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Distance to cannabis-shops and age of onset of cannabis use

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Abstract

In the Netherlands cannabis use is quasi-legalized. Small quantities of cannabis can be bought in cannabis-shops. We investigate how the distance to the nearest cannabis-shop affects the age of onset of cannabis use. We use a Mixed Proportional Hazard rate framework to take account of observable as well as unobservable characteristics that influence the uptake of cannabis. We find that distance matters. Individuals who grow up within 20 kilometers of a cannabis-shop have a lower age of onset.

Keywords: cannabis use; coffeeshops; drugs policy

JEL codes: C31, I10, I18

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1 Introduction

In the Netherlands cannabis use is quasi-legalized. Small quantities of cannabis can be bought in cannabis shops, retail outlets which are referred to as "coffeeshops". Cannabis-shops 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. The quasi-legal status makes it easy for consumers to buy cannabis. This situation is not unique in the world. In the United States some states have medical marijuana dispensaries which also make access to cannabis easy. The potential effects of the presence of these medical marijuana dispensaries have been analyzed in a number of studies. Cerdá et al. (2012) find that the states which had legalized medical marijuana in 2004 experienced increased rates of cannabis use, cannabis abuse and cannabis dependence. However, cannabis abuse and cannabis dependence rates among current users are found to be very similar in states with and without medical marijuana laws. Wall et al. (2011) find that states with medical marijuana laws have higher past-month cannabis use rates. Harper et al. (2012) replicate the results of Wall et al. (2011) by using similar data but applying a difference-in-difference methodology also controlling for time-invariant state specific characteristics. They find that passing medical marijuana laws does not seem to have caused an increase in cannabis use. In fact, their estimates suggest that reported cannabis use might actually decrease after passing the medical marijuana laws. Anderson et al. (2012) find that the introduction of the medical marijuana laws did not cause an increase in the probability of cannabis use in the past 30 days. They also find no effect on the probability of frequent cannabis use and the number of admissions to cannabis treatment programs.

The easy access to cannabis through cannabis-shops has led to worries about potential negative spillover effects to youngsters. If it is easy to access cannabis, youngsters may be tempted to start using cannabis earlier on in their lives. Early onset of cannabis may have negative effects on individuals in various dimensions. Early onset of cannabis use increases the intensity of use and the probability of subsequent drug use (Yamaguchi and Kandel

(1984)). Van Ours and Williams (2007) using Australian data find that individuals who start using cannabis at earlier ages are less likely to quit at later ages. Van Ours (2007) finds for cannabis users in Amsterdam that quitting rates increase with the age of onset. Van Ours et al. (2013) using data from New Zealand find that early onset of cannabis use may lead to mental health problems i.e. to suicidal thoughts.

The Netherlands is an interesting country to study the uptake of cannabis because selling or buying small quantities of cannabis in cannabis-shops is not prosecuted. We investigate to what extent living nearby a cannabis-shop affects the age of onset of cannabis use. There are many reasons why this could be the case. The availability of cannabis-shops nearby decreases transaction costs that might otherwise be incurred to search and obtain cannabis. Moreover, individuals are forming expectations about possible future adverse effects of cannabis. Having seen people smoking cannabis at cannabis-shops, young people may think that the negative health effects are overrated. Nevertheless, cannabis-shops are just one way to get access to cannabis. In the absence of a nearby cannabis-shop, cannabis can be accessed through friends or dealers. Whether or not indeed the distance to a cannabis-shop matters is an empirical issue.

Our main research question is whether the presence of a cannabis-shop in a municipality or a municipality nearby induces individuals to start using cannabis earlier on in their life. We analyze data that were collected in a survey in 2008. Using information on the reported age of onset of cannabis use, we apply a hazard rate framework to model the starting rate, i.e. the transition rate from non-use to use. The hazard rate framework allows us to take account of observable as well as unobservable characteristics that influence the uptake of cannabis. We find that youngsters have a lower starting rate of cannabis use if they live more than 20 kilometers away from a municipality with a cannabis-shop. To investigate whether there is indeed a causal effect from distance to uptake of cannabis use we perform a counterfactual analysis in two parts. First, we show that for the uptake of tobacco the distance to a coffeeshop does not matter. This suggests that people who live close to a coffeeshop do not have a different attitude toward other drugs use, i.e. towards smoking.[1] Second, we show

[1] Van Ours (2006) shows that correlation between the unobserved characteristics affecting the onset ages

that the effect of distance on cannabis uptake is only present for the youngest birth cohort. Individuals from an older birth cohort who grew up before the era of cannabis-shops are not affected by present-day distance to a coffeeshop. This is additional evidence that it is not the case that cannabis-shops were located in an environment where people are more likely to start using cannabis anyway.

The set-up of our paper is as follows. In section 2 we discuss cannabis policy in the Netherlands and the role of cannabis-shops as a policy instrument. Section 3 presents our data and gives some stylized facts. In section 4 we present our empirical model and in section 5 we discuss our parameter estimates. Section 6 concludes.

2 Cannabis Policy in the Netherlands

Drug policy in the Netherlands focuses on health issues (De Graaf et al. (2010)) and can be summarized with one word: *tolerance* (Van Solinge (1999)). The basic aim of drug policy is to reduce the harm done to users and their environment. 'Harm reduction' aims to reduce the demand for drugs by means of strong prevention measures, campaigning against the production and trade of drugs and taking preventive and legal measures against any disturbance to public order.

The history of the drug policy of the Netherlands starts with the introduction of the first two opium laws which date back to 1919 and 1928, respectively. The laws intended to regulate trade and production of certain drugs that were considered to be highly addictive and a threat to the health of its users. The first two laws were later entrenched in the main (and the third) Opium Law introduced in 1976. In this law a distinction is made between soft drugs and hard drugs. The production or trade of soft drugs is accepted to be a much more severe offense than personal use. Moreover even though personal use of soft drugs is tolerated, hard drugs are illegal. Cannabis is the most common soft drug and readily available in retail outlets called coffeeshops – a name which has to be used instead of cannabis-shops as the retail outlets are not supposed to advertise their merchandise (Korf (2002)). According to the

of cannabis and smoking cigarettes is an important phenomenon.

Opium Law, possession of any amount less than 30 grams of cannabis was considered not as an offense but as a misdemeanor and therefore not prosecuted. Allowing a possession of less than 30 grams of cannabis paved the way for house dealers which later turned into cannabis-shops. The tolerance policy aims at providing quasi-legal access to cannabis. Grapendaal et al. (1995) consider this as a 'normalization model of social control policy'. The intention is to provide an organized environment for selling of cannabis and keeping potential customers away from otherwise illegal ways where they can come across dealers of more harmful drugs. Cannabis-shops are regulated by law. Some of the fundamental rules are: no sale of hard drugs, no advertising, no sale to youngsters below 18 years of age, no nuisance and no more than 500 grams of cannabis on the premises. Failures to operate within the regulations might result in shutting down of the shop where the duration of shut down depends on the seriousness of violations committed by the owner.

