Marijuana on Main Street: What if?

Liana Jacobi and Michelle Sovinsky[1]

Preliminary and Incomplete

April 3, 2012

Abstract

Abstract: Illicit drug use is prevalent around the world. While the nature of the market makes it difficult to determine the total sales worldwide with certainty, estimates suggest sales are around $150 billion a year in the United States alone. Among illicit drugs marijuana is the most commonly used, where the US government spends upwards of $7.7 billion per year in enforcement of the laws for marijuana sales (Miron, 2005). For the past 30 years there has been a debate regarding whether marijuana should be legalized. There are two important avenues through which legalization could impact use: legalization would make marijuana easier to get, and it would remove the stigma (and cost) associated with illegal behavior. Studies to date have not disentangled the impact of limited accessibility from consumption decisions based solely on preferences. However, this distinction is particularly important in the market for cannabis as legalizing the drug would impact accessibility. Hence, if most individuals do not use because they don't know where to buy it, but would otherwise use, we would see a large increase in consumption ceteris paribus, which would be important to consider for policy. On the other hand, if accessibility plays little role in consumption decisions, then making drugs more readily available would impact the supply more. In order to access the impact of legalization on use, it is necessary to explicitly consider the role played by accessibility in use, the impact of illegal actions in utility, as well as the impact on the supply side. In this paper, we develop and estimate a model of buyer behavior that explicitly considers the impact of illegal behavior on utility as well as the impact of limited accessibility (either knowing where to buy or being offered) an illicit drug on using the drug. We use the demand side estimates to conduct counterfactuals on how use would change under a policy of legalization. We conduct counterfactuals under different assumptions regarding how legalization would impact the supply as well as various tax policies on the price of cannabis.

---

[1] Liana Jacobi is at the University of Melbourne; Michelle Sovinsky is at the University of Zurich and CEPR. We are grateful to Peter Arcidiacono, Eve Caroli, Sofronis Clerides, Carlos Noton, Alison Ritter, and seminar participants at Duke, University of Cyprus, University of Dauphine (Paris), University of Virginia, Warwick, and the Cannabis Policy Conference (Melbourne) and the IIOC meetings for helpful comments and suggestions.

1 Introduction

Illicit drug use is prevalent around the world. While the nature of the market makes it difficult to determine the total sales worldwide with certainty estimates suggest sales are around \$150 billion a year in the United States alone. Among illicit drugs marijuana is the most common, where the US government spends upwards of \$7.7 billion per year in enforcement of the laws for marijuana sales (Miron, 2005). For the past 30 years there has been a debate regarding whether marijuana should be legalized. More recently California residents were asked to decide if growing marijuana should be legal for personal use.[2] Those in favor of legalization cite the high expenditures on enforcement and the harsh consequences a criminal record can have for young users who are otherwise law-abiding citizens. Furthermore, as in the case of California, state governments could benefit from legalization by taxing the sales. Those opposed are concerned that legalization could result in lower prices, hence generating higher use. This is of particular concern if marijuana usage serves as a "gateway" to subsequent consumption of other harder drugs.[3]

Previous literature has examined the impact of decriminalization on cannabis use.[4] However, decriminalization and legalization differ in significant ways. The first important way concerns limited accessibility. Given that illicit drugs are not as easy to find as legal products, one can argue that non-users have very little information about how to get cannabis, which is the first step to being becoming a user. Under decriminalization it is still necessary to seek out suppliers in order to purchase the drug. If cannabis were legalized purchasing it would be as difficult as purchasing cigarettes or alcohol.

Second, while decriminalization removes criminal penalties, using the drug is still illegal. In fact, a significant fraction of non-users report not using cannabis because it is illegal. Legalization would obviously remove this hindrance, which may result in use among some current non-users.

The third way in which decriminalization and legalization differ concerns the impact on dealers. Decriminalization makes it less costly for potential users in that they face a fine

[2] The use of cannabis is already decriminalized in California where possession is an infraction, the lowest level of offence under state law. Adults caught with an ounce of marijuana will get a \$100 ticket but no criminal record.

[3] See, for example, Van Ours (2003), Bretteville-Jensen and Jacobi (2011).

[4] See, for example, Adda et al (2011), Damrongplasit and Hsaio (2008), Damrongplasit et al (2010).

for using the drug instead of the harsher cost of a criminal punishment. In contrast, selling the drug is still illegal and hence dealers, should they be arrested, incur the same penalties regardless of the decriminalization status of the state. In other words, decriminalization does not impact the marginal costs (broadly defined to include the risk of criminal prosecution) faced by dealers, while legalization eliminates the risk of arrest leading to lower marginal cost of production.

In order to access the impact of legalization on use, it is necessary to explicitly consider the role played by accessibility in use, the impact of illegal actions in utility, as well as the impact on the supply side. In this paper, we develop and estimate a model of buyer behavior that includes the impact of illegal behavior on utility as well as the impact of limited accessibility (either knowing where to buy or being offered an illicit drug) on using cannabis. We obtain estimates for price elasticities of demand (for an illicit good) taking into account selection into access. We find that selection into who has access to cannabis is not random, and the results suggest estimates of the demand curve will be biased unless selection is explicitly considered.

We use the demand side estimates to conduct counterfactuals on how use would change under a policy of legalization. We apply the model to data collected in the Australian National Drug Strategy Household Survey. These data contain information on access and use, and so are particularly suited to examine the role of accessibility in cannabis use. In addition, we conduct counterfactuals under various assumptions regarding how legalization would impact the supply as well as various tax policies on the price of cannabis. We also look at differences across age groups and conduct counterfactuals of how much price would need to increase to return the probably of use to what it was before legalization.

Our paper is related to the theoretical literature on illicit markets and addictive goods, including Grossman and Chaloupka (1998), Becker and Murphy (1988), and Stigler and Becker (1977). There is a broad but small literature on the benefits/costs of decriminalization in illicit drugs markets. These include Glaeser and Shleifer (2001), Becker et al (2006), and Pudney (2010). *More to come.*

The paper is structured as follows. Section 2 gives an overview of cannabis and the legal policies in Australia. In Section 3 we discuss the data. Sections 4 and 5 present the model and the estimation technique. Section 6 outlines our parameter estimates and counterfactual results.

2 Background

Cannabis comes in a variety of forms and potency levels. The herbal form consists of the dried flowering tops, leaves and stalks of the plant. The resinous form consists of the resin secreted from the plant and resin oil In this paper we focus on the most commonly used forms of cannabis: the leaf of the plant, the flowering tops (or head) of the plant, and a high potency form selectively bred from certain species (sinsemilla, called skunk). The leaf, head, and skunk are collectively known as marijuana.[5]

The major psychoactive chemical compound in marijuana is delta-9-tetrahydrocannabinol (or THC). The amount of THC absorbed by marijuana use differs according to the part of the plant that is used, the way the plant is cultivated, and the method used to imbibe cannabis. On average marijuana contains about 5% THC, where the flowering tops contain the highest concentration followed by the leaves (Adams and Martin, 1996). Cannabis that is grown hydroponically (hydro), indoors under artificial light with nutrient baths, is thought by some to have higher concentrations of THC than naturally grown cannabis (Poulsen and Sutherland, 2000). Given that the forms of marijuana vary in THC content and users may select the forms based on THC content we include a variable to capture the level of THC in the model.

