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Examining the Impact of Marijuana Legalization on Marijuana Consumption

Insights from the Economics
Literature

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Examining the Impact of Marijuana Legalization on Marijuana Consumption: Insights from the Economics Literature

**By
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Abstract

A central question in the debate regarding the legalization of marijuana in California is whether consumption would rise and by how much. In this report, we review the economics literature which provides insights regarding how consumption might change and why. A key finding of the review is that the current state of the literature is limited, having not yet fully explored how average consumption among existing users will change in response to changes in price and legal risks. However, information regarding the prevalence of marijuana, both in terms of new users as well as regular users, is available. A review of this literature is considered in terms of the responsiveness of marijuana initiation, regular use and heavy use to changes in the price of marijuana, enforcement risk, decriminalization and other legal risks. From this review it is clear that total consumption will rise in response to legalization due to increases in the number of new users, increases in the number of regular and heavy users, and probable increases in the duration in which marijuana is consumed for average users.

I. Introduction

A vast literature has developed over the past twenty years examining the etiology of and factors influencing marijuana consumption. A variety of disciplines have contributed to the development of this literature, including sociology, psychology, epidemiology, criminology, and economics, all emphasizing different factors that are important for influencing the decision to use marijuana. The economics literature, in particular, has focused on examining the relative importance of changes in price and income as determinants of the decision to use marijuana and length of use careers. Now, with the current debate regarding the legalization of marijuana in California, the findings from this economics literature in particular have found themselves at the center of the debate, as it lends important insights into what could happen to marijuana consumption in California if the voters decide to legalize marijuana. Legalization is expected to significantly influence the monetary price people have to pay to obtain marijuana, as currently with the prohibition, there is a black market risk premium that is added to the cost of providing marijuana to the market and this risk premium will no longer exist (see Caulkins 2010 for a careful description of this). So, with the expected decline in the price consumers have to pay for marijuana, how is consumption likely to change?

The price elasticity of demand is typically used by economists to describe how consumption changes in response to a change in the price of any good or service. In particular, it tells you the percent change in consumption associated with a 1% change in price, and is derived by examining small changes along a single market demand curve. Market demand curves represent the aggregation of individual choices of quantities of the good consumed at various price points that could be observed in the market, holding all non-price determinants of consumption constant. Examples of non-price determinants held constant include the legal risk of consuming a good, other non-pecuniary aspects of the cost facing buyers – such as time it takes to search for the exact product they want, income of the consumers, and the prices of alternative products that could be consumed instead. So estimates of the price elasticity of demand for marijuana, like those for any other good or service, are valuable for explaining how consumption might change in response to a change in price when all other factors are held constant.

There are two problems with using price elasticities to understand how marijuana consumption will change with a change in a policy like legalization. First, the elasticities are calculated off of relatively small changes in price, because the slope of the demand curve (which is used to calculate the elasticity of demand) is only constant in very small ranges around a given price. For most market demand curves, the elasticity of demand changes depending on where along the curve a change is being evaluated. The precise nature of the market curve for marijuana has not been empirically evaluated for marijuana (see Kilmer et al., 2010, for a description of how the shape of the demand curve impacts estimates of the change in consumption). Second, the assumption that all *other things are held constant* is not met when considering a policy change like legalization. Specifically, legalization represents a change not just in the monetary price of the good but also a change in other factors, including the legal risk associated with using marijuana, the perceived health risks associated with use, and the social norms regarding the appropriateness of using marijuana for recreational purposes.¹ While economists have considered the impact of changes in some of these components, as economists

¹ There is significant empirical evidence in the economics literature as well as other literatures suggesting that social norms, as reflected by aggregate measures of perceived harmfulness, disapproval, and peer effects, are important correlates of marijuana use (Bachman et al., 1988, 1998; Pacula et al., 2001; Jacobson, 2005).

interpret “price” more broadly to represent several non-pecuniary aspects of the decision to use marijuana such as the legal risks, price elasticities are typically calculated with respect to only one aspect of price holding everything else constant.²