In 1980, the policy of tolerance of coffeeshops was publicly announced and this announcement was followed by a sharp increase in the number of cannabis-shops (Jansen (1991)). In the mid 1990s there were around 1500 cannabis-shops. However, the 1990s also marked increased criticism against the tolerant cannabis policy of the Netherlands from inside the country as well as from other countries. In 1995 the Dutch government changed the rules under which cannabis-shops could operate. From 1996 onwards the limit for personal possession of cannabis was decreased from 30 grams to 5 grams. Moreover the monitoring and punishment of production and trade of cannabis were increased and local governments were given the opportunity to decide whether or not they wanted to have a cannabis-shop in their municipality. These policies were followed by a substantial decrease in the amount of cannabis-shops in the country to an estimated number of around 1200 in the late 1990s (Bieleman et al. (2007)). In 1999 the so called 'Damocles' law gave more flexibility to local governments for closure of cannabis-shops in their municipalities. The law resulted in further decline in the total number of cannabis-shops.[2] In 1999 there were 846 cannabis-shops across the Netherlands, a number that went down to 651 in 2011. Figure 1 shows the evolution of the number of cannabis-shops in the Netherlands from 1999 to 2011. Even

[2]From 1999 onwards the number of cannabis-shops started being monitored.

though the total number of cannabis-shops decreased, the number of 100 municipalities with at least one cannabis-shop remained roughly the same and it is still the case that 80% of the municipalities do not have a cannabis-shop at all (Bieleman et al. (2012)).[3]

An important question for our research is the importance of cannabis-shops as a supply channel for cannabis users. If individuals are obtaining cannabis from other sources, then policies on cannabis-shops may not have an important effect on cannabis use or the age of onset of cannabis use. A study by Abraham et al. (1999) shows that about 40% of people aged between 12 and 17; and almost 50% of people aged 18 or above purchase cannabis in cannabis-shops. Cannabis-shops are the most commonly used supply channel. They are followed by relatives and friends, dealers, pubs and strangers. Wouters and Korf (2009) find that in municipalities without a coffeeshop less cannabis is purchased through coffeeshops. Wouters et al. (2012) analyze a sample of people between 15 and 35 years who visit nightlife venues finding that there is no relationship between the proximity to a cannabis-shop and the prevalence or intensity of cannabis use. One gram of cannabis costs around 7.5-15 Euros depending on the quality of the cannabis. Cannabis bought at cannabis-shops is mostly consumed in so called "joints" with tobacco by using 0.5-1 gram of cannabis in each joint[4].

3 Data and Stylized Facts

3.1 Data

Our data are from the Alcohol and Drugs study, one of the assembled studies of the Longitudinal Internet Studies for the Social Sciences (LISS) panel. Although the LISS panel provides longitudinal data, we use data from a single wave in November 2008 which focused on questions about alcohol and drugs. Individuals were asked whether they ever used cannabis and if they answered affirmative they were faced with the following question: *At*

[3]In 2012 a further policy change was introduced according to which tourists can legally be banned from entering cannabis-shops.

[4]Note that there are various other ways that people consume cannabis. The main means of use are waterpipe, brownies/cookies, tea, pancakes, etc.

what age, approximately, did you first use cannabis? In our analysis we distinguish between two birth cohorts depending on whether or not their behavior was potentially influenced by the presence of cannabis-shops. The youngest cohort is born between 1974 and 1992 (988 observations), the oldest cohort is born between 1955 and 1973 (1615 observations). The cannabis use of the youngest cohort might have been affected by the presence of cannabis-shops. For the oldest cohort such an effect is not very likely. Many individuals in this cohort have grown up when cannabis-shops simply did not exist.

Table 1 presents information about the composition of the two samples and of the relationship between personal and municipality characteristics and the use of cannabis and tobacco. The variables which have been used throughout the study and their descriptions are presented in Appendix 1. In terms of observable characteristics the samples do not display any striking difference. The first rows of Table 1 show that lifetime prevalence, i.e. the percentage of people who have ever used cannabis is higher among males than among females. Among the men in the youngest cohort more than 40 percent had ever used cannabis, which is around 30 percent for women. This gender difference is also present in the older birth cohort although lifetime prevalence is substantially smaller than among the younger birth cohort. Also for tobacco use lifetime prevalence is higher among males than among females, a difference of about 3.5%-points. The lifetime prevalence of smoking in the younger cohort is about 10%-point lower than in the older cohort. Lifetime use for cannabis and tobacco does not differ much between native Dutch and immigrants. The self-reported religious status of parents correlates strongly, both with cannabis use and tobacco use. Of the non-religious individuals in the younger cohort more than 40 percent ever used cannabis, while for similar individuals in the older cohort this is about 25 percent. For individuals from both cohorts lifetime prevalence for cannabis is below 20 percent. Also for smoking there are such relationships although the gradients are less steep. Panel d of Table 1 indicates that individuals living in highly urbanized municipalities are more likely to be cannabis users than individuals from rural municipalities. For smoking a similar relationship only holds in the younger cohort. For the older cohort the probability to be a lifetime tobacco user is higher

in rural municipalities than in urbanized areas. Distance to the nearest municipality with cannabis-shops is calculated as the geographical distance in kilometers between the municipality where an individual lives and the nearest municipality with at least one cannabis-shop. Furthermore, the number of cannabis-shops in each municipality is obtained from Bieleman et al. (2007), which provides detailed information about the number of cannabis-shops in each municipality in the Netherlands between years 1999 and 2007. Panel e shows that the presence of a cannabis-shop in the municipality coincides with a higher lifetime prevalence of cannabis use. Finally, the distance to a municipality with a cannabis-shop seems to matter. More than half of the individuals in our samples live in a municipality that has a cannabis-shop or has a distance to a municipality with a cannabis-shop that is less than 5 km. In the younger cohort the individuals in this distance range had a lifetime cannabis use of 40 percent while individuals living more than 20 km away from a cannabis-shop had a lifetime prevalence of 16.9 percent. As was to be expected for the older cohort, the distance effect on lifetime prevalence of cannabis use is almost absent. Also, there does not seem to be a relationship between distance to a cannabis-shop and lifetime prevalence of tobacco use.

3.2 Stylized facts

Figure 2 gives an overview of the distribution of cannabis-shops in the Netherlands. The left-hand side graph shows the distribution of the absolute number of cannabis retail outlets per municipality. Only Amsterdam and Rotterdam have more than 60 cannabis-shops. There are however also many municipalities without a cannabis-shop. Nevertheless, the distribution of cannabis-shops is spread out across the country, such that many inhabitants are not far away from a cannabis-shop. The right-hand side graph shows the distribution in terms of cannabis-shops per capita. A little less than half of the respondents in our sample live in a municipality which had at least one cannabis-shop in 2007. About 10 percent lives within 10 km of a municipality with a cannabis-shop, 25 percent lives in between 10 to 20 km from a cannabis-shop and 10 percent lives more than 20 kilometers from a cannabis-shop. Cannabis-shops are not randomly distributed across the Netherlands. In Appendix 2 we

perform an exploratory analysis on the determinants of the number of cannabis-shops in each municipality. We find that larger municipalities and municipalities near the Belgian border have more cannabis-shops.

To calculate age-dependent starting rates for cannabis use, we assume that individuals become vulnerable to the risk of initiation into cannabis use at age 12. Therefore, for anyone in the sample, time until failure is the time elapsed from age 12 until the age of first cannabis use. Any duration which is not related to a transition into cannabis use in 2008 or at the observed age is considered to be right-censored. The top graph of Figure 3 shows the evolution of the cannabis starting rate by age. The general pattern of uptake of cannabis is the same for both cohorts although the level of the uptake is very different. Individuals seem to have the highest starting rate around ages 16 and 18. There is another peak at age 20. For the youngest cohort the peak at age 16 is at 12 percent. This indicates that for those individuals that had not used cannabis up to age 16, 12 percent started using at that age. For the oldest cohort the peak at age 16 is only 5 percent. The bottom graph of Figure 3 shows the cumulative starting probabilities by age. These are based on the estimated starting rates. For both cohorts there is hardly an increase of the cumulative starting probability beyond age 21. The growth of the cumulative starting probability for cannabis use levels at at about 40 percent for the youngest cohort and about 25 percent for the oldest cohort. All in all, the age range 15 to 25 is important. If individuals have not taken up cannabis at age 25 they are very unlikely to do so later on in life. To the extent that cannabis-shops have an effect on the uptake of cannabis it will be in the crucial age range 15 to 25.