In Australia the use of cannabis for any purpose is illegal, however, all states/territories have introduced legislation to allow police to deal differently with minor offenses. Table 1 presents an overview of the policies across states. Four jurisdictions (South Australia (SA), Northern Territory (NT), Australia Capital Territory (ACT), and Western Australia (WA)) have decriminalized the possession of small quantities of cannabis via the introduction of infringement schemes. Under an infringement scheme individuals which are found to have violated the law with a minor cannabis offence are fined but are not jailed. What constitutes a minor offense and the fine varies by state. These include possession of small amount of cannabis plant material (i.e., bulbs, leaves)(SA and NT), growing of one plant (SA) or two plants. The quantity considered a minor offence varies by cannabis type (plant versus resin), ranging from 100 grams of plant material in SA to 25 grams in ACT. Infringement schemes were introduced at different times across the states: SA was the first to implement them in 1987, followed by NT in 1992 and ACT in 1996. In 2004 WA moved to this

[5] We do not consider hashish use (the resin or resin oil of the plant), as these forms are much harder to obtain and have a much higher level of the psychoactive component.

system. In other states and territories (Tasmania (TAS), Victoria (VIC), New South Wales (NSW), and Queensland (QLD)) possession of any amount of cannabis is a criminal offence, and individuals may be jailed for possession of any quantity. However, these jurisdictions have introduced "diversion schemes" where the police may issue a caution of diversion into treatment or education for a minor offence instead of jail time. The number of cautions issued before a criminal conviction varies by jurisdictions. The diversion schemes were introduced at different times: in 1998 in TAS and VIC; in 2000 in NSW, and 2001 in QLD. The state of WA gradually introduced the schemes between 2000 to 2003.[6] We construct two measures of the degree of decriminalization. These include whether the state uses an infringement scheme and the maximum number of grams for which possession is a minor offense. Table 1 summarizes the policies across states.

State	Decrimilized?	Year Diversion Scheme Introduced	Maximum grams still a minor offence
New South Wales	No	2000	15
Victoria	No	1998	50
Queensland	No	2001	50
Western Australia	2004	2000	30
South Australia	1987	Decrimilized	100
Tasmania	No	1998	50
ACT	1996	Decrimilized	25
Northern Territory	1992	Decrimilized	50

Table 1: Cannabis Legislation by State

3 Data

3.1 Individual-Level Data

We use data from two sources. The first is an individual-level cross-section survey called the Australian National Drug Strategy Household Survey (NDSHS). The NDSHS was designed to determine the extent of drug use among the non-institutionalized civilian Australian population aged 14 and older.[7] About 20,000 individuals are surveyed every 2 or 3 years

[6] Minor cannabis offences only refer to the possession of cannabis, not the possession of a plant. Trafficking and possessions of larger amounts of cannabis are serious offences that incur large monetary fines and long prison sentences.

[7] Respondents were requested to indicate their level of drug use and the responses were sealed so the interviewer did not know their answers.

from all Australian states/territories. We use data from three waves: 2001, 2004, and 2007. These contain demographic information, information on cannabis use, as well as accessibility measures.

As Table 2 shows over 40% of individuals report that they have ever used cannabis. The average age of onset is 19 across all years. An individual is observed to use cannabis if they answer yes to the question “Have you used cannabis in the last 12 months.” In 2001 just over 16% reported using cannabis in the past year, but this declined to around 12% by 2007. The use of hydro has increased in Australia, which is consistent with patterns seen in the rest of the world.[8] Although the rates of cannabis use are considerable, most people who use cannabis do so infrequently. Those that report they use cannabis daily or habitually is around 3%. We should note that hard core drug users are less likely to return the survey or to be available for a telephone survey. Hence, our study will reflect more recreational users.

	Year		
	2001	2004	2007
Demographics			
Male	43%	42%	42%
Age	38	39	40
Married	62%	60%	63%
Aboriginal Descent	2%	2%	2%
City	62%	60%	59%
Cannabis Use			
Used Cannabis Ever in Life	44%	45%	46%
Used Cannabis in Last 12 Months	16%	15%	12%
Report Use of Cannabis is a Habit	3%	3%	2%
Use Leaf	7%	6%	5%
Use Head	13%	11%	9%
Use Hydro	23%	19%	40%
Average Age First Used	19	19	19
Number of Observations	18370	19583	13343

Table 2: Descriptive Statistics

Cannabis use varies with age and is the most prevalent among those in their twenties and thirties. Use declines to under 0.4% for those in their sixties. We restrict the data to individuals aged between 14 and 60. The average age of a respondent in our sample is just under 40. Approximately 60% are married and 2% of the sample are of Aboriginal descent. Finally, we construct an indicator variable equal to one if individuals report their health

[8] According to the Australian Bureau of Criminal Intelligence, (1996), the increase in hydroponic systems may be related to the fact that, unlike external plantations, hydroponic cultivation is not affected by the growing seasons of the region.

status is good, very good, or excellent. About 56% of individuals report being in good or better health.[9]

The NDSHS data also ask questions relating to accessibility of cannabis, which is particularly suited to the focus of this research. We construct a measure of accessibility (a_{im}) from the answers to three questions. If the individual reports that they had the opportunity to use or had been offered the drug in the past 12 months then they must have had access to the drug, so $a_{im} = 1$. They report how difficult it would be to obtain cannabis. If they indicate it is very easy then we set $a_{im} = 1$, if the response is impossible, very or fairly difficult, or fairly easy then we set $a_{im} = 0$. If they do not answer these questions, they were asked why they didn't use the drug: it was "too difficult to get" or they had "no opportunity" to use it in which case we set $a_{im} = 0$. [10] We examine the robustness of our results to our definition of accessibility by modifying our measure of accessibility.

Finally, to assess the role the legal status of cannabis plays in the decision to use, we construct the variable l_{im} that is intended to capture the disutility associated with doing something illegal. It is defined from responses to questions of the form "If marijuana/cannabis were legal to use, would you..." where

$$l_{im} = \begin{cases} 0 & \text{Not use it - even if legal and available} \\ 1 & \begin{array}{c}\text{Try it} \\ \text{Use it as often or more often than I do now}\end{array} \\ -1 & \text{Use it less often than I do now} \end{cases} .$$

3.2 Prices

Our pricing data comes from the Australian Bureau of Criminal Intelligence, Illicit Drug Data Reports which are collected during undercover buys. Given that cannabis is an illicit drug there are a few data issues to resolve regarding the prices. First, we do not observe

---

[9] Our measure of health status is the self-reported answer to "Would you say your health is: 1=excellent; 2=very good; 3=good; 4=fair 5=poor." Clinical research has shown that THC stimulates appetite and reduces nausea, which can be beneficial to cancer patients on chemotherapy treatment and individuals with HIV/AIDS.