Economic theory suggests that the legalization of marijuana could influence consumption through a number of mechanisms, including: changes in monetary price, change in legal risk of using, change in availability, changes in perceived health harm, and changes in the risk of sanctions outside the criminal justice system (e.g., affecting employment, eligibility for sports, scholarships, housing, etc.). To varying extents, most of these factors have been considered in the economics literature and provide some insights regarding how each incrementally might change consumption. Many factors that are also important determinants of use and could change with legalization, such as cultural norms, peer effects and informal sanctions (e.g., from parents), however, are not been as carefully considered in the economics literature explicitly.³ Therefore, the economics literature cannot solely be used to assess the effects of a change in the proposed policy; in other work that is part of this volume (MacCoun 2010) we consider the influence of non-economic factors on consumption given a change in policy, as is evident from experiments in other countries and/or other vices.

In this chapter we review the existing economic literature that can help inform how consumption might change in response to changes in both the monetary price of marijuana as well as changes in the legal risk and enforcement of marijuana laws in California. The review focuses on these domains as they are areas in which the literature is the most developed. Unlike other reviews, this review pays particular attention to what we know regarding the responsiveness of use among particular user groups, who are key for making inferences regarding what will happen to either the number of users or the total quantity consumed. Marijuana markets, not unlike markets for other goods, are characterized by a number of different types of consumers, all of whom contribute (to varying amounts) to the total expenditure in the market. Different types of consumption behavior that matter when thinking about the current and future size of the marijuana market include the following:

- Initiators and light users - new users who are experimenting with marijuana or consuming small doses on a very infrequent basis.
- Regular users – individuals who consume in relatively small or moderate doses on a more frequent basis.
- Heavy users - individuals who consume on a near daily basis or who meet DSM-IV criteria for dependence or abuse.

² Economists interpret “price” more broadly than just the monetary cost of obtaining a good or substance. While the monetary price is certainly important, it is but one component of the “full price” of consuming a good that is factored into the individual’s decision (Bretteville-Jensen 2006; Grossman, 2005; Pacula et al., 2001 ; Cook and Moore, 2000; Chaloupka and Warner, 2000). The “full price” has considered a variety of non-pecuniary aspects of the decision, including (a) the legal risks associated with obtaining and using the good, (b) the health risks associated with using the good, and (c) the time costs associated in obtaining and using the good. All of these aspects influence the overall cost the individual must pay to engage in the behavior. That being said, very few studies are actually able to control for all these components of the full price of marijuana simultaneously when assessing the influence of just one component.

³ While they have been considered in greater detail in the psychology and sociology literatures, these literatures ignore the role of price, legal risk and availability, and hence do not allow us to understand how simultaneous changes in both groups of factors could influence use and levels of consumption.

- Quitters – individuals who decide to no longer use marijuana, the timing of which identifies the typical use career for participants in the market.

Prevalence rates combine changes in the behaviors of new initiates just experimenting or starting their use careers with the behaviors of casual, regular or heavy users who decide to quit. Thus, when prevalence rates are seen to increase, it means that either more people are starting use or fewer people are quitting (or some combination of both). Decreases in prevalence rates mean that either fewer people are starting or more people are quitting, or a combination of both of these.

Even understanding perfectly the prevalence, or number of users, may still tell us very little regarding the total quantities that are likely to be consumed. This is because there is great variation in how much is consumed by different types of users. Research shows clearly that for nearly every intoxicating substance, including alcohol and cigarettes, consumption among new initiates and individuals early in their use career is less frequent and smaller in terms of amounts used than consumption among regular and heavy users (Grossman, 2005; Chaloupka and Pacula, 2003; Manning et al., 1996; Everingham and Rydell, 1994). This is also true for marijuana (Kilmer and Pacula, 2009; Clements and Zhao, 2009; Wilkins et al, 2005; Caulkins and Pacula, 2003). Indeed, overall consumption is usually dominated by a minority of the heaviest users. So total consumption can go up if the number of heavy users increases, even while the total number of users declines.