3.3 Exploratory Analysis

By way of exploratory analysis we investigate whether the distance to a cannabis-shop has an effect on the age of uptake of cannabis and tobacco. We specify the following relationship for the uptake of cannabis:

$$y(t|age > t) = x'\beta + \rho_t d_s + \varepsilon \tag{1}$$

in which $y(t|age > t)$ indicates whether or not an individual has ever used cannabis at age t conditional on being older than age t. Furthermore, x are personal and municipality characteristics, d_s is the distance to a cannabis-shop and ε is an error term. We estimate this equation for various ages between 16 and 21 using linear probability models. The relevant parameter estimates of ρ_t are reported in Table 2. We first discuss the top part of the table which presents the parameter estimates for the younger cohort. After that we will briefly discuss the bottom part that presents the parameter estimates for the older cohort. The first row of Table 2 shows that at age 16, there is a significant negative effect of distance of -0.23. This indicates that conditional on the observed characteristics, an increase in the distance to a cannabis-shop of 10 km reduces the probability of having used cannabis at age 16 by 2.3 percent. The first column shows that this estimated effect is the largest at age 20. The estimates in the first column indicate that the distance to a cannabis-shop has a significant negative effect on the uptake of cannabis. However, this could be caused by the presence of unobserved characteristics that cause individuals to live in municipalities with cannabis-shops (or live closer to ones with cannabis-shops). Nevertheless, unobserved characteristics that might make an individual more vulnerable to the risk of cannabis use at earlier ages can also make him vulnerable to smoking cigarettes. If such unobserved characteristics also lead individuals to move closer to a municipality with cannabis-shops, then we would expect the distance variable to be significant in the analysis of the age of onset of smoking. Therefore, we use the analysis on the age of onset of smoking cigarettes as counterfactual analysis.

The second column shows that the uptake of tobacco is not affected by the distance to a cannabis-shop. This suggests that it is not the case that unobserved characteristics are responsible for the negative relationship between distance to cannabis-shops and uptake of cannabis. Nevertheless, the third column shows that the significance of the distance-to-cannabis-shop effect on uptake of cannabis disappears when the urban character of municipalities is taken into account. As discussed when presenting Table 1, lifetime prevalence of cannabis use is lower in urban municipalities which are on average further away from a cannabis-shop. To investigate whether the distance effect is related to the urban character

of the municipality rather than a "true" distance effect, the fourth column of Table 2 only considers rural municipalities. Then, we again find a significant negative distance effect. The bottom part of Table 2 shows the parameter estimates for the older cohort. Here we do not expect any effect from distance to a cannabis-shop on the uptake of cannabis as for the individuals in this cohort there were no cannabis-shops when they were in the age range when they were vulnerable to the potential uptake of cannabis. Indeed, for the uptake of cannabis none of the parameter estimates is significantly different from zero. For the uptake of tobacco we find a significant positive effect. This effect might be related to the rural character of municipalities with a long – hypothetical – distance to cannabis-shops.

All in all, the exploratory analysis suggests that the distance to a cannabis-shop has a significant effect on the uptake of cannabis that goes beyond the rural character of the municipalities in which individuals who live far from cannabis-shops usually reside. The effect is significant for individuals from the youngest cohort while it is not present for individuals from the oldest cohort. For them, the distance is a fictitious measure as when they were young no cannabis-shops were present at all. Further supporting evidence comes from the uptake of tobacco which is not influenced by the distance to a cannabis-shop, as one would expect.

4 Empirical Model

When modeling the uptake of regular cannabis use, we assume that potential exposure to cannabis occurs from age 13. The starting rate for regular cannabis use at time t ($t = 0$ at age 13) conditional on observed characteristics x, the distance to the nearest cannabis-shop and unobserved characteristics u is specified as

$$\theta_c(t \mid x, d_s, u) = \lambda_c(t) \exp(x'\beta_c + \rho_c d_s + u) \tag{2}$$

where d_s represent the distance to the nearest cannabis-shop.[5] Furthermore, $\lambda_c(t)$ represents individual duration dependence and β represents a vector of parameters to be estimated. Unobserved heterogeneity u accounts for differences in individuals susceptibility to cannabis use. We model duration (age) dependence in a flexible way by using a step function $\lambda_c(t) = \exp(\Sigma_k \lambda_k I_k(t))$, where k (= 1,..,8) is a subscript for age categories and $I_k(t)$ are time-varying dummy variables that are one in subsequent categories, 7 of which are for individual ages (age 13, ..,19) and the last interval is for ages above 19 years. Because we also estimate a constant term, we normalize $\lambda_{c,1} = 0$. A description of our explanatory variables is provided in Appendix 1.

The parameter ρ is of particular interest as it indicates whether the distance to the nearest cannabis-shop has an effect on cannabis uptake. The conditional density function of the completed durations until the uptake of cannabis use can be written as

$$f_c(t \mid x, d_s, u) = \theta(t \mid x, d_s(t), u) \exp(-\int_0^t \theta(s \mid x, d_s, u) ds) \tag{3}$$

We integrate out the unobserved heterogeneity such that density function for the duration of time until cannabis uptake t conditional on x is

$$f_c(t \mid x, d_s(t)) = \int_u f(t \mid x, d_s, u) dG(u) \tag{4}$$

where $G(u)$ is assumed to be a discrete distribution with 2 points of support u_a and u_b reflecting the finding of two types of individuals in the hazard rate for cannabis uptake. The two mass points imply that conditional on observed characteristics there are two types of individuals. The associated probabilities are denoted as follows: $\Pr(u = u_a) = p$ and $\Pr(u = u_b) = 1 - p$ with $0 \leq p \leq 1$, where p is modeled using a logit specification, $p = \frac{\exp(\alpha)}{1+\exp(\alpha)}$.

[5]Note that in principle the distance to a cannabis-shop is a time-varying variable. However, whereas the number of cannabis-shops per municipality has changed a lot over time the distance to the nearest municipality with a cannabis-shop only changes if the number of cannabis-shops in that municipality drops to zero or alternatively because a municipality introduces a cannabis-shop for the first time. This is rarely the case. In our sample only a few individuals were confronted with this.

To account for the fact that we only observe age in intervals we specify the loglikelihood as follows:

$$\sum_{i=1}^{n} d_i \log\left[F(t_i - 1) - F(t_i)\right] + (1 - d_i) \log\left[1 - F(t_i)\right] \tag{5}$$

where d is a dummy indicating whether the individual started using cannabis in the interval $t-1$ to t or whether the individual in time t had still never used cannabis.

As a counterfactual analysis we also investigate in a similar way how the distance to a cannabis-shop affects starting rate of smoking using a similar specification as for cannabis:

$$\theta_s(t \mid x, d_s(t), v) = \lambda_s(t) \exp(x'\beta_s + \rho_s d_s + v) \tag{6}$$

where ρ_s measures of the distance to the nearest cannabis-shop indeed has an effect on the uptake of smoking. The related density function for complete durations until smoking is

$$f_s(t \mid x, d_s(t)) = \int_v f(t \mid x, d_s, v) dG(v) \tag{7}$$

where v are the unobserved components which may affect the starting rate of smoking and also G(v) is assumed to be a discrete distribution with 2 points of support.

5 Parameter Estimates

5.1 Baseline estimates

The first column of Table 3 shows the parameter estimates for our baseline specification of cannabis uptake for individuals from the youngest cohort. First and foremost, the distance to a cannabis-shop has a significant negative effect on the starting rate for cannabis use. This result indicates that those who live in the municipalities where there are cannabis-shops or live closer to the municipalities with cannabis-shops start using cannabis at earlier ages.

