special schools including technical schools, specialized in construction, chemistry, engineering etc. Without graduation. *Secondary with graduation:* Grammar schools; higher vocational, higher specialized education, without university diploma/degree. *Higher vocational*: Higher vocational education. *University:* University degree. Reference group: Primary – compulsory up to age 15.

Regions: Dummy variables: Central Bohemia, Southwest, Northwest, Northeast, Southeast, Central Moravia, Moravia-Silesia; Reference group: Capital Prague.

Table 1: Parameter Estimates Starting Rate of Cannabis Use 2012 and 2008; MPH Model

	2012		2008	
Effect of decriminalization (δ)	0.03	(0.2)	0.19	(1.4)
Men	0.58	(3.0)**	0.12	(1.3)
Education				
Secondary	0.04	(0.1)	-0.50	(3.7)***
Secondary w. grad.	-0.87	(2.9)***	-0.37	(3.0)***
Higher vocational	-1.20	(2.1)***	-0.30	(0.8)
University	0.10	(0.4)	-0.57	(2.3)**
Birth cohort	0.01	(0.5)	0.10	(7.8) ***
Region				
Central Bohemia	0.06	(0.2)	-0.08	(0.5)
Southwest	-0.15	(0.4)	-0.35	(1.9)*
Northwest	0.11	(0.3)	-0.08	(0.5)
Northeast	0.30	(1.0)	0.12	(0.7)
Southeast	-0.53	(1.5)	-0.04	(0.3)
Central Moravia	-0.04	(0.1)	-0.27	(1.5)
Moravia-Silesia	0.26	(0.8)	-0.33	(2.0)*
Age dependence				
Age 15	2.56	(6.3)***	2.16	(11.4)***
Age 16	3.54	(9.0)***	2.89	(16.1)***
Age 17	4.46	(10.9)***	3.79	(21.3)***
Age 18	5.47	(11.2)***	4.02	(21.0)***
Age 19	5.54	(9.4)***	4.33	(20.9)***
Age 20	5.24	(8.4)***	4.37	(18.7)***
Age 20+	4.40	(7.1)***	4.91	(19.8)***
Constant (u_1)	-5.65	(2.1)***	-13.22	(10.9)***
$u_2 - u_1$	-3.46	(8.9)***	-4.87	(13.2)***
α	-1.04	(6.0)***	0.22	(3.4)***
-Log likelihood	1159.9		3039.8	
Observations	708		1673	

Absolute t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: We also estimated the same model with sampling weights. This did not have any effect on results - for 2008 data the estimated δ parameter was 0.18 with a p-value of 0.319, for 2012 0.02, p-value of 0.935.

TABLE 2: PARAMETER ESTIMATES OF THE EFFECT OF DECRIMINALIZATION (δ); SENSITIVITY ANALYSIS

	2012		-LogL	N	2008		-LogL	N
a. Baseline	0.03	(0.2)	1159.9	708	0.19	(1.4)	3039.8	1673
b. Effect ≤ 25	0.14	(0.7)	1159.7	708	0.20	(1.7)*	3039.2	1673
c. No treatment effect	0.00	(–)	1159.9	708	0.00	(–)	3040.6	1673
d. Men only	0.12	(0.4)	604.5	336	0.10	(0.6)	1674.5	857
e. Women only	0.02	(0.1)	537.2	372	0.31	(1.4)	1331.1	816

N = number of observations; absolute t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

TABLE 3: OPINIONS RELATED TO CANNABIS USE; DIFFICULTY TO OBTAIN CANNABIS WITHIN NEXT 24 HOURS (%)

Answer	2008	2012
Impossible	0.6	1.9
Quite difficult	2.5	5.8
Relatively difficult	4.4	0.0
Relatively easy	44.7	32.7
Very easy	<u>47.8</u>	<u>59.6</u>
Total	100.0	100.0
Observations	159	52

We excluded individuals who either did not respond, or responded "don't know" (only 2012 survey) from the analysis.

λ	0.35	(1.6)
Men	0.29	(1.8)*
Age	0.04	(1.7)*
Education		
Secondary	-0.19	(0.9)
Secondary w. grad.	-0.17	(0.8)
Higher vocational	-0.42	(0.6)
University	-0.98	(2.4)**
Region		
Central Bohemia	-0.11	(0.3)
Southwest	0.37	(0.9)
Northwest	0.36	(1.0)
Northeast	0.32	(0.9)
Southeast	-0.01	(0.0)
Central Moravia	-0.10	(0.3)
Moravia-Silesia	0.02	(0.1)
-Loglikelihood	194.5	
LR test $\lambda = 0$	2.9*	
Observations	211	

The threshold parameters (γ's) are not reported; absolute t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

18

Table A1: Descriptives

Variable	2012				2008			
	Mean	Weighted mean	Min	Max	Mean	Weighted mean	Min	Max
Cannabis use	0.47	0.46	0	1	0.56	0.56	0	1
Age	23.4	23.2	15	30	23.0	23.2	15	30
Men	0.47	0.48	0	1	0.51	0.51	0	1
Education								
Primary	0.20	0.28	0	1	0.31	0.31	0	1
Secondary	0.38	0.33	0	1	0.32	0.32	0	1
Secondary w. grad.	0.20	0.20	0	1	0.28	0.28	0	1
Higher vocational	0.05	0.04	0	1	0.02	0.02	0	1
University	0.17	0.15	0	1	0.07	0.07	0	1
Birth cohort	0.89	0.85	0.82	0.97	0.85	0.85	0.78	0.93
Region								
Capital Prague	0.13	0.13	0	1	0.11	0.11	0	1
Central Bohemia	0.11	0.12	0	1	0.11	0.11	0	1
Southwest	0.10	0.09	0	1	0.12	0.12	0	1
Northwest	0.09	0.11	0	1	0.10	0.11	0	1
Northeast	0.15	0.15	0	1	0.15	0.14	0	1
Southeast	0.19	0.18	0	1	0.15	0.15	0	1
Central Moravia	0.11	0.11	0	1	0.13	0.13	0	1
Moravia-Silesia	0.12	0.11	0	1	0.13	0.13	0	1
Observations	708				1673			