[10] About 100 respondents answered the question "Why did you not use cannabis in the past 12 months...," while having reported using in the past 12 months. We drop these observations.

prices in all years due to different state procedures in filling in forms and the frequency of drug arrests of that certain cannabis form. To deal with missings across time we use linear interpolation when we observe the prices in other years. Second, the price per gram is the most frequently reported price, but in some quarters the only price available is the price per ounce. We cannot simply divide the price per ounce by 28 to convert it to grams as quantity discounts are common (Clements 2006). However, assuming price changes occur at the same time with gram and ounce bags, when we observe both the gram and ounce prices we substitute the corresponding price per gram for the time period in which it is missing when the price per ounce is the same in the period where both are reported. Third, some prices are reported in ranges in which case we use the mid-point of the reported price range. Finally, when skunk prices are not available we use the price per gram for hydro. We deflate the prices using the Federal Reserve Bank of Australia Consumer Price Index for Alcohol and Tobacco where the prices are in real 1998 AU$. These data are reported on a quarterly or semi-annual basis. We construct an annual price per gram measure by averaging over the periods.[11] Figure 1 presents real leaf prices across years by state.[12]

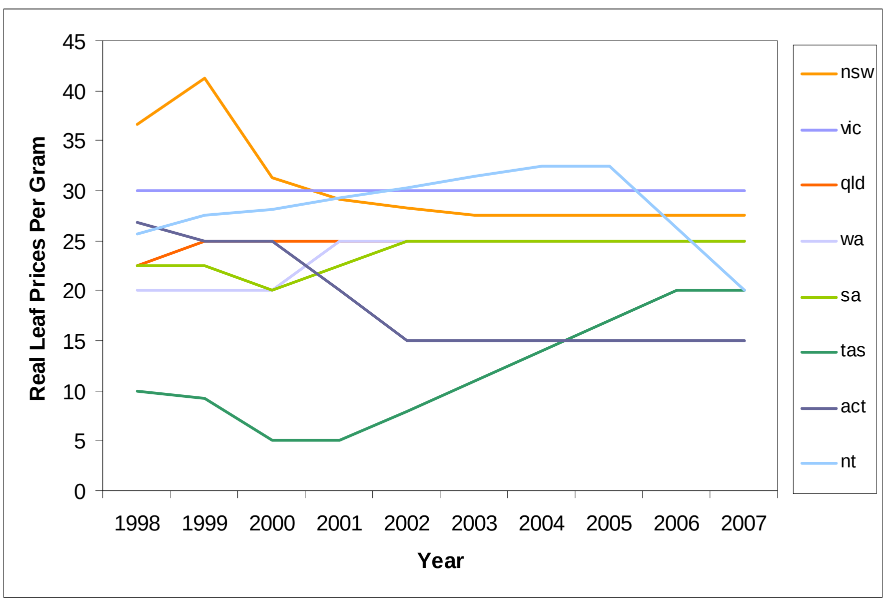

Figure 1: Leaf Prices By State

[11] A joint contains between 0.5 to 1.5 grams of plant material (McKenzie et al, 2010).

[12] We also considered using pricing data reported in the Illicit Drug Reporting System National Reports. These are self-reported prices from users. Unfortunately they are less believable in that there is virtually no variation in nominal prices across years, states, and quality types: 88% of the observations are either 20 or 25 (with a mean of 23 and standard deviation of 3).

Table 3 reports descriptive statistics by state. They indicate that cannabis use varies across states, ranging from 12% in Victoria to over 20% in the Northern Territory. Between 32% and 47% of the population report having access to cannabis. Not surprisingly both use and access are higher in states where cannabis use is decriminalized. Interestingly, if we compute the percentage of users among those with access (as opposed to the percentage of users among the entire population) the percent with access that report using cannabis has a higher mean and lower variance across states.

State	Percent Used Cannabis in Last 12 Months	Percent Report Access To Cannabis	Percent With Access that Use Cannabis	Average Price of Cannabis	Number of Observations
New South Wales	13.02%	34.41%	37.78%	41.79	13910
Victoria	12.54%	32.79%	38.21%	33.51	10758
Queensland	14.28%	35.80%	39.86%	33.09	9230
Western Australia	19.09%	44.62%	42.76%	42.31	5744
South Australia	15.40%	40.27%	38.22%	41.05	4152
Tasmania	15.07%	40.66%	37.06%	26.08	2290
ACT	14.09%	36.23%	38.86%	28.38	2614
Northern Territory	21.16%	47.81%	44.20%	38.18	2598
Decrimilized State	16.43%	40.74%	40.29%	38.90	12743
Not Decrimilized	13.96%	35.75%	39.02%	36.26	38553

Table 3: Descriptive Statistics by State

We constructed an individual-specific price using a weighted average across per-gram prices for various cannabis forms, where the weights are the percentage of that form that individual i reports using as reported in the survey. Consistent with other studies, we find that marijuana is expensive in New South Wales, which contains the city of Adelaide, which is known to be the center of the marijuana industry. The price of cannabis is higher on average in decriminalized states. This is consistent with the fact that decriminalization doesn't affect the suppliers as it is only applicable to users who use small amounts. So there is no shift in the supply curve brought about by lower risk/costs. However, the risk/cost has declined for small-users so the demand curve shifts up, resulting in higher prices on average.

Table 4 provides descriptive statistics by access and use. Males and younger people are more likely to have access and, conditional on having access to use cannabis. About 6% of those individuals who have access to cannabis but don't use it report they would use cannabis if it were legal. Among current users, approximately 13% report they would use cannabis more often than they currently due. Use and access is higher in states where cannabis is decriminalized.

	Have Access	Don't Have Access	Conditional on Having Access: Don't Use	Use
Male	48%	39%	44%	54%
Age	33.85	41.85	35.38	31.51
In Good, Very Good, or Excellent Health	52%	59%	56%	47%
Live in City	58%	61%	57%	61%
Would Use Cannabis if Legal	9%	4%	6%	13%
Decriminalized	27%	23%	27%	28%
Price	36.98	36.89	37.13	36.74
Number of Observations	18973	32323	11503	7470

Table 4: Descriptive Statistics by Access and Use

4 Model

An individual chooses whether or not to consume cannabis in market m which is defined as a state-year combination. The indirect utility individual i obtains from using cannabis in market m is given by

$$U_{im1} = p_i\alpha_1 + p_i d_i^{age\prime}\alpha_2 + d_i^{\prime}\beta_1 + x_m^{\prime}\beta_2 + L_m^{\prime}\delta_1 + L_m^{decr} d_i^{age\prime}\delta_2 + \varepsilon_{im1}, \quad (1)$$

where p_i is the price. The d_i is a vector of exogenous individual attributes including gender, age in brackets (young adult, college age, pensioner, etc), a dummy for aboriginal descent, health status, and the (dis)utility from engaging in illegal behavior.[13] The d_i^{age} is subset of the vector of individual attributes that includes only the age brackets. The x_m and L_m are market-specific, where x_m includes year fixed effects and the proportion of high quality cannabis sold in the market,[14] while L_m include variables related to legality including whether cannabis use is decriminalized and the amount of cannabis that can be grown for a minor offense. The L_m^{decr} is a dummy variable for whether cannabis is decriminalized in

[13] We do not include potentially endogenous covariates that may impact the utility from using cannabis such aslifetime use, education status, labor force participation, marital status, and number of children. We would need to instrument for them and the impact of these variables on cannabis use is not the primary focus of this paper.

[14] As an alternative to including market-specific legalization variables we also estimate a specification that includes state fixed effects. We present these results in section 6.

market m.[15] Individuals have utility from not using cannabis, which we model as

$$U_{im0} = x_{m0} + \epsilon_{im0}.$$

We normalize x_{m0} to zero, because we cannot identify relative utility levels. The $\varepsilon_{im} = \varepsilon_{im0} - \varepsilon_{im1}$ is a mean zero stochastic term distributed i.i.d. normal across markets and individuals.