Although not the focus of our analysis, the other determinants of cannabis uptake are

interesting too. The parameter estimate for female is found to be negative. So, on average females start using cannabis at a later age. Height of the individual has a positive and significant coefficient. We assume that height of adolescents serves as a proxy for the nutrition in early childhood and therefore partly reflects the economic environment in the family. Religiosity is found to be highly significant with a negative coefficient indicating that as the parents are more religious, the starting rate for cannabis use of the children goes down and thus the age of initiation to cannabis use increases.[6] Migrant status of the individual is found to be insignificant. As noted before, the literature provides mixed results for the effect of ethnicity on cannabis use. On the one hand, non-Dutch agents might start using cannabis at earlier ages because of the systematic differences between Dutch and non-Dutch individuals that cannot be controlled in the model. On the other hand, certain groups of immigrants might be more cautious towards drug use because of some cultural and traditional factors. The degree of urbanization of the municipality does not have a significant effect on the uptake of cannabis. Finally, birth year does not seem to be an important determinant of cannabis uptake.

As Figure 3 suggested, there are peaks in the uptake of cannabis at ages 16 and 18. This is indeed what the parameter estimates in the lower part of the first column show. The mass point estimate of column 1 shows that unobserved heterogeneity is indeed significant in the data at hand. The estimate of α implies a probability of 0.90; which indicates that 90% of the youngsters have a positive starting rate of cannabis whereas 10% of them have a zero starting rate, i.e. they will never start consuming cannabis.[7]

5.2 Counterfactual analysis

To investigate the robustness of our findings we perform two types of counterfactual analysis. First, we investigate whether, also for an older cohort of individuals, the uptake of cannabis

[6]Note that we specify religiosity as a continuous variable. Specifying religiosity using a set of dummy variables does not change any of the results presented in the paper.

[7]Note that this seems at odds with Figure 3 but could be a consequence of the young age of the cohort so that it is difficult to identify unobserved heterogeneity. If we ignore unobserved heterogeneity the parameter estimates hardly change.

in the past is affected by the current presence of cannabis-shops. If we find a positive impact, we know that this is not a causal effect. The vast majority of the individuals in the older cohort were already above 20 years old when the first cannabis-shops were opened. Considering that most people mature out of drug use in their mid 20s, we can safely argue that individuals in old cohorts had already, by and large, taken their decision before they could have been affected by the presence of cannabis-shops. Therefore, using the distance variable in the analysis for the older cohort enables us to observe if there are municipality related unobserved factors affecting cannabis use. If there was a different attitude towards cannabis use in certain municipalities (such that this attitude affects both cannabis use patterns in the municipality and the opening-up of cannabis-shops), it would be reflected in the distance variable. So, a positive effect of distance to the nearest coffeeshop on the uptake of cannabis would be due to reverse causality: cannabis-shops are located in the neighborhood of individuals who are prone to start using cannabis. If we find no positive impact, this is supporting the causal effect of cannabis-shops on the uptake of cannabis for the younger cohort. Second, we investigate whether the uptake of tobacco is affected by the presence of cannabis-shops. If we find a positive impact, again we know that this is not a causal effect because cigarettes are not sold in cannabis-shops. The explanation would then be that cannabis-shops are located in areas with individuals who are prone to start using tobacco early. Since unobserved heterogeneity for cannabis uptake and for tobacco is correlated this would also imply that cannabis-shops are located in areas with individuals who are likely to start using cannabis anyway.

The parameter estimates of our counterfactual analysis on the older cohort are shown in Column 2 of Table 3. Clearly, we do not find a significant effect of distance. An unreported MPH estimation on the uptake age of cannabis for people who were born between 1945 and 1955 also confirms our counterfactual findings that municipality related unobserved factors are not driving results. Some of the other parameter estimates are different but by and large to pattern of the estimates is very much the same. The third and fourth column of Table 3 show the parameter estimates for the uptake of tobacco by the individuals in the two cohorts.

Again, there is no significant effect from the distance to cannabis-shops. In both cases of counterfactual analysis there is no significant effect of distance to cannabis-shop. Thus, it seems likely that the effect of distance to cannabis-shops on the uptake of cannabis for the younger cohort is a causal effect.

5.3 Sensitivity analysis

Table 4 shows the results of some sensitivity analysis with respect to the distant measure. Instead of using a linear distance term we investigated nonlinearities by using dummy variables for distance categories. Using 1-5 km as the reference category we introduced dummy variables for distances 6-10, 11-15, 16-20, and 20+ km. As shown in panel *a* only the 20+ category has a significant negative effect on the uptake of cannabis. Indeed, from a comparison of the likelihood values of estimates 2 and 3 we can calculate the LR-test statistic to be equal to 5.0, which is not significant (With 3 degrees of freedom the 5% critical χ^2-value is 7.82.) Panels *b* to *d* show that the 20+ dummy variable has no significant effect in the counterfactual estimates, confirming earlier results about the exogeneity of distance variable. Table 5 shows some additional sensitivity analysis, starting with an analysis based on a birth cohort 1986-92. Individuals who start using cannabis usually do so between age 12 and 25. To establish whether the age of onset is influenced by the presence of cannabis-shops or the distance to cannabis-shops we need to have information about cannabis-shops in the years in which individuals where "at risk" to start using cannabis. The limited number of 393 observations on cannabis-shops over time put a considerable restriction on the sample we can use for our analysis as we can only use information about those who were born in or after 1987 in order to have an inflow sample. The reason is that the oldest cohort, people who are at risk of failure in year 1999 – the first year about which we have information on the number of cannabis-shops – consists of those born in 1987.

The first estimate of Table 5 shows that the number of cannabis-shops in a municipality specified as a time-varying variable does not have a significant effect on the uptake of cannabis. The time-invariant number of cannabis-shops in 1999 has a significant positive

effect on the uptake of cannabis but as the third estimate shows this effect is driven by the large municipalities. Once these are removed there is no longer a significant effect. The fourth estimate shows that the presence of one of more cannabis-shops in a municipality does not affect the uptake of cannabis. Finally, the fifth estimate shows that also for this youngest sample there is a significant negative effect of distance to cannabis-shop on the uptake of cannabis.

The lower part of Table 5 shows parameter estimates for the youngest cohort of individuals using distance to cannabis-shop as a linear measure. Row 6 shows that ignoring the degree of urbanization of a municipality does not remove the distance effect. Row 7 shows that if the sample is restricted to rural municipalities there is still a significant negative distance effect on the uptake age of cannabis.[8] The last two rows of Table 5 reports the effect of the distance variable on the quit rate from cannabis use. The LISS panel includes questions on the last month use of cannabis. We assume that if the individual reports no use of cannabis in the last 30 days, that individual has stopped using cannabis. Even though we do not observe the exact time of quitting, we can still estimate the effect of distance on quitting thanks to the interval censored nature of the data. The conditional density function for the completed durations until the last use of cannabis can be written as

$$f_q(\tau \mid x, d_s, u) = \theta_q(\tau \mid x, d_s(t), u) \exp(-\int_0^\tau \theta_q(r \mid x, d_s, u) dr) \tag{8}$$

The duration of cannabis use will lie in the interval [0,t_r] where t_r is the difference between age at the time of survey and the age of the first use. This means that we can integrate out the conditional density function over this period to account for the uncertainty of quitting time and obtain the distribution function, F_q. Individuals who report using cannabis in the last month are assumed to be right censored in their quitting. Since the quitting analysis is performed on those who ever use cannabis there are no left censored individuals. As in the analysis of the uptake of cannabis, there are 2 unobserved heterogeneity groups where

[8] Although not reported in the text, we also estimated the same MPH models on this young cohort to see if the distance effect is age specific by adding interactions of age dummies with distance. However there is no evidence for such an age specific distance effect since we cannot reject the hypothesis of a constant effect.

the probabilities are modeled in logistic forms. The last two rows of Table 5 show that the distance to a cannabis-shops has a positive effect on the quit rate from cannabis use however the effect is only positive at a 10% significance level.