Estimates of the frequency or quantity consumed by marijuana users, however, have not been as carefully examined as general prevalence estimates. It is for this reason that we will not be attempting to estimate what will happen to total marijuana consumption in this chapter. Instead, we rely on the modeling exercise described in Kilmer, et al (2010) to project potential effects of legalization on total marijuana consumption within the state of California, as through that modeling exercise we can do a better job incorporating all the factors that could influence it and project the uncertainty that underlies all the different assumptions feeding into the model (e.g. decline in price, tax evasion, non-pecuniary aspects of use). This chapter focuses on just a few particular elements that are important for informing the general model, most notably the price elasticity of demand, the importance of legal sanctions and enforcement risk, and how changes in these factors are likely to influence prevalence rates for different types of users. To assist the reader in considering this important distinction between changes in total consumption and changes in prevalence rates, we review the economics literature in a manner that isolates the relative responsiveness of particular types of marijuana use (initiation, regular use, heavy use, quit behavior) to changes in the price of marijuana, enforcement risk, decriminalization, and any other component of full price that has been considered in the literature.⁴ We will also discuss income effects, as they are likely to play a role in the behavioral change observed with legalization in light of the relatively large price decrease that is anticipated with the reduction in legal risk.

II. The Responsiveness of Initiation

⁴ Decriminalization, as frequently examined in U.S. analyses, is a reduction in the legal penalties associated with possession of small amounts of marijuana, typically amounts of an ounce or less. It has been interpreted as also changing the criminal status of marijuana possession offences, but in many states like California, the offence – although not a felony – is still classified as a misdemeanor, and hence generate a criminal record for the individual if conditions for expungement are not met. See Pacula, Chriqui and King (2003) for a discussion of this.

II.A. Summary of findings from the literature

According to self-reported information from the 2008 National Survey on Drug Use or Health (NSDUH, 2009), 61.8 percent of the 2.2 million individuals who reported using marijuana for the first time in the past year were under the age of 18 (SAMHSA, 2009). Indeed the average (mean) age of first marijuana use for the entire household population is below 18 years of age (17.8). Thus, if the goal is to understand factors influencing marijuana initiation, then one must start by looking at use among adolescents. While claims have been made that legalization could lead to less use of marijuana among adolescents because of more effective regulations to keep these products away from kids, the fact that the average age of both first alcohol (17.0 years) and first cigarette use (17.4) are lower than that for marijuana challenges belief in the effectiveness of regulated legal delivery at limiting youth access (SAMHSA, 2009).

Table 1 summarizes the findings with respect to the effects of the monetary price, decriminalization, and the legal risk (penalties and police enforcement) on the decision to use marijuana among youth. It is clear from the table that marijuana initiation among youth is very sensitive to changes in the price of marijuana, although the range of plausible initiation elasticities range from -0.3 (Pacula et al., 2001) to -0.5 (van Ours and Williams, 2007). Policies that reduce the price of marijuana by 10% therefore, will lead to a 3-5% increase in the number of new marijuana users among youth, all else equal. The findings with respect to legal risks also suggest that youth are sensitive to changes in statutory penalties associated with marijuana use, although there is some inconsistency from study to study as to whether it is jail sentences or higher fines that reduce prevalence.⁵ It is important to note, however, that in most of the cases, the impact of the legal risk on prevalence is generally small, and when frequency of marijuana use is examined among youth users, legal risks are generally insignificant.