This paper concerns the role of accessibility in cannabis use.[16] The probability person i has access to cannabis in market m, denoted ϕ_{im}, is assumed to be a function of individual i's observed characteristics and market characteristics:

$$\phi_{im} = \Pr(h_i'\gamma_1 + w_m'\gamma_2 + L_m^{decr\prime}\gamma_3 + \eta_{im} > 0). \tag{2}$$

The vector of individual attributes, h_i, includes whether the individual lives in a city, gender, a dummy for aboriginal descent, age in brackets, and education variables. The market-specific variables that influence access (w_m) include arrests-per-capita for cannabis use (as a proxy of prevalence) and year-fixed effects.[17]

It is likely that access to cannabis and the use decision are correlated (selection). Some individuals may have high levels of utility associated with using cannabis, and therefore will search for where to purchase it. For this reason, the error terms in equations (1) and (2) are likely to be correlated. The probability that individual i chooses to use cannabis depends upon the probability they know where to purchase cannabis (ϕ_{im}) and the probability they would use it given availability. Let

$$R_i \equiv \{U_{im1}(p_i, d_i, x_m, L_m, \epsilon_{im1}) \geq U_{im0}(p_i, d_i, x_m, L_m, \epsilon_{im0}), \phi_{im}^*(h_i, w_{m,} L_m^{decr\prime}, \eta_{im}) > 0\}$$

define the set of variables that results in consumption of cannabis given the parameters of

[15] There may be individual characteristics that are not observed by the econometrician that impact the utility one obtains from cannabis use. We estimated specifications that include random coefficients on legality and prices. However, once we include demographich interactions there is not enough additional variation to identify the random coefficients.

[16] We are not modeling the frequency of use rather the decision to use in the past 12 months. For this reason we focus on whether an individual has access to cannabis, which is different than whether they can buy it each time they want it due to supply side (potential) shortage reasons or the dealer not being available, etc.

[17] Arrests-per-capita refer to arrests of suppliers, not users. For this reason, arrests-per-capita are unlikely to impact the utility associated with using cannabis but are likely to impact the prevalence of cannabis for sale.

the model, where $\phi^*_{im} = h_i'\gamma_1 + w_m'\gamma_2 + L_m^{decr\prime}\gamma_3 + \eta_{im}$. The probability i chooses to use cannabis is given by

$$P_{im} = \int_{R_i} dF_{\varepsilon,\eta}(\varepsilon,\eta) \tag{3}$$

where $F(\cdot)$ denote joints distribution functions and the latter equality follows from independence assumptions.

An implicit assumption in economic models that have been considered in this literature is that all individuals have access to cannabis. In our framework, this is equivalent to assuming $\phi_{im} = 1$ and the errors in equations (1) and (2) are not correlated.

5 Econometric Specification

We specify an econometric model for cannabis access and utility to estimate the parameters from a sample of subjects for whom we observe cannabis use and access. Suppose we have a sample of $i = 1, .., n$ consumers. Let $a_{im} = 0, 1$ denote whether a consumer has access to cannabis ($a_{im} = 1$) or not ($a_{im} = 0$). Whether a subject has access to cannabis will depend on some random shock η_{im} and some covariate vector. Here we assume that an individual's indicator of having access to cannabis can be modeled in terms of a probit

$$a_{im} = I[\mu^a_{im} + \eta_{im} > 0] \text{ where } \eta_{im} \sim N(0,1),$$

where $\mu^a_{im} \equiv h_i'\gamma_1 + w_m'\gamma_2 + L_m^{decr\prime}\gamma_3$ so that $\phi_{im} = \Pr(a_{im} = 1) = \Phi(\mu^a_{im})$. Further, we let $u_{im} = 0, 1$ denote whether individual i has a positive utility from using cannabis. For ease of exposition, we refer to u_{im} as net-utility. We have

$$u_{im} = I[U_{im1} > U_{im0}] = I[\mu^u_{im} > \varepsilon_{im}],$$

where $\mu^u_{im} \equiv p_i\alpha_1 + p_i d_i^{age\prime}\alpha_2 + d_i'\beta_1 + x_m'\beta_2 + L_m'\delta_1 + L_m^{decr} d_i^{age\prime}\delta_2$ and $\varepsilon_{im} = \varepsilon_{im0} - \varepsilon_{im1}$. We let $(\eta_{im}, \varepsilon_{im}) \sim N_2(0, \Xi)$ where Ξ is $2x2$ covariance matrix with 1 on the diagonal and ρ on the off-diagonal.

In our setting with limited access, the net-utility from cannabis is not observed for all subjects, but only reflected in the observed consumption decisions of those subjects with access. We define the observed indicator $c_{im} = 0, 1$ to denote whether consumer i is observed using cannabis. Observed consumption can be expressed in terms of access and preferences (net-utility) based on our joint model as

$$\Pr(c_{im} = 1) = \Pr(a_{im} = 1)\Pr(u_{im} = 1|a_{im} = 1)$$

$$\Pr(c_{im} = 0) = \Pr(a_{im} = 0) + \Pr(a_{im} = 1)(\Pr(u_{im} = 0|a_{im} = 1).$$

where $\Pr(u_{im} = j|a_{im} = 1)$ is the net-utility conditional on access. While cannabis consumption reflects access and positive net-utility, zero consumption is the results of two cases: (1) no access or (2) access and negative net-utility. In other words, the observed zero consumption is inflated with zeros reflecting access only. Observing access allows us to contribute those zeros correctly to the access model. For consumers with access, the decision whether to use cannabis reflects the net-utility from use so that for those subjects $u_{im} = c_{im}$.

We let $\mathbf{a}_m = \{a_{1m}, ..., a_{n_m m}\}$ denote the vector of access variables for all n_m subjects in market m, $\mathbf{u}_m = \{u_{1m}, ..., u_{n1_m m}\}$ the vector of net-utility variables for the n_{1_m} subjects in market m with access to cannabis and $\mathbf{W}_m = \{\mathbf{W}_{1m}, ..., \mathbf{W}_{n_m m}\}$ the matrix of all covariates. For the sample we then define $\mathbf{a} = \{a_1, ..., a_M\}$, $\mathbf{u} = \{u_1, ..., u_M\}$ and $\mathbf{W} = \{\mathbf{W}_1, ..., \mathbf{W}_M\}$. We group the subjects in each market by cannabis access and define the sets I_{m1} for all subjects with access and I_{m0} for all subjects with no access. We can express the likelihood $f(\mathbf{a}, \mathbf{u}|\boldsymbol{\theta}, \mathbf{W})$ for all subjects as

$$\prod_{m=1}^{M} \left[\prod_{I_{m0}} \Pr(a_{im} = 0|W_{im}, \boldsymbol{\theta}) \prod_{I_{m1}} \Pr(a_{im} = 1, u_{im} = j|W_{im}, \boldsymbol{\theta}) \right] \tag{4}$$

where $m = 1, ..., M$ refers to the different markets and the vector $\boldsymbol{\theta}$ to the model parameters, $j = 0, 1$. For subjects with no access to cannabis, the likelihood contribution is a probit for access and for subjects with access we have a bivariate probit for access and cannabis use. The exclusion restrictions are the prevalence of cannabis use by state and whether the consumer lives in a major city, both of which may impact accessibility but are assumed not to impact utility, and the presence of medical conditions, which may impact utility but not accessibility.

We estimate the model via standard classical estimation methods and via Bayesian MCMC methods. The latter framework is also used for our predictive counterfactual analysis. The MCMC algorithms for the model estimation and the prediction are based on the methods discussed in Chib and Jacobi (2008) and Bretteville-Jensen and Jacobi (2011).

6 Results

Table 5 presents results from two baseline specifications that show the importance of considering selection into access. The first three columns are for the baseline specification where the decriminalization status of the state is included in the use and access equations. The last three columns present estimates for the baseline specification where state fixed effects are included in the use and access equations. Both specifications show that males and individuals in their teens and twenties are more likely to use cannabis relative to females and other age categories. Individuals who are of aboriginal descent are more likely to use and those who report being in better health are less likely to use cannabis.