We also performed some additional sensitivity analysis of which the parameter estimates are not reported. First, we included information about the educational attainment as explanatory variables. The reason why we do not include any variables for education of the respondents is that the main sample at hand is young. This means the most of the respondents are still in the process of receiving their education which would possibly violate any assumption on the exogeneity of the educational level with respect to drug use. The baseline results presented in the first column of Table 3 are not affected by the inclusion of educational attainment. Second, we omitted information about religiosity as this might be an endogenous variable. This too did not affect our baseline estimates. Finally, we investigated how sensitive our parameter estimates are for the choice of the two birth cohorts with 1973/1974 as the distinguishing birth year. We find that taking 1970/71 or 1976/77 as the distinguishing birth year does not affect the main parameter estimates.[9]

Finally, to give an impression on the magnitude of the distance effect on the starting age of cannabis use we use the parameter estimates reported in row 3 of Table 4 to simulate the cumulative starting probabilities. The results in Table 6 report the estimated cumulative starting probabilities for a reference person (a Dutch male who has an average height, non religious parents, living in a moderately urban municipality and born in 1980). The numbers in the table indicate a substantial effect of distance to a cannabis-shop. About 30 percent of the individuals who live within 20 km of a cannabis-shop have started using cannabis at age of 20. If they live 20 kilometers away or more from a cannabis-shop this is 17 percent.

6 Conclusions

In some countries cannabis use is illegal and cannabis can only be bought through an illegal supplier. In other countries cannabis is more easily available. In the Netherlands cannabis

[9]Note that both of these birth year choices preserve the counterfactual nature of the older cohort.

use is quasi-legalized. Small quantities of cannabis can be bought at retail outlets which are called coffeeshops although everyone is actually aware that these are cannabis-shops. The quasi-legal status makes it easy for consumers to buy cannabis. If it is easy to buy cannabis youngsters may be tempted to start using cannabis earlier on in their life. Early onset of cannabis may have negative effects on individuals in various dimensions such as education and mental health.

Our main research question is whether the distance to a cannabis-shop has negative spillover effects on inhabitants in terms of an increase in the take-up rate of cannabis. The main challenge is to distinguish between the treatment effect of the presence of cannabis-shops and the correlated effect of cannabis-shops being present in an environment where people are more likely to start using cannabis. We use data from a 2008 survey with retrospective question on the age of onset of cannabis use. This allows us to exploit a hazard rate framework to model the starting rate of cannabis use. This way we can take account of observable characteristics as well as unobservable characteristics that influence the uptake of cannabis. We find that for a cohort of individuals born between 1974 and 1992, distance has a positive effect on the starting rate of cannabis use. To motivate that this is indeed a causal effect we perform two types of counterfactual analysis. In the first counterfactual analysis we investigate whether an older birth cohort, born between 1995 and 1973, the distance to a cannabis-shop has a positive effect too. This older birth cohort could not have been affected by the presence of cannabis-shops because when they grew up and started using cannabis there were no cannabis-shops at all. If we would have found a distance effect for this birth cohort, then we would know that this could not be a causal effect and such a finding would cast doubt on the effects we find for the younger cohort. However, for the older birth cohort, we find no significant effect of the distance to a cannabis-shop on the uptake of cannabis. In the second counterfactual analysis we relate the uptake of tobacco to the distance to a cannabis-shop. Again, there cannot be a causal effect and if we would have found a positive distance effect, then this would suggest that cannabis-shops are located in areas where individuals are more likely to start smoking and use cannabis. Again, we find no significant

distance effects.

All in all, after an extensive sensitivity analysis we conclude that youngsters who live more than 20 kilometers from a municipality with a cannabis-shop have a lower starting rate of cannabis use. Youngsters living closer to cannabis-shops are more likely to start using cannabis earlier on. This does not necessarily imply that living closer to a cannabis-shop has a negative effect on overall welfare. The overall welfare effect also depends on how the closeness of cannabis-shops affects the intensity of use, total cannabis consumption and the uptake of other drugs.

References

Abraham, M. D., P. D. A. Cohen, R. J. van Til, and M. A. L. de Winter (1999). *Licit and illicit drug use in the Netherlands.* Amsterdam: CEDRO.

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

Bieleman, B., A. Beelen, R. Nijkamp, and E. de Bie (2007). *Coffeeshops in Nederland. Aantallen en gemeentelijk beleid in 2007 ("Coffeeshops in the Netherlands. Numbers and local policy in 2007").* Groningen: Intraval.

Bieleman, B., R. Nijkamp, and T. de Bak (2012). *Coffeeshops in Nederland. Aantallen en gemeentelijk beleid 1999-2011 ("Coffeeshops in the Netherlands. Numbers and local policy 1999-2011").* Groningen: Intraval.

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.

De Graaf, R., M. Radovanovic, M. Van Laar, B. Fairman, and L. Degenhardt. (2010). Early cannabis use and estimated risk of later onset of depression spells: epidemiologic evidence from the population-based world health organization world mental health survey initiative. *American Journal of Epidemiology 172.*

Grapendaal, M., E. Leuw, and H. Nelen (1995). *A World of Opportunities. Life-Style and Economic Behavior of Heroin Addicts in Amsterdam.* New York: State University of New York Press.

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.

Jansen, A. (1991). *Cannabis in Amsterdam. A geography of hashish and marihuana.* Muiderberg: Countinho.

Korf, D. (2002). Dutch coffeeshops and trends in cannabis use. *Addictive Behaviors 27*, 851–866.

Reuband, K. H. (1995). Drug use and drug policy in Western Europe. Epidemiological findings in a comparative perspective. *European Addiction Research 1*, 32–41.

Van Ours, J. C. (2006). Cannabis, cocaine and jobs. *Journal of Applied Econometrics 21*, 897–917.

Van Ours, J. C. (2007). Cannabis use when it's legal. *Addictive Behaviors 32*, 1441–1450.

Van Ours, J. C. and J. Williams (2007). Cannabis prices and dynamics of cannabis use. *Journal of Health Economics 26*, 578–596.

Van Ours, J. C., J. Williams, D. Fergusson, and L. Horwood (2013). Cannabis use and suicidal ideation. *Journal of Health Economics 32*, 524–537.

Van Solinge, T. (1999). Dutch drug policy in a European context. *Journal of Drug Issues 29(3)*, 511–528.

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.

Wouters, M., A. Benschop, M. van Laar, and D. J. Korf (2012). Cannabis use and proximity to coffeeshops in the Netherlands. *European Journal of Criminology 9*, 337–353.

Wouters, M. and D. J. Korf (2009). Access to licensed cannabis supply and the separation of mmarket policy in the Netherlands. *Jurnal of Drug Issues 39*, 627–651.

Yamaguchi, K. and D. B. Kandel (1984). Patterns of drug use from adolescence to young adulthood: III. predictors of progression. *American Journal of Public Health 74*, 673–681.

Appendix 1: Details on the LISS data

Table 7 provides a description of the variables we use in the analysis and provides descriptive statistics for young and old cohorts separately. As expected time dependent variables such as income, conditional/unconditional duration and age differ between the old sample and the sample of youngsters. However, time invariant variables such as female, average height, migrant status and living in a municipality which has at least one cannabis-shop are similar across the two samples. Around 53% of the individuals live in municipalities with at least 1 cannabis-shops and average duration until cannabis uptake is about 4 years for youngsters, indicating an average age of onset of those that start using cannabis of around 16.

A comparison of individuals living in municipalities within 20 km distance from a cannabis-shop and those living further away than 20 km is presented in Table 8. The figures are obtained for everyone born between 1945 and 1992 with whom we run MPH estimations throughout the paper. There are 3885 observations with a distance smaller than 20 km and 375 observations with a distance smaller than 20km. Restricting sample to those born between 1955 and 1992 yields very similar results with 2369 observations with a distance smaller than 20km and 234 observations with a distance larger than 20km. It is clear that in terms of observed characteristics both samples are very much alike.