Table 1: Summary of findings related to initiation and use by youth

Economic Variable of Interest	Summary Estimates	Studies
Monetary price	Participation elasticities range from -0.002 to -0.69	Pacula et al (2001); Pacula Chriqui and King (2003); Desimone and Farrelly (2003); Jacobson (2005); van Ours and Williams (2007); Bretteville-Jensen and Williams (2010)
Decriminalization	Mixed results all over the place	Johnston, et al., (1981); Chaloupka, Grossman and Tauras (1999); Chaloupka et al., (1999); DiNardo and Lemieux (2001); Pacula et al (2003)
Penalties (fine, jail)	Mixed, when significant though effects are SMALL	Chaloupka Grossman and Tauras (1999); Farrelly et al., (2001) ; Pacula et al (2003) ; Markowitz and Tauras (2009)
Police enforcement	Participation elasticities range 0 to -0.287	Farrelly et al (2001); Desimone and Farrelly (2003), Pacula et al (2003)

There are some inconsistencies in the findings for youth with respect to the effects of decriminalization, which may be due a combination of weak analytic approaches, the non-uniqueness of this policy in terms of actual penalties faced by users, and the apparent lack of

⁵ The author's own analysis of these statutory penalties confirms a high degree of correlation. Given studies vary in terms of the inclusion of fines and/or jail time, the inconsistency may be driven by the correlation in these variables.

knowledge about these policies (MacCoun et al., 2010; Room et al., 2008; Pacula, Chriqui and King, 2003). As there has been very little variation in decriminalization policies since the late 1970s and in light of what has been learned about identifying causal effects, it is truly difficult to infer anything from results with respect to the decriminalization status variable. That being said, subsequent analyses have tried to focus on various components of these policies: enforcement risk, penalties if caught, and social norms. These results tend to suggest that if actual penalties (fines and jail time) are reduced and social norms become more accepting of marijuana use, marijuana initiation and use among youth will increase. In the case of penalties, the effect sizes are very small on this subgroup and hence could be reasonably ignored. We will now provide a more detailed descriptions of the key studies informing this general summary of the findings for youth.

II.B. Review of the literature regarding initiation and use by youth

The Monitoring the Future (MTF) Survey has provided information on trends in initiation and consumption of a variety of legal and illicit substances among a nationally representative sample of high school seniors since 1975, with information from a nationally representative sample of 8th and 10th graders being collected since 1991. Although the data have not been used by economists to examine initiation specifically, examination of annual and thirty day prevalence rates from these data can provide reasonably good information on initiation as most individuals who are reporting use are in the very early stages of their use career, most are new initiates and few are daily users.⁶ The MTF shows that there are jumps in initiation between 8th and 10th grade and then again into 12th grade (Johnston, et al., 2009), so it is clear that these data do a good job of capturing early use. There are a few other nationally representative surveys that also capture youth drug use during these early years, including the National Longitudinal Survey of Youth 1997 (NLSY97), the National Household Survey on Drug Use/National Survey on Drug Use or Health (NHSDA/NSDUH), and the National Educational Longitudinal Survey (NELS). Various studies have examined early use of marijuana in all of these.

Initial studies examining these data had limited information on monetary prices so marijuana decriminalization status and legal risks were the main components of the full price of marijuana examined. Studies examining the effects of decriminalization and changes in legal risks focusing on youth have generated highly variable results. In one of the earliest studies of the effects of state decriminalization policies, Johnston et al. (1981) used data from several waves of the Monitoring the Future Survey to examine trends in marijuana use after California decriminalized possession of small amounts of marijuana in 1976. They compared the trend in prevalence rates post decriminalization to those of non-decriminalized states and found that trends in both increased suggesting that decriminalization itself did not lead to an increase in use. However, the study was limited by the fact that it only had data for one year in California prior to the policy change, so it is not clear whether the policy in fact differentially influenced trends in use.

DiNardo and Lemieux (2001) found a similar null effect of decriminalization in their examination of thirty-day prevalence rates from the 1980-1989 Monitoring the Future Surveys of high school seniors. DiNardo and Lemieux used state-level aggregated data to estimate bivariate probit models of the likelihood of using alcohol and marijuana, and was the first to consider the potential correlation between the demands for these two substances including measures of the

⁶ According to self-reports from the MTF, approximately 5% of high school seniors report daily marijuana use (Johnston et al., 2009).

price of alcohol and minimum legal drinking age. However, they did not include any additional measures of marijuana legal risk in their models. That is problematic inasmuch as subsequent papers examining the effects of marijuana decriminalization on youth participation rates in the United States generally find that the effects of decriminalization are only apparent when additional measures of legal risk or monetary price of marijuana are included (Markowitz and Tauras, 2009).