Selection results indicate that living in a city makes individuals less likely to have access to cannabis. This is consistent with the reported growing patterns of cannabis in Australia, where it is usually grown in sparsely populated areas ("the outback") and hence it is not surprising it is easier to obtain outside of cities. Access results indicate that, conditional on age, individuals whose highest education is a trade degree are more likely to have access. Finally, if police enforcement is relatively consistent across states, then a higher supplier arrest rate could proxy for prevalence of cannabis in the market. The results indicate higher prevalence is consistent with higher access.

The results from the probit and the selection models differ in that the probit model indicates individuals are more sensitive to prices than the models that correct for selection. The selection model results show that the decriminalization status of cannabis use matters more for access than use. Furthermore, the results show that the unobservables from cannabis use and access are positively related (the estimate of Rho is always significantly positive.)

The elasticities of legalization, decriminalization, and price are all significantly different in the selection model relative to the standard approach. In fact, the selection model indicates individuals are less price sensitive and less sensitive to changes in the legalization variables. The standard model overestimates the sensitivity of demand to changes in legal status. The selection model indicates demand is much more inelastic with respect to price where we find an elasticity of participation that is consistent with the corresponding range estimated for cigarette participation for youth (between -0.3 and -0.5, Chaloupka, Warner 2000).

	Specification with Decriminalization Effects			Specification with State Fixed Effects		
	Bivariate Probit with Selection		Probit	Bivariate Probit with Selection		Probit
	Cannabis Use	Access	Cannabis Use	Cannabis Use	Access	Cannabis Use
Individual Attributes						
Male	0.327***	0.270***	0.325***	0.329***	0.273***	0.328***
	(0.0210)	(0.0120)	(0.0147)	(0.0218)	(0.0120)	(0.0147)
Aged in Teens	1.082***	1.144***	1.190***	1.064***	1.133***	1.190***
	(0.0720)	(0.0266)	(0.0333)	(0.0757)	(0.0266)	(0.0334)
Aged in Twenties	1.080***	1.184***	1.226***	1.068***	1.180***	1.228***
	(0.0695)	(0.0189)	(0.0262)	(0.0737)	(0.0189)	(0.0263)
Aged in Thirties	0.773***	0.733***	0.847***	0.765***	0.732***	0.846***
	(0.0484)	(0.0175)	(0.0256)	(0.0512)	(0.0175)	(0.0257)
Aged in Fourties	0.528***	0.427***	0.542***	0.522***	0.427***	0.542***
	(0.0394)	(0.0180)	(0.0267)	(0.0408)	(0.0180)	(0.0267)
Of Aboriginal Descent	0.165***	0.324***	0.211***	0.142**	0.336***	0.177***
	(0.0617)	(0.0451)	(0.0502)	(0.0631)	(0.0450)	(0.0508)
In Good, Very Good, or Excellent Health	-0.229***		-0.279***	-0.232***		-0.282***
	(0.0191)		(0.0148)	(0.0192)		(0.0149)
Highest Education is High School		-0.0283	-0.0427*		-0.0249	-0.0327
		(0.0194)	(0.0236)		(0.0194)	(0.0238)
Highest Education is Trade Degree		0.0637***	0.0278		0.0653***	0.0298
		(0.0156)	(0.0196)		(0.0156)	(0.0197)
Highest Education is University Degree		-0.154***	-0.108***		-0.148***	-0.0927***
		(0.0176)	(0.0227)		(0.0175)	(0.0228)
Market and Policy Variables						
Price	-0.00562***		-0.00665***	-0.0108***		-0.0120***
	(0.00128)		(0.00138)	(0.00166)		(0.00193)
High Potency	0.0898		-0.187	-0.0523		-0.286*
	(0.165)		(0.153)	(0.179)		(0.152)
Decriminalized	0.119***	0.162***	0.178***			
	(0.0252)	(0.0140)	(0.0191)			
Grams Possession is not Minor Offense	-0.000879*		-0.00192***	0.000257		0
	(0.000458)		(0.000441)	(0.000460)		(0.000545)
Would Use Can if Legal	0.333***		0.467***	0.336***		0.468***
	(0.0294)		(0.0277)	(0.0295)		(0.0277)
Arrests Per Capita of Suppliers (Prevalence)		0.118***	0.274***		0.204***	0.350***
		(0.0318)	(0.0506)		(0.0308)	(0.0868)
Live in City		-0.109***	0.0191		-0.117***	-0.0209
		(0.0120)	(0.0159)		(0.0120)	(0.0163)
Rho		0.506***			0.472***	
		(0.152)			(0.154)	
Number of Observations	51296	51296	51248	51296	51296	51248

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: MLE Estimates of Selection Model and Probits

Recall that the price we use in estimation is an weighted average price across individuals and qualities, where the weights are based on the reported quality type purchased. As the prices are not individual reported purchase price there may be some concern that price is correlated with the error term, and, therefore endogenous. As discussed in Section 3, prices are higher the higher is potency, which can be thought of as measure of the quality of the cannabis. We include a measure of the potency to control for quality to ameliorate this concern. However, we are still concerned about potential price endogeneity so we try to determine if this is an issue in our data by taking advantage of reported purchase prices from the 2007 wave of the NDSHS. Recall in 2007, respondents were asked to report the price per gram of the most recent purchase and the quality of cannabis purchased. As these are individual prices reported by quality type they are less likely to be correlated with the error term. Table B1 in Appendix B provides the MLE estimates comparable to those in Table 5 using reported prices. The estimates for the price parameter in the specification with Decriminalization effects is (-0.009) and the estimate for the state fixed effects specification is (-0.011) both of which are significant at the 99% level. Unfortunately reported prices are only available in one wave so we cannot use them for the entire analysis. However, given that the estimates using reported prices are not significantly different from those using our measure of prices, we are less concerned that price endogeneity is an issue once quality of cannabis is accounted for.

Table 6 presents selected parameter results of three models with interactions (for the specification with state fixed effects in use and access). All specifications include the same control variables as in Table 5. The results from price and age interactions show that individuals aged in their teens and twenties are less sensitive to price changes than older individuals. This implies that increases in prices (via a tax for example) will have less of an impact on the use among younger individuals. Price and potency interactions show that individuals are willing to pay more for cannabis with higher levels of THC. The final specification shows that if cannabis where legal this would increase use relatively more as individuals age. This suggests that variables associated with legality and prices (two policy instruments) will both have less of an impact among teenagers and individuals in their twenties.