Finally, Table 9 shows that the distribution of individuals over the various distance to a cannabis-shop intervals is almost the same for the young cohort and the old cohort.

Appendix 2: Determinants of the number of coffeeshops

In our analysis we assume that the distance to the nearest cannabis-shop and the number of cannabis-shops are exogenous to the uptake of cannabis, i.e. there are no unobserved variables that affect both the distance to a cannabis-shop and the age of onset. One of the concerns we have to address is whether openings or closures of cannabis-shops are driven by demand for cannabis. Historical evidence suggests that the decreasing number of cannabis-shops is a result of stricter policies imposed by local policy makers rather than changes in the demand for cannabis. If the number of cannabis-shops was actually driven by the trends in use then we would see comparable patterns in the history of use and the number of cannabis-shops. However, the trends in the consumption of cannabis in the Netherlands are very similar to those in other European countries where there are no cannabis-shops at all (Korf (2002)). Furthermore, whereas prevalence of cannabis use has increased over time, the number of cannabis-shops in the Netherlands dropped sharply after the early 1990s. This is not surprising because since then Dutch drug policy aimed at curbing the number of cannabis-shops in the country (Korf (2002)). The general trend in the number of cannabis-shops is driven by the actions of local policy makers rather than by the demand for cannabis (Reuband (1995)). All in all, there is no reason to argue that differences in the policies followed by the local governments are the results of different prevalence rates in the municipalities. In fact, in most of the municipalities prevalence rates are quite similar except for Amsterdam which has higher rates. An interesting decrease in the number of

cannabis-shops from 59 to 5 occurred in Venlo, a town close to German border, between 1991 and 1995. There is no immediate reason to think that such a decrease might be result of changes in the demand for cannabis from the local population because prevalence rates in Venlo were not very different from the average prevalence rates. In fact, the stricter policy was implemented to reduce cannabis 'tourism' from Germany.

Cannabis-shops are not randomly distributed across the Netherlands. By way of descriptive analysis we relate the number of cannabis-shops in each municipality to population size, average gross income per capita, the share of immigrants in the population and whether the municipality is on Belgian or German border.[10] We also add time effects, province fixed effects and the interactions between time and province fixed effects. Because many municipalities have no cannabis-shops, we use a random effect Tobit model and a pooled panel data model that is also estimated with robust standard errors clustered on each municipality. Table 10 presents the parameter estimates. As shown the size of the municipality – measured as the population in the municipality – is highly significant. As expected municipalities on the Belgian border have systematically higher number of cannabis-shops whereas the ones on the German border are not different than the rest. A higher percentage of immigrants indicates a larger number of cannabis-shops and income per capita in the municipality is inversely related to the number. Both of these effects are due to the fact that in the large cities in the Netherlands the share of immigrants in the population is high while income per capita is low. Time effects, fixed effects and the interaction terms mostly are insignificant. So, the number of cannabis-shops in a municipality is determined by the characteristics of that municipality.

In a further exploratory analysis we investigated whether cannabis use prior to 1976 when the new Opium Law induced the creation of cannabis-shops affected presence of a cannabis-shop later on. Using our LISS data on individuals born before 1964 (who turned 12 in 1976) we estimated a linear probability model. In these estimates the dependent variable is the presence of a cannabis-shop in the municipality while the explanatory variables are whether the individual used cannabis prior to 1976 and the degree of urbanization of the municipality. We find an insignificant effect of cannabis consumption on the presence of a cannabis-shop, again confirming that cannabis-shops were not located in municipalities that had a population that was prone to cannabis use.

[10]The data on the number of cannabis-shops are from Bieleman et al. (2012). The data on the characteristics of the municipalities are from Statistics Netherlands.

Table 1: Means of variables, lifetime cannabis use and lifetime tobacco use; two birth-cohorts

Variable category	Cohort 1974-92			Cohort 1955-73		
	Means of variables	Cannabis use	Tobacco use	Means of variables	Cannabis use	Tobacco use
a. Gender						
Female	59.0	32.1	52.0	55.5	16.6	62.6
Male	41.0	41.2	55.3	44.5	31.9	66.2
b. Migrant status						
Dutch	86.0	36.2	53.5	86.4	23.7	64.2
Immigrant	14.0	33.3	52.2	13.6	21.4	64.6
c. Religiosity						
Never	47.5	41.6	57.1	38.9	24.2	64.5
Less often	10.6	42.9	58.1	5.9	26.3	67.4
Only on special days	17.0	35.1	51.8	11.5	25.3	64.5
Around once a month	7.9	33.3	52.6	7.6	26.8	59.4
Once a week	9.5	22.3	44.7	28.8	21.3	65.4
More than once a week	6.8	10.5	40.3	6.7	19.4	59.3
Every day	0.7	14.3	14.3	0.6	10.0	70.0
d. Urban character municipality						
Extremely	14.6	48.6	63.2	12.1	32.8	63.1
Very	27.9	37.0	52.5	24.0	24.6	62.5
Moderate	21.4	36.5	51.7	24.0	21.1	60.6
Slightly	21.2	30.6	48.8	22.4	24.4	67.6
Not	15.0	27.7	54.0	17.6	17.3	68.0
e. Coffeeshop in municipality (1999)						
No	48.7	31.2	52.2	50.2	20.7	66.7
Yes	51.3	40.2	54.4	49.8	26.1	61.7
f. Distance to cannabis-shop						
1-5 km	56.9	40.2	53.7	55.1	25.5	62.6
6-10 km	10.9	40.7	57.4	12.0	21.2	64.8
11-15 km	13.9	29.9	51.1	15.8	21.6	64.7
16-20 km	9.3	30.4	56.5	8.2	17.4	70.4
20+ km	9.0	16.9	46.1	9.0	22.1	66.9
Total	100.0	35.8	53.3	100.0	23.4	64.2

Cohort 1974-92: 988 observations, cohort 1955-73: 1615 observations

Table 2: Estimates linear probability models of the effect of distance to a cannabis-shop (km/100) on the starting probability of cannabis use and tobacco use conditional on age

	All municipalities				Rural municipalities	
	Cannabis	Tobacco	Cannabis	Observ.	Cannabis	Observ.
Age	(1)	(2)	(3)		(4)	
1. Cohort 1974-92						
16	-0.23 (2.1)**	0.30 (1.7)*	-0.22 (1.3)	988	-0.49 (2.7)**	329
17	-0.16 (1.1)	0.11 (0.6)	0.01 (0.0)	922	-0.55 (2.3)**	301
18	-0.23 (1.3)	0.14 (0.7)	-0.14 (0.6)	856	-0.90 (3.2)**	266
19	-0.52 (2.7)**	0.14 (0.7)	-0.41 (1.5)	782	-1.03 (3.4)**	214
20	-0.61 (3.0)**	0.07 (0.3)	-0.32 (1.1)	726	-0.97 (3.0)**	214
21	-0.54 (2.4)**	0.04 (0.2)	-0.10 (0.3)	680	-0.84 (2.3)**	193
2. Cohort 1955-73						
16	-0.02 (0.2)	0.30 (2.1)**	0.04 (0.5)	1615	0.05 (0.6)	645
17	-0.04 (0.6)	0.36 (2.5)**	-0.02 (0.2)	1615	-0.08 (0.7)	645
18	-0.04 (0.5)	0.45 (3.1)**	-0.05 (0.4)	1615	-0.14 (1.0)	645
19	-0.12 (1.2)	0.40 (2.8)**	-0.11 (0.8)	1615	-0.16 (1.0)	645
20	-0.14 (1.3)	0.40 (2.8)**	-0.13 (0.9)	1615	-0.16 (0.9)	645
21	-0.12 (1.1)	0.40 (2.8)**	-0.05 (0.3)	1615	-0.06 (0.4)	645

All estimates have female, height, religious, migrant status and birth year as explanatory variables. Estimate (3) also includes 4 dummy variables representing the degree of urbanization. Absolute t-statistics based on robust standard errors in parentheses.