Note: Birth cohort = (Year of survey-age-1900)/100. Weights were calculated by polling agencies and are based on following variables: age, gender, education, NUTS 2, size of municipality, economic status. Population information from National Census data are provided by Czech Statistical Office. In the analysis we use sampling weights denoting the inverse of probability that the observation is included because of the sampling design.
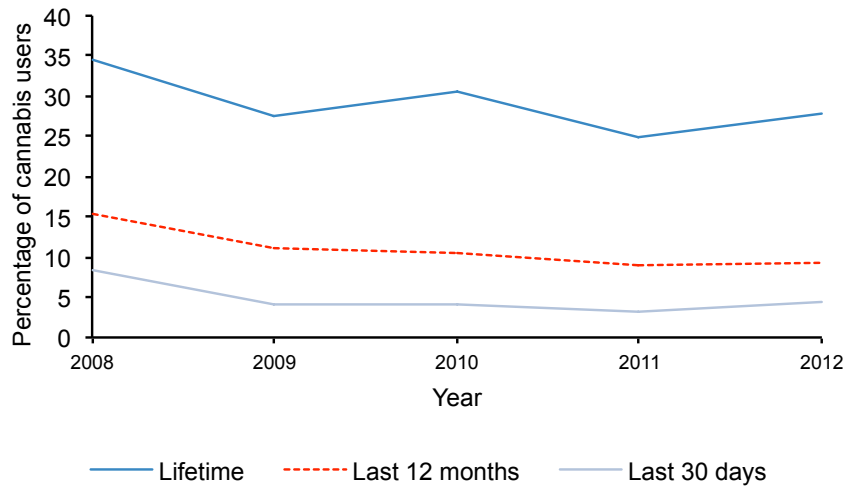
Source: National Monitoring Centre for Drugs and Addiction

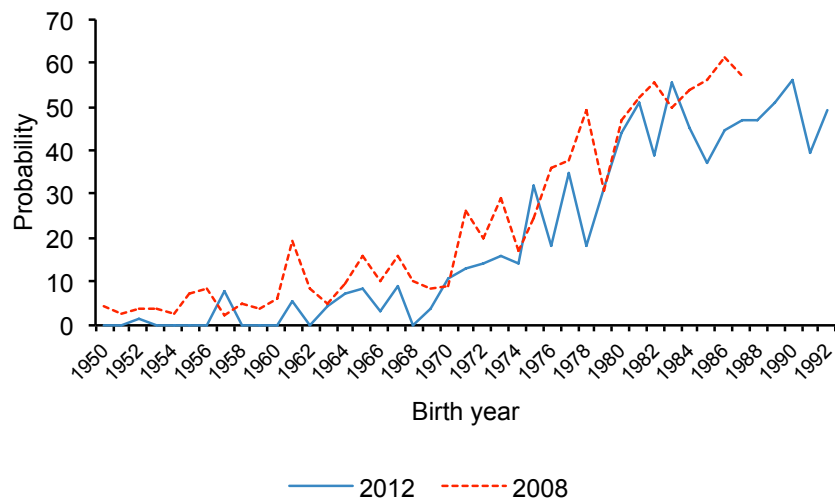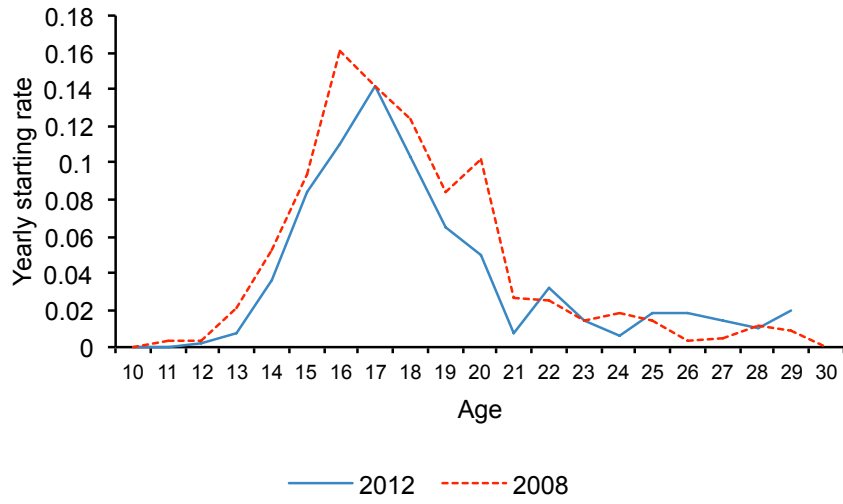FIGURE 2: PROBABILITY TO HAVE USED CANNABIS BY AGE 20; BIRTH YEARS 1950 ONWARDS

FIGURE 3: CANNABIS USE STARTING RATES AND CUMULATIVE STARTING
PROBABILITIES BY AGE

A: CANNABIS USE STARTING RATES

B: CANNABIS USE CUMULATIVE STARTING PROBABILITIES