		Bivariate Probit with Selection (with State Fixed Effects in Use and Access)					
	Interactions with:	Price and Age		Price and Potency		Legality and Age	
		Cannabis Use	Access	Cannabis Use	Access	Cannabis Use	Access
Age		-0.0224***					
		(0.00263)					
Aged in Teens			1.145***	1.100***	1.145***	1.119***	1.144***
			(0.0266)	(0.0695)	(0.0266)	(0.0684)	(0.0266)
Aged in Twenties			1.184***	1.104***	1.185***	1.088***	1.185***
			(0.0189)	(0.0668)	(0.0189)	(0.0660)	(0.0189)
Aged in Thirties			0.731***	0.785***	0.732***	0.755***	0.732***
			(0.0175)	(0.0464)	(0.0175)	(0.0466)	(0.0175)
Aged in Fourties			0.427***	0.532***	0.427***	0.496***	0.427***
			(0.0180)	(0.0382)	(0.0180)	(0.0389)	(0.0180)
Price		-0.0191***		-0.0239***		-0.0107***	
		(0.00238)		(0.00355)		(0.00163)	
High Potency		-0.0766		-2.515***		-0.0657	
		(0.181)		(0.595)		(0.175)	
Price Interactions:	Aged in Teens	0.00651**					
		(0.00295)					
	Aged in Twenties	0.0105***					
		(0.00253)					
	Aged in Thirties	0.00833***					
		(0.00178)					
	Aged in Fourties	0.00796***					
		(0.00125)					
	High Potency			0.0620***			
				(0.0145)			
Would Use if Legal		0.334***		0.327***			
		(0.0288)		(0.0299)			
Legal Interactions:	Aged in Teens					0.108*	
						(0.0618)	
	Aged in Twenties					0.280***	
						(0.0473)	
	Aged in Thirties					0.430***	
						(0.0543)	
	Aged in Fourties					0.525***	
Grams Possession not Minor Offense		0.000592		0.000491		0.000708	
		(0.000487)		(0.000489)		(0.000480)	
Rho		0.438***		0.565***		0.568***	
		(0.129)		(0.165)		(0.161)	

Notes: Includes all other controls from table 5 . Includes time fixed effects and state fixed effects in use and access. Standard errors are in parenthesis.

Table 6: Selected Parameter Estimates for Price, Age, and Illegality Interactions

6.1 Policy Analysis

We use the results from the selection model to investigate the effect of legalization of the cannabis market and improve the understanding about individual's decision making in that context. Our analysis aims to address the following policy concerns: (i) what role does access play in terms of using marijuana; and (ii) what role do other factors such as demographic characteristics, illegality of the drug, prices etc. play in the decision to use the drug.

We conduct the counterfactuals under different assumptions regarding how legalization would impact the demand side and the supply side, as well as consider the impact on use of various cannabis tax policies. More specifically, if cannabis were legalized then accessibility would not be as large of a hurdle.[18] In the model this implies that ($\phi_{im} = 1$). Furthermore, the disutility associated with illegal activity would be zero (in the model this means setting the legal variable to one).

Dealers would also be affected in that they would face different legal ramifications for selling. To address this issue, we compute the counterfactuals under various assumptions about how price would change: (i) price would not change; (ii) price would increase by 20%; (iii) price would decline to the price of cigarettes; and (iv) price would decline to the marginal costs of production for other herbs (based on the price of plants, growing fertilizer, labor, etc.). Notice that since we don't model the supply side so prices are taken as exogenous.

Environment			Predicted Probability of Use For Consumers in Current Environment with		
Accessibility	Legality	Price	All	No Access	Access
No Change	No Change	No Change	14.6%	0.0%	27.3%
Accessible	No Change	No Change	22.2%	18.9%	27.5%
Accessible	Legal	No Change	35.7%	32.3%	41.8%
		20% Increase	34.3%	30.8%	40.3%
		Cigarette Prices	43.0%	38.9%	49.4%
		Production Cost	43.0%	38.9%	49.4%

Notes: This is a prediction for a person with the typical access characteristics to use.
Based on baseline specification with state fixed effects

Table 7: Counterfactual Results

Table 7 displays the counterfactual results based on the state fixed effects baseline specification. The results indicate that both the accessibility and legality barriers play a substantial role in the decision to use cannabis. Use would increase to 22.3% from 14.6% if accessibility were not an issue. Furthermore, 19.6% of the current users who report no access would use cannabis. If cannabis were legalized and accessibility were not an issue use would more than double to 31.8%. Obviously there would be an impact on prices due to the law change, if cannabis prices declined to cigarette prices then use would increase to over 40%.

[18] It would continue to be a hurdle for underage users in the same sense that obtaining alcohol or cigarettes is not as easy for underage users.

Environment			Predicted Probability of Use by Age Group					
Accessibility	Legality	Price	All	Teenager	Twenties	Thirties	Forties	Over Forty
No Change	No Change	No Change	14.6%	27.5%	27.2%	16.1%	10.3%	3.7%
Accessible	No Change	No Change	22.2%	36.7%	35.7%	25.0%	19.1%	8.6%
Accessible	Legal	No Change	35.7%	52.7%	52.3%	40.4%	32.9%	17.6%
		Cigarette Prices	43.0%	60.5%	60.2%	48.4%	40.5%	23.3%
Percent Report Current Access			37.0%	57.7%	58.4%	40.7%	30.2%	17.5%

Notes: This is a prediction for a person with the typical access characteristics to use using estimates from the state fixed effects specification with price-age group interactions.

Table 8: Counterfactual Results by Age Group

As the results from Table 6 showed, the impact of prices and legality varies by age group. Table 8 presents the counterfactual results by age group. These results show that making marijuana legal and removing accessibility barriers would have a smaller relative impact on younger individuals. Current use among teenagers is 27.5% and use would increase by less than twice to 48.6% if marijuana were legal and there were no barriers to use. However, use among individuals in their thirties and forties would almost triple.

More results forthcoming...

7 Conclusions

We present a model of marijuana use that disentangles the impact of limited accessibility from consumption decisions based solely on preferences. We find that both play an important role and that individuals who have access to the illicit market are of specific demographics. We consider the role played by accessibility in use, the impact of illegal actions in utility, as well as the impact on the supply side. Our results indicate that unobservables from cannabis use and access are positively related and that the elasticities of legalization, decriminalization, and price are all significantly different in the selection model relative to the standard approach. The selection model indicates demand is much more inelastic with respect to price. We obtain estimates for price elasticities of demand (for an illicit good) taking into account selection into access. We find that selection into who has access to cannabis is not random, and the results suggest estimates of the demand curve will be biased unless selection is explicitly considered. Counterfactual results indicate that making marijuana legal and removing accessibility barriers would have a smaller relative impact on younger individuals but still a large impact in magnitude. Use among teenagers would (a little less than) double and use among individuals in their thirties and forties would almost triple. *More conclusions forthcoming...*

References

Adda J., B. McConnell and I. Rasul (2011) "Crime and the Depenalization of Cannabis Possession: Evidence from a Policing Experiment," Mimeo,

Australian Crime Commission Illicit Drug Data Report 2006-07 Australian Crime Commission Illicit Drug Data Report 2003-04 Australian Crime Commission Illicit Drug Data Report 2000-01

arseneault.l, m.cannon, j.witten and r.murray (2004) "Causal Association Between Cannabis and Psychosis: Examination of the Evidence", British Journal of Psychiatry 184:110-17.

Becker, G., Murphy K., and Grossman M. (2006) "The Market for Illegal Goods: The Case of Drugs" *Journal of Political Economy* 114 (1), pp. 38-60.

Bretteville-Jensen and Jacobi, L (2010) "Climbing the Drug Staircase: A Bayesian Analysis of the Initiation of Cannabis Use," Journal of Applied Econometrics.

Caulkins et al (2006)

Caulkins, J. (2010) "Estimated Costs of Production for Legal Cannabis," Santa Monica, CA: RAND.

Caulkins, J., Kilmer, B., MacCoun, R. Pacula R. and P. Reuter (2011) "Design Considerations for Legalizing Cannabis: Lessons Inspired by Analysis of California's Proposition 19," Addiction

Chaloupka, F.J., and K. Warner (2000) The Economics of Smoking. In Newhouse J.P., Cuyler A.J., editors. The Handbook of Health Economics Volume 1, Part 2. Amsterdam: Elsevier, p. 1539-627

Chib and Jeliazkov (2001)

Chib and Greenberg (1995,1998)

Clements, K. (2006) "Pricing and Packaging: The Case of Marijuana," *Journal of Business*, 79(4): 2019-2044.