Table 3: Parameter estimates of the effects of distance to cannabis-shops (km/10) on the starting rates for cannabis and smoking; two cohorts

	Cannabis		Tobacco	
	Cohort 1974-92	Cohort 1955-73	Cohort 1974-92	Cohort 1955-73
Distance	-0.28 (2.9)**	0.01 (0.1)	0.09 (1.1)	0.07 (1.2)
Female	-0.33 (2.7)**	-0.93 (6.4)**	0.18 (1.6)	0.04 (0.7)
Height	0.02 (2.1)**	0.02 (1.5)	0.01 (1.2)	0.00 (0.8)
Religious	-0.22 (4.6)**	-0.06 (1.7)*	-0.11 (3.0)**	-0.04 (2.3)**
Immigrant	-0.06 (0.3)	-0.24 (1.2)	-0.05 (0.3)	-0.08 (0.8)
Extremely urban	0.28 (1.1)	0.71 (2.5)**	-0.16 (0.8)	-0.26 (1.9)*
Very urban	-0.10 (0.5)	0.58 (2.2)**	-0.10 (0.5)	0.02 (0.2)
Moderate urban	0.04 (0.2)	0.25 (0.9)	0.05 (0.2)	0.08 (0.7)
Slightly urban	0.05 (0.3)	0.61 (2.7)**	-0.09 (0.5)	0.04 (0.4)
Birth year	0.20 (0.2)	4.24 (3.5)**	-0.66 (0.7)	-0.37 (0.6)
Age (duration) dependence				
14	0.86 (2.6)**	0.56 (1.2)	1.68 (4.6)**	1.40 (6.3)**
15	1.59 (5.3)**	1.62 (3.8)**	1.98 (5.4)**	1.51 (6.8)**
16	2.16 (7.0)**	2.51 (6.2)**	2.79 (7.9)**	2.35 (11.1)**
17	1.71 (5.0)**	2.00 (4.7)**	3.27 (9.3)**	2.73 (13.0)**
18	1.91 (5.0)**	2.71 (6.5)**	3.57 (10.1)**	3.10 (14.6)**
19	0.81 (1.8)*	1.90 (4.3)**	3.02 (7.8)**	2.40 (10.1)**
20	1.00 (2.2)**	2.38 (5.5) **	4.02 (10.5)**	3.27 (14.5)**
20+	-0.66 (1.4)	0.71 1.6)	3.31 (7.9)**	2.97 (12.7)**
Second masspoint	$-\infty$	$-\infty$	$-\infty$	$-\infty$
α	2.15 (0.7)	-0.31 (1.7)**	0.39 (5.0)**	0.58 (11.3)**
-Loglikelihood	1319.8	2008.1	1728.7	3363.8

Note: The α's imply the following probabilities: 90, 42, 60, 64%. Absolute t-statistics in parentheses. The number of observations are 988 for the young cohort and 1615 for the old cohort.

Table 4: MPH estimates of the effect of distance to a cannabis-shop on the starting rate of cannabis use; various distance measures

	Parameter estimate	-Loglikelihood
a. Cannabis Cohort 1974-92		
1. Distance (km/10)	-0.28 (2.9)**	1319.8
2. Distance 6-10 km	0.25 (1.2)	1316.5
11-15 km	-0.27 (1.3)	
16-20 km	-0.14 (0.5)	
20+ km	-0.87 (3.0)**	
3. Distance 20+ km	-0.81 (3.0)**	1319.0
b. Cannabis Cohort 1955-73		
4. Distance (km/10)	0.01 (0.1)	2008.1
5. Distance 20+ km	0.11 (0.4)	2008.0
c. Tobacco Cohort 1974-92		
6. Distance (km/10)	0.09 (0.1)	1728.7
7. Distance 20+ km	0.32 (1.5)	1728.2
d. Tobacco Cohort 1955-73		
8. Distance (km/10)	0.07 (1.2)	3363.8
9. Distance 20+ km	0.05 (0.4)	3364.6

Note that estimates 1, 4, 6 and 8 are reported – in full detail in Table 3. Cohort 1974-92: 988 observations, cohort 1955-73: 1615 observations; absolute t-statistics in parentheses.

Table 5: Sensitivity analysis MPH estimates of the effect of distance to a cannabis-shop on the starting rate and quit rate of cannabis use

Birth cohort 1986-92	Estimate	-Loglikelihood
Starting rate		
1. Number of cannabis-shops	0.001 (0.4)	451.6
2. Cannabis shops 1999	0.004 (2.0)*	450.1
3. Cannabis shops 1999 – no big cities	-0.001 (0.0)	419.0
4. Presence of cannabis-shops	0.03 (0.1)	451.6
5. Distance (km/10)	-0.55 (3.4)**	444.1
Birth cohort 1974-92; distance (km/10)		
6. Starting rate – no urbanization dummies	-0.24 (3.0)**	1320.2
7. Starting rate – only rural municipalities	-0.69 (3.9)**	388.6
8. Quit rate	0.19 (1.5)	155.6
9. Quit rate – no urbanization dummies	0.20 (1.7)*	158.9

Cohort 1986-92: 393 observations, line 3 excludes big cities: 366 observations, line 6 with only rural municipalities: 355 observations. For the quit rates 351 observations are available.

Table 6: Simulated cumulative starting probabilities for different age and distance to a cannabis-shop

Age	<20 km	≥20 km
12	0	0
15	0.09	0.04
18	0.27	0.15
20	0.30	0.17

Note that the reference person is a Dutch male who has an average height, non religious parents, living in a moderately urban municipality and born in 1980. The simulations are based on the estimates of which the distance effect is reported in row (3) of Table 4.

Table 7: Descriptions and descriptive statistics of variables; two samples

		1974-1992				1955-1973			
Variable	**Description**	**Obs**	**Mean**	**min**	**max**	**Obs**	**Mean**	**min**	**max**
Female	1 if the responder is female	988	0.59	0	1	1615	0.55	0	1
Age	Calender age of the responder	988	24.98	16	34	1615	44.00	34	53
Immigrant	1 if the responder has a non-Dutch background (0 for the first and second generation immigrants)	988	0.14	0	1	1615	0.14	0	1
Religious	Degree of religiosity of the parents of responder at age of 15 (measured in a scale of 0-6 as the frequency of visiting church)	988	1.45	0	6	1615	2.04	0	6
Duration	Time elapsed from age 12 until the first use of cannabis (measured in years)(all sample)	988	10.38	1	23	1615	26.92	1	42
Duration	Time elapsed from age 12 until the first use of cannabis (measured in years)(if ever used)	354	4.62	1	16	405	8.02	1	30
Tall-f	Height for males	583	169.95	150	190	896	168.76	149	187
Tall-m	Height for females	405	184.09	150	204	719	182.33	150	203
Dshop	1 if there is at least one cannabis-shop in the municipality	988	0.54	0	1	1615	0.53	0	1
Distance	Distance in km to closest municipality with cannabis-shops (normalized to 1 if there is a cannabis-shop in the municipality)	988	7.25	1	44.5	1615	7.30	1	44.5
Sted	Urban character of the municipality (measured in a scale of 1-5 based on the number of people living in the municipality)	988	2.94	1	5	1615	3.09	1	5

Note that Height is the deviation from mean height for males and females separately. Since descriptives of this variable is not very informative, height of females and males are reported in the table instead.