However, studies that consider additional measures of the legal risk of consuming marijuana or also include a measure of the price of marijuana have generally found that marijuana decriminalization has a positive and statistically significant effect (Chaloupka, Grossman and Tauras, 1999; Chaloupka et al., 1999; Pacula, Chriqui and King, 2003; Williams 2004). Using data from the 1982 and 1989 waves of the Monitoring the Future Survey, Chaloupka, Grossman and Tauras (1999) examined the effect of marijuana decriminalization and state-level median fines for possession and sale of marijuana on marijuana consumption. In models that accounted for family structure and parental education, they find that marijuana decriminalization is associated with higher prevalence of marijuana in the past year (representing infrequent and irregular new users) but not in the past month (which is taken to represent more regular users). Simulations based on these estimates suggest that annual prevalence would be 4 to 5 percent higher if all states decriminalized marijuana. However, they find that decriminalization status is not associated with frequency of use conditional upon reporting any use either in the past year or the past month, suggesting that the legal risk deters initiation but does not deter consumption once someone starts to use. Higher median fines for possession of small amounts of marijuana were associated with not only lower annual and thirty day prevalence of marijuana, but also lower frequency of use among users. The find no effect of median fines for the sale of marijuana and marijuana use among youth.

Using later waves of the MTF survey (1992-1994) and including respondents from the 8th and 10th grades, Chaloupka et al (1999) again explore the effects of marijuana decriminalization and median fines on marijuana prevalence in the past month, but this time they also include a measure of median jail time served.⁷ As the purpose of the paper was to examine the relationship between cigarette and marijuana use, cigarette and alcohol prices were also included in the marijuana demand equations. Decriminalization status was found to be positive and statistically significant in both the thirty-day prevalence and conditional frequency equations when additional measures of the legal risk were included in the model.

In a comprehensive assessment of the influence of legal risk on youth initiation and of marijuana, Pacula et al. (2003) examined the effect of marijuana decriminalization on prevalence rates among a group of 10th grade students from the 1990 wave of the National Educational Longitudinal Survey of 1988. In their analysis, Pacula et al. (2003) systematically introduced to empirical specifications of annual and thirty day prevalence equations different dimension of marijuana depenalization policies (changes in criminal status, reduced time in jail, lower fines, relative enforcement). They found, contrary to expectation, that as more aspects of legal risk were accounted for in the model, the decriminalization dummy variable (which was believed to capture the criminal status and harshness of penalties) got larger in magnitude and remained statistically significant. Their interpretation of these results, in light of the fact that some of the legal penalties were also statistically significant, is that social norms toward marijuana are more favorable to use in states that have decriminalized possession. Their results also show that a one-

⁷ As 8th and 10th graders were included in this sample, thirty day use will largely reflect new initiation or casual experimentation with marijuana.

day increase in minimum jail time is associated with a 7 to 9 percentage point reduction in annual prevalence rates and a 4 percentage point reduction in thirty-day prevalence rates among 10th graders, suggesting that criminal penalties do influence youth use. Higher fines were associated with less use, but not significantly so.

In another study Farrelly et al. (2001) show that both higher average fines and greater enforcement risk, as measured by the number of marijuana possession arrests divided by the number of marijuana users at the state level, are associated with lower past month prevalence rates among youth using the 1990-1996 NHSDA. Youth are defined a bit differently, including individuals between the ages of 12 to 20 years of age. Nonetheless, the results from their preferred specification suggest that a 10% increase in the probability that a marijuana user is arrested for possession decreases the probability that a youth reports use of marijuana in the past month by 3%. They also find that higher average fines are statistically associated with lower thirty day prevalence rates, but the magnitude of these effects are quite small. Conditional upon deciding to use marijuana, they find that the frequency of marijuana consumption is not influenced by either the average fine for possession or the likelihood of getting arrested.