Damrongplasit, K., C. Hsaio, and X. Zhao (2010) "Decrimilization and Marijuana Smoking Prevalence: Evidence from Australia," *Journal of Business and Economic Statistics*, 28(3): 344-356.

Damrongplasit, K. and C. Hsaio (2008) "Decrimilization Policy and Marijuana Smoking Prevalence: a Look at the Literature,"

Galenianos, M., Pacula R., and N. Persico (2009) "A Search-Theoretic Model of the Retail Market for Illicit Drugs," NBER Working Paper 14980.

Glaeser, E.L. and A. Shleifer (2001) A reason for quantity regulation, American Economic Review, Papers and Proceedings, 91, 431-435.

Kilmer et 2010 RAND

miron.j.a and j.zwiebel (1995) “The Economic Case Against Drug Prohibition”, Journal of Economic Perspectives 9: 175-92.

Miron, J.A.(2005)

Miron, J.A. (2008) The Effect of Marijuana Decriminalization on the Budgets ofMassachusetts Governments, With a Discussion of Decriminalization’s Effect on Marijuana Use: An Update of Miron (2002a), mimeo, Harvard University

Pacula R. “Examining the Impact of Marijuana Legalization on Cannabis Consumption: Insights from the Economics Literature,” Santa Monica, CA: RAND; 2010

Pudney (2006)

pudney.s.e (2010) “Drugs Policy: What Should we do About Cannabis?”, Economic Policy 25: 165-211.

Rhodes (2007)

Saffer, H. and F. Chaloupka (1999) “The Demand for Illicit Drugs,” *Economic Inquiry* 37(3), pp. 401-11.

Sickles R., and P. Taubman (1991) “Who Uses Illegal Drugs?” *American Economic Review, Papers and Proceedings* 81(2):248-251.

Sovinsky Goeree, M (2008) “Limited Information and Advertising in the US Personal Computer Industry, ” Econometrica

National Cannabis Prevention and Information Centre "Cannabis Potency.".

United Nations Office on Drugs and Crime. 2009-06-29. "Why Does Cannabis Potency Matter?".

Van Ours.J (2003) “Is Cannabis a Stepping-stone for Cocaine?”, Journal of Health Economics 22: 539-54.

A MCMC Methods

A.1 Model Fitting for Probit Model with Selection

For the discussion of the model fitting of the Probit model for cannabis use with selection based on binary access via MCMC methods we condense the notation and introduce the latent continuous access and cannabis use variables $\{a^*_{im}\}$ and $\{u^*_{im}\}$ and use the common latent variable representation of the probit where

$$a^*_{im} = \tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma} + \eta_{im}, \quad a_{im} = I[a^*_{im} > 0]$$

$$u^*_{im} = \tilde{\mathbf{x}}'_{im}\boldsymbol{\beta} + \varepsilon_{im}, \quad u_{im} = I[u^*_{im} > 0] \qquad if \quad a_{im} = 1$$

where for each sample subject $\tilde{\mathbf{h}_{im}}$ refers to the combined covariate vector for the access model containing intercept, individual attributes, market-specific variables influencing access, and $\tilde{\mathbf{x}}_{im}$to the combined covariate vector for the net utility model that contains the price variables,individual attributes, market specific variables and year fixed effects in addition to the intercept. As before we assume that $(\eta_{im}, \varepsilon_{im}) \sim N_2(0, \Xi)$ where Ξ is $2x2$ covariance matrix with 1 on the diagonal and ρ on the off-diagonal. We define the vector of model parameters as $\boldsymbol{\theta} = (\boldsymbol{\gamma}, \boldsymbol{\beta}, \boldsymbol{\rho})$. The likelihood of the model, $f(\mathbf{a}, \mathbf{u}, \{a^*_{im}\}, \{u^*_{im}\}|\boldsymbol{\theta}, \mathbf{W})$ can be now expressed in terms of the latent data to improve the tractability of the likelihood (Albert and Chib 1993)

$$\prod_{i:a_{im}=0} \mathcal{N}(a^*_{im}|\tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}, \mathbf{1})\, I[a^*_{im} \leq 0]^{a_{im}} \prod_{i:a_{im}=1} \mathcal{N}(a^*_{im}|\tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}, \mathbf{1}) I[a^*_{im} > 0]^{1-a_{im}}\ \mathcal{N}(u^*_{im}|\tilde{\mathbf{x}}'_{im}\boldsymbol{\beta} + \rho(a^*_{im} - \tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}\ , 1-\rho^2$$

For the Bayesian analysis we proceed with the common assumption of Normal priors for the slope coefficients and correlation coefficient. The latter is restricted to the region $R = -1 < \rho < 1$ to ensure the positive definiteness of $\boldsymbol{\Xi}$. The joint prior is given by

$$\pi(\boldsymbol{\theta}) = \mathcal{N}(\boldsymbol{\beta}|\mathbf{b}_0, \mathbf{B}_0)\ \mathcal{N}(\boldsymbol{\gamma}|\mathbf{g}_0, \mathbf{G}_0)\ \mathcal{N}(\rho|r_0, R_0) \times R \tag{5}$$

The prior means are set at zero. In combination with large prior variances this implies relatively uninformative prior assumptions. The posterior distribution with the parameter space augmented by the latent access and cannabis variables, $\pi(\boldsymbol{\theta}, \mathbf{a}^*, \mathbf{u}^*|\mathbf{a}, \mathbf{u})$ which is proportional to product of the likelihood and the prior, is simulated in five blocks with normal updates for the latent variables and the slope coefficients and a Metropolis Hastings update for the correlation parameter.

First, we draw a^*_{im} from $\mathcal{N}(a^*_{im}|\tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}, 1)\ I[a^*_{im} < 0]$ for $i \in I_0$ and from $\mathcal{N}(a^*_{im}|\tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma} + \rho(u^*_{im} - \mu^u_{im}), 1 - \rho^2)\ I[a^*_{im} \geq 0]$ for those subjects with $i \in I_1$.

In the second step, we draw u^*_{im} for all subjects $i \in I_1$ from $\mathcal{N}(u^*_{im}|\tilde{\mathbf{x}}'_{im}\boldsymbol{\beta} + \rho(a^*_{im} - \tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}), 1 - \rho^2)\ I[u^*_{im} \leq 0]$ if $u_{im} = 0$ or from $\mathcal{N}(u^*_{im}|\tilde{\mathbf{x}}'_{im}\boldsymbol{\beta} + \rho(a^*_{im} - \tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}), 1 - \rho^2)\ I[u^*_{im} > 0]$ if $u_{im} = 1$.