Table 8: Comparison of individuals based on distance variable

	Distance≤20		Distance>20	
	Mean	St.Dev.	Mean	St.Dev.
Immigrant	0.13	0.34	0.12	0.32
Female	1.54	0.50	1.56	0.50
Education	3.42	1.52	3.22	1.42
Height (m)	1.74	0.10	1.74	0.10
Age (/10)	4.70	1.57	4.65	1.62
Smoke	0.66	0.47	0.64	0.48
Religious	2.19	1.93	2.29	1.92
Observations	3885		375	

Smoke is a dummy variable indicating if the individual ever smoked cigarettes before.
For all of the variables above, we fail to reject the null hypothesis that means are equal.

Table 9: Distribution of distance to a municipality with at least one cannabis-shop in 2007; two samples (percentages)

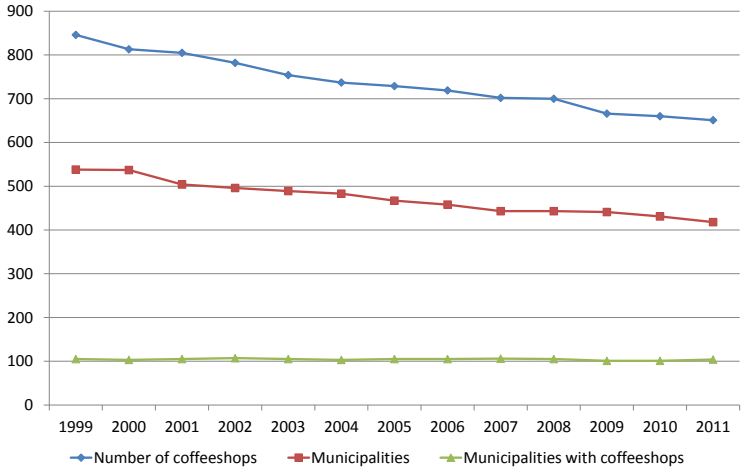
	Sample 1974-92	Sample 1955-73
No coffeeshop in municipality		
Distance to coffeeshop		
≤ 5 km	1	1
6-10 km	11	12
11-20 km	23	24
> 20 km	9	9
Total no coffeeshop	44	46
At least one coffeeshop	56	54
Total	100	100

Table 10: Parameter estimates of tobit models for the number of cannabis-shops in each municipality

Characteristic Municipality	Panel Tobit (1)	Pooled Tobit (2)
Population size (1000)	0.008 (25.56)***	0.005 (2.61)***
Income (1000 Euro)	-0.067 (-4.46)***	-0.097 (-3.12)***
Immigrants (%)	0.097 (17.65)***	0.139 (6.35)***
Near Belgian border	0.447 (3.18)***	0.740 (2.82)***
Near German border	-0.058 (-0.53)	0.058 (0.31)

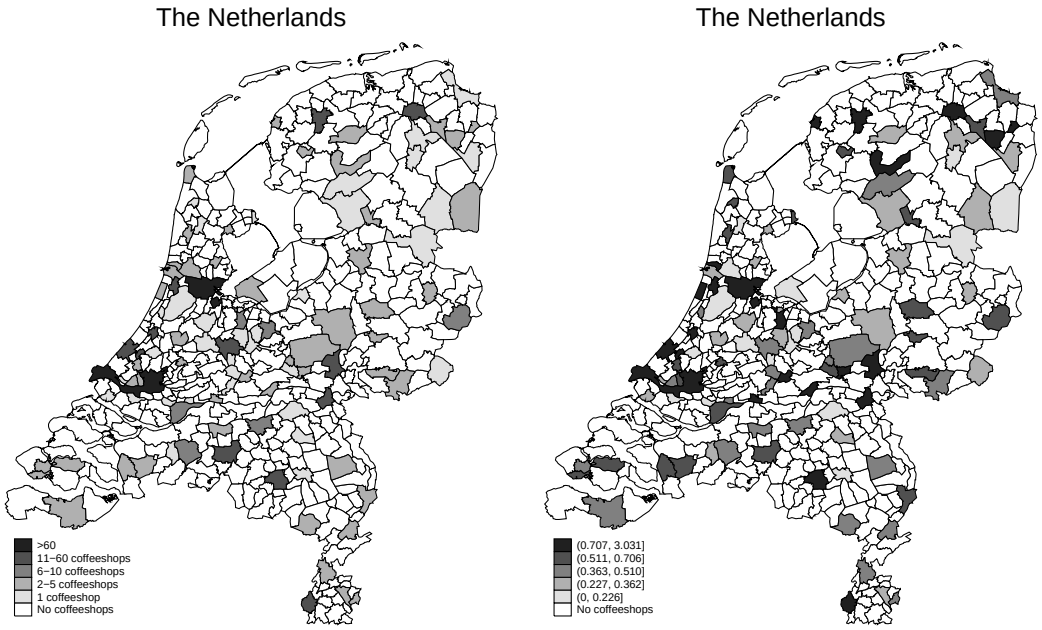
Note that both estimates are based on 3537 observations (9 years, 393 municipalities); both estimates contain fixed effects for provinces, calendar years and the interaction between provinces and calendar years.
t-statistics are in parenthesis

Figure 1: Number of cannabis-shops, municipalities and municipalities with cannabis-shops in the Netherlands



Source: Bieleman et al. (2012)

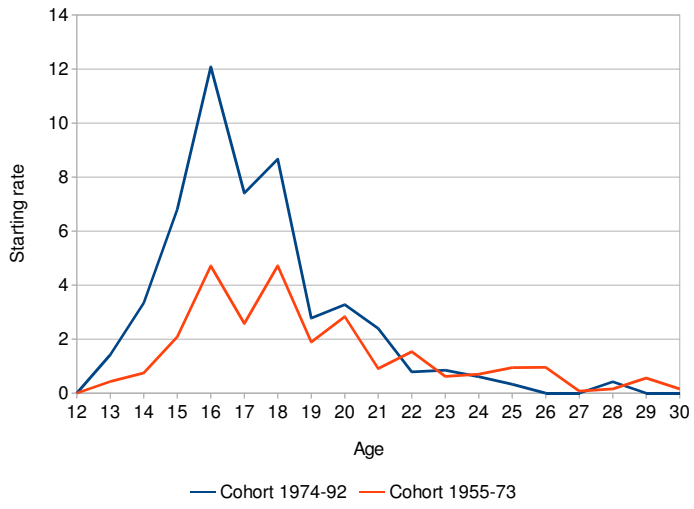
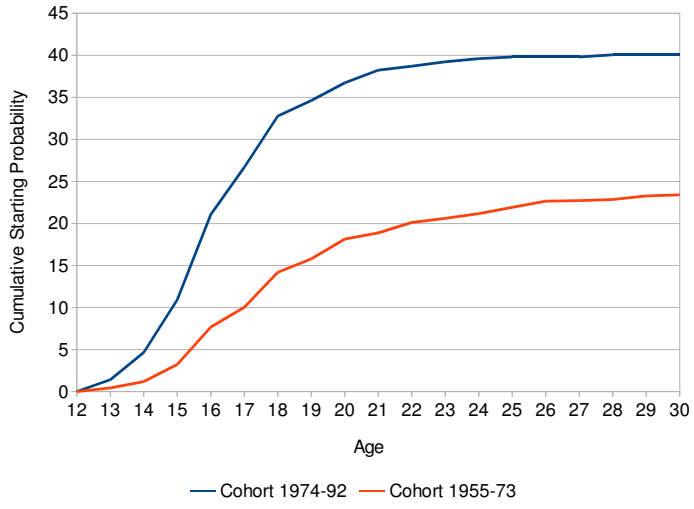
Figure 2: Cannabis-shops by municipality; absolute number (left) and per capita (right); 2007



The categories of per capita cannabis-shop map on the right are based on the quantiles of the per capita cannabis-shops in 2007.

Figure 3: Starting rates and cumulative starting probabilities cannabis use; two birth-cohorts

a. Starting rates



b. Cumulative starting probabilities