Studies that have included a measure of the price of marijuana have found that youth marijuana participation is also sensitive to changes in price, although prevalence and frequency of use respond differently. Studies that have examined just the prevalence of use in samples of youth in high school or elementary school find evidence that higher prices are associated with less annual and thirty day use of marijuana (Pacula et al., 2003; Jacobson 2005; Pacula et al., 2001). The effect sizes tend to be small. Pacula et al (2001) is the only study that uses the results to generate participation elasticities of demand for youth. Ranges of estimates were generated from a variety of different models on the same sample that accounted for other aspects of the legal risk and even potency of marijuana. Annual participation elasticities fell in the range of -0.06 to -0.47, while thirty day participation elasticities generated a wider range of -0.002 and -0.69. Across all the models, when the preferred specification is employed, the price elasticity for both annual and thirty day prevalence is -0.30, implying that a 10% reduction in the price of marijuana would lead to an increase in the number of high school seniors reporting past year and past month use of 3%.

Additional evidence of the importance of price on the prevalence of marijuana use among teenagers comes from Jacobson's analysis of the size of birth cohorts and marijuana use using youth cohorts from the National Survey on Drug Use or Health (Jacobson, 2005). Jacobson provides important evidence demonstrating that annual prevalence trends in marijuana use among high school seniors and household youths between the ages of 15-19 track incredibly closely to the size of youth cohort. She examines what could be driving this positive correlation, considering factors related to resource constraints and law enforcement, scale economies in drug markets, and intergenerational attitude transfers. Her results suggest that it is the supply channel (lower prices during large birth cohorts because of bigger markets) that explains the largest share of the association, explaining at least a quarter and possibly more of the relationship.

Previous research had suggested that the most significant factors influencing initiation and use rates among youth were changes in perceived harm and disapproval (Bachman et al., 1998, 1988). Pacula et al. (2001) challenged this notion by examining the relative importance of purity-adjusted price vis-à-vis perceived harm, disapproval and peer effects in predicting trends in use over time. Using both time series and panel data techniques, the study showed that changes in quality-adjusted price contributed significantly to the trends in youth annual and

thirty-day use rates between the period of 1982-1998, but played a particularly strong role during the contraction of use from 1982 to 1992. Of course, perceived harm and disapproval were also important, and played a larger role in the expansion of use period that was considered.

A rather extensive international literature also exists examining the effects of various aspects of the full price of marijuana on prevalence rates (Ramful and Zhao, 2009; Williams 2004; Williams and Mahmoudi, 2004; Zhao and Harris, 2004; Clements and Daryal, 2003; Cameron and Williams, 2001), although relatively few explicitly examine use rates among youth (age ≤ 18). This makes it difficult to compare findings from this literature for youth in particular, so we review most of these studies later when discussing findings from the general using population. There are two important exceptions however that actually examine initiation behavior itself.

Van Ours and Williams (2007) construct cannabis use histories from the 1998 Australian Household Survey to estimate hazard models of the initiation and quitting behavior among young marijuana users. The model included a larger age range than discussed thus far, with individuals as old as 22, but their data show that most initiation occurs before age 18, with the peak at age 16. And given the focus on the decision to initiate (and quit for those using), the study provides interesting insights into the responsiveness of this isolated decision to changes in the full price of marijuana. The price of marijuana was found to be statistically significant in all of the equations, with the initiation elasticity ranging from -0.31 to -0.70. The past year initiation elasticity of their preferred model, which accounted for unobservable state fixed effects and a calendar trend picking up the downward price in marijuana over the study period, was -0.50.