In the third step, we draw $\boldsymbol{\gamma}$ from $\mathcal{N}(\hat{\boldsymbol{\gamma}}, \hat{\mathbf{G}})$ with

$$\hat{\boldsymbol{\gamma}} = \hat{\mathbf{G}}[\mathbf{G}_0^{-1}\mathbf{g}_0 + \sum_{i \in I_0} \tilde{\mathbf{h}}_{im} a^*_{im} + \sum_{i \in I_1} \tilde{\mathbf{h}}_{im}(1-\rho^2)^{-1}(a^*_{im} - \rho(u^*_{im} - \tilde{\mathbf{x}}'_{im}\boldsymbol{\beta})]$$

$$\hat{\mathbf{G}} = [\mathbf{G}_0^{-1} + \sum_{i \in I_0} \tilde{\mathbf{h}}_{im}\tilde{\mathbf{h}}'_{im} + \sum_{i \in I_1} \tilde{\mathbf{h}}_{im}(1-\rho^2)^{-1}\tilde{\mathbf{h}}'_{im}]^{-1}$$

where $i \in I_0$ refers to the subset of subjects with no access and $i \in I_1$ to those with access. In the fourth step we draw $\boldsymbol{\beta}$ based on the subjects in I_1 from $\mathcal{N}(\hat{\boldsymbol{\beta}}, \hat{\mathbf{B}})$ where

$$\hat{\boldsymbol{\beta}} = \hat{\mathbf{B}}[\mathbf{B}_0^{-1}\mathbf{b}_0 + \sum_{i \in I_1} \tilde{\mathbf{x}}_{im}(1-\rho^2)^{-1}(u^*_{im} - \rho(a^*_{im} - \tilde{\mathbf{h}}'_{im}\boldsymbol{\gamma}))]$$

$$\hat{\mathbf{B}} = [\mathbf{B}_0^{-1} + \sum_{i \in I_1} \tilde{\mathbf{x}}_{im}(1-\rho^2)^{-1}\tilde{\mathbf{x}}'_{im}]^{-1}$$

In the last step we update ρ in Metrolpolis Hastings step based on the subjects in I_1, since the conditional posterior distribution of ρ is not tracktable. Following Chib and Greenberg (1995,1998) we generate proposal values for ρ' from a tailored student-t density $t_\nu(\mu, V)$ where μ is the mode of

$$ln(\prod_{I \in I_1} \mathcal{N}(a^*_{im}, u^*_{im}|W_{im}\boldsymbol{\delta}, \Xi) \ , \quad \text{where} \quad \mathbf{W}_{im} = \begin{pmatrix} \tilde{\mathbf{h}}'_{im} \\ \\ \tilde{\mathbf{x}}'_{im} \end{pmatrix}, \ \boldsymbol{\delta} = \begin{pmatrix} \boldsymbol{\gamma} \\ \\ \boldsymbol{\beta} \end{pmatrix} \ \text{and} \ \Xi = \begin{pmatrix} 1 & \rho \\ \\ \rho & 1 \end{pmatrix}$$

and V is the inverse of the Hessian of the density evaluated at μ. The proposed value ρ' is accepted with probability

$$\alpha = \min\left(1 \ , \ \frac{\pi(\rho') \ \prod_{I \in I_1} \mathcal{N}(a^*_{im}, u^*_{im}|\mathbf{W}_{im}\boldsymbol{\delta}, \Xi') \ t_\nu(\rho|\mu, V)}{\pi(\rho) \ \prod_{I \in I_1} \mathcal{N}(a^*_{im}, u^*_{im}|\mathbf{W}_{im}\boldsymbol{\delta}, \Xi) \ t_\nu(\rho'|\mu, V)}\right)$$

A.2 Counterfactuals/Prediction of Cannabis Use

We report the probablities of cannabis use for various counterfactual scenarios in the paper. The probabilities are obtained using the standard Bayesian approach for prediction, allowing us to both use all the information from the parameter estimation summarized in the posterior distribution and to compute credible intervals. Let $n = 1$ refer to a random subject from the sample with demographic characteristics and market features $\tilde{\mathbf{x}}_{n+1,m}$ for whom we want to predict the probabiltiy of cannabis use given the observed data $\Pr(u_{n+1,m} = 1|\mathbf{a}, \mathbf{u})$.

Using the Normal model for cannabis use and the information on the model parameters from the posterior distribution we can obtain the probability of cannabis use based on following integral expression

$$\Pr(u_{n+1,m} = 1|\mathbf{a}, \mathbf{u}) = \int \Phi(m_{n+1,m})\ \pi(\boldsymbol{\beta}|\mathbf{a}, \mathbf{u})\ \ p(\tilde{\mathbf{x}}_{n+1,m}|\mathbf{a}, \mathbf{u})\ d\boldsymbol{\theta}\ \ d\ \tilde{\mathbf{x}}_{n+1,m},$$

where $m_{n+1,m} = \ \tilde{\mathbf{x}}'_{n+1,m}\ \boldsymbol{\beta}$,refers $\pi(\boldsymbol{\beta}|\mathbf{a}, \mathbf{u})$ to marginal posterior distribution of the vector and to the empirical distribution of the given the sample data. The integral expression can be estimated by by using the draws from the posterior distribution from the MCMC algorithm discussed in the previous section. Essentially, at each iteration of the MCMC algorithm after the burn-in phase, a vector $\tilde{\mathbf{x}}_{n+1,m}$ is drawn from the data and $\Phi(\tilde{\mathbf{x}}'_{n+1,m}\ \boldsymbol{\beta})$ computed using the current MCMC draw on $\boldsymbol{\beta}$. All these draws give as a predictive distribution of the probability of use and we report the mean probability and the 95% credibitiliy interval. For the probabities by various demographic groups, randomly draw the $\tilde{\mathbf{x}}_{n+1,m}$ from the corresponding subsample.where the summand is the normal pdf of the full conditional posterior distribution of β as described above.

B Price Endogeneity Estimates

	Decriminalization Effects		With State Fixed Effects	
	Cannabis Use	Access	Cannabis Use	Access
Individual Attributes				
Male	0.300***	0.259***	0.298***	0.260***
	(0.0571)	(0.0242)	(0.0591)	(0.0243)
Aged in Teens	0.599***	0.936***	0.580***	0.939***
	(0.177)	(0.0546)	(0.186)	(0.0546)
Aged in Twenties	0.586***	1.096***	0.569***	1.099***
	(0.182)	(0.0380)	(0.193)	(0.0380)
Aged in Thirties	0.427***	0.677***	0.414***	0.677***
	(0.128)	(0.0349)	(0.135)	(0.0350)
Aged in Fourties	0.392***	0.392***	0.382***	0.391***
	(0.0989)	(0.0361)	(0.102)	(0.0362)
Of Aboriginal Descent	0.00764	0.290***	-0.0224	0.269***
	(0.134)	(0.0825)	(0.134)	(0.0831)
In Good, Very Good, or Excellent Health	-0.305***		-0.304***	
	(0.0419)		(0.0421)	
Highest Education is High School		-0.0857**		-0.0707*
		(0.0423)		(0.0426)
Highest Education is Trade Degree		0.0568*		0.0607*
		(0.0335)		(0.0337)
Highest Education is University Degree		-0.230***		-0.213***
		(0.0370)		(0.0373)
Market and Policy Variables				
Reported Purchase Price	-0.00880***		-0.0119***	
	(0.00216)		(0.00239)	
High Potency	0.748**		0.913**	
	(0.350)		(0.437)	
Decriminalized	-0.0736	0.150***		
	(0.0533)	(0.0267)		
Grams Possession is not Minor Offense	0.00125		0.00124	
	(0.00109)		(0.00178)	
Would Use Can if Legal	0.130**		0.125**	
	(0.0625)		(0.0627)	
Arrests Per Capita of Suppliers (Prevalence)		0.229***		
		(0.0663)		
Live in City		-0.0993***		-0.126***
		(0.0246)		(0.0263)
Rho		0.0682		0.0550
		(0.227)		(0.239)
Number of Observations	13301	13301	13301	13301

Notes: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B1: Bivariate Probit with Selection Estimates using Reported Price