Bretteville-Jensen and Williams (2010) use data from the 2007 Australian National Household Survey on Drug Use to estimate a proportional hazard model of the conditional probability of starting to use marijuana, building on work in the previous study. In this study they also consider the influence of decriminalization and the model includes individuals from all ages groups (although sensitivity analyses examine youth under the age of 18 to those older than 18). They find that state-level marijuana prices have a negative and statistically significant effect on the likelihood that individuals report using marijuana, but that the effect is driven by the sample of youth under the age of 18. The monetary price of marijuana was not statistically significant for predicting initiation of marijuana for individuals who choose to start after age 18. Interestingly, they find that after controlling for the monetary price of marijuana and other unobservable state effects, decriminalization status has no statistically significant effect on the probability of initiating marijuana. They are cautious interpreting their result as indicating that a change in the legal treatment of marijuana possession has no effect on initiation, as they note that counteracting factors and unobserved changes in enforcement toward youth may explain the lack of a finding on initiation rates even though their own analyses of the same data show effects on general prevalence rates.

II.C Implication of findings in terms of potential effect of legalization

Our review of the current literature on initiation and use among youth (age < 18 years of age) is that initiation and consumption by this group is in fact sensitive to changes in prices. Lower monetary prices that could accompany legalization will mean more kids will initiation use. How much? Price elasticities are imprecise measures given that the probable change in price is unlikely to be small, but if we use the literature to provide a very conservative estimate then it suggests that youth initiation rates could increase 3 to 5 percent with every ten percent

reduction in price from the current black market levels. This of course represents only a change in consumption associated with the change in monetary price, and has been noted throughout, initiation and use by youth is sensitive to other factors that will be influenced by legalization, such as legal penalties and enforcement risk. The literature suggests that for youth, the legal penalties have only a negligible effect on use, not because they are statistically unimportant but because they are a pretty precisely estimated zero. In light of this, it seems that enforcement elasticities are more important, and it is not at all clear how enforcement toward minors would change under the change in policy, as none of the initiatives to legalize marijuana in California allow minors under the age of 21 to use marijuana. Assuming the goal of a change in policy is not to focus our criminal resources on youth, a useful rule of thumb suggested by the literature is that prevalence of marijuana use would increase 2% for every 10% reduction in the enforcement risk.

Legalization would have an additional impact on consumption by youth by influencing perceived harms of marijuana and social norms, which have not been the focus of the economics literature. However, one particular study Pacula et al (2001) considered this in conjunction with other economic variables and their results suggest that a 10% decrease in the perceived harm of marijuana would generate a 28.7% increase in annual prevalence of marijuana use among youth, which is substantially larger than the results found for monetary prices, legal risks and law enforcement. Importantly, this effect will occur above and beyond any effect of changes in the monetary price or legal risk of using. Thus, the total impact of legalization on marijuana use among youth could be quite substantial depending on how large (in percentage terms) price and perceived harms decline in response to the policy change.

III. The responsiveness of regular use

III.A. A summary of the literature on regular use

Due to data limitations, the economic literature typically defines “regular users” as individuals who report use on at least a monthly basis (so reporting that they used some positive amount in the past 30 days or at least 12 times in the past year). Clearly, this is a very imprecise measure of regular marijuana users, as this could easily capture new initiates as well. However, nationally representative data provide no more reliable definitions that can be systematically compared across states or countries.

Importantly, regular users also get defined by specific age group, as epidemiological data consistently demonstrate that regular use of marijuana peaks during young adulthood. According to the 2008 NSDUH 16.5% of individuals between the ages of 18-25 report having used marijuana in the past month, while only 6.7% of 12-17 year olds report use in the past month and 4.2% of individuals aged 26 and older. If you look at the age groupings for the older groups in finer detail, they demonstrate that 10.5% of 26-29 year olds report use in the past month; 7.2% of 30-34 year olds, 6.1% of 35-39 year olds, and 4.1% of 40-44 year olds. Thus, prevalence rates clearly decline with age after age 30.

There is a far larger economics literature on marijuana use among “regular users” than that for any other group. Most analyses examining specific aspects of the full price of marijuana (monetary price, legal risks, enforcement) on use examine prevalence, not frequency of use however. Table 2 provides a summary of some key studies that have considered the influence of various economic components of the full price among young adults and adult samples. Several more studies, reviewed herein, consider changes in annual prevalence rates as well. These

studies are excluded from the summary table so as to focus attention on results for regular users, as defined above. Given the inconsistency in age groups included in various samples across studies and the probable compositional impact this is likely to have on findings, an additional column is added to Table 2 to capture the age of the sample (and assist with interpretation).

Table 2: Summary of Findings from Literature Examining Regular (Past Month) Users

Policy	Summary Estimates	Studies	Age of sample
Monetary price	-1.01 to -1.51 (full demand elasticity); -0.7 to -1.0 (30 day participation elasticity).	Nisbet and Vakil (1972)	College students – own sample
	-0.24 (30 day participation elasticity)	Williams et al (2004)	College students – Harvard College Alcohol Study (HCAS)
	-0.26 (30 day participation elasticity)	Williams et al (2006)	College students - HCAS
	-.40(full demand elasticity)	Clements and Zhao (2009)	Constructed from aggregate data and assumes MJ price doesn't vary (only alc and legal prices do)
Decriminalization	No effect on prevalence or frequency of use	Thies & Register (1993) ; Pacula (1998)	NLSY79 Young adults (21-30)
	Past month use participation elasticity: 0.07-0.09.	Saffer and Chaloupka (1999).	1988, 1990, 1991 NHSDA (includes illicit drug prices)
Penalties	-0.008 effect of median fine on thirty day use. No effect on frequency of use	Farrelly et al (1999) *controls for enforcement too	21-30 NSDUH (1991-1994, 1996)
	Median fine insignificant	Williams et al (2004)	College – HCAS
Enforcement	Crime per officer ratio positive and significant (elasticity not specified)	Pacula (1998)	NLSY79 young adults (1984 wave)
	Past month participation elasticity for MJ arrests to users: -0.157 to -0.176	Farrelly et al (1999) Monetary price measure included	21 – 30 NHSDA

Several key insights can be taken away from the review. First, regular users are sensitive to changes in the monetary price of marijuana. Prevalence estimates suggest that a 10% decline in price could lead to a 2.4 to 2.5 percent increase in rates of use among regular users. Full consumption effects, in terms of level of use, may even be larger, as indicated by the full demand elasticities, although international studies focusing on conditional quantity consumed in the past year suggests otherwise. Results from these studies (not in the table) suggest that the level of consumption among past year users is not responsive to changes in marijuana prices although they are responsive to changes in enforcement. This stands in stark contrasts to findings from the alcohol and tobacco literature, which consistently find that quantities consumed among users are also sensitive to changes in price (Chaloupka and Wechsler, 1997; Chaloupka and Grossman, 1996; Manning et al., 1995; Lewit and Coate, 1982). The difference in results regarding marijuana consumption and alcohol or tobacco consumption is probably a function of the relatively weaker data we have available on conditional quantities consumed and

prices for marijuana and the fact that the bulk of the studies examined level of use among users in the past year (rather than the past month).

A second key insight from this literature is that very few studies have considered the impact of penalties and enforcement on level of use among regular users. Although a number of studies examine the impact of decriminalization policy, the findings here are generally inconsistent. Studies that instead explicitly examine penalties and enforcement risk show that use among regular users may be sensitive to certain dimensions. Studies examining effects with respect to median fines, for example, show mixed results and even when the result suggests a sensitivity to this penalty, the effect sizes are small in magnitude. Studies examining enforcement, however, consistently show that risk of arrest influences both level and frequency of use above and beyond the influence of a price change. The precise magnitude of this enforcement effect on regular users, however, is still being evaluated. We now turn to a more detailed review of each of the studies.

III.B. A review of the literature on regular use of marijuana

The very first study to examine the price elasticity of demand for marijuana was a study that drew its sample from the population of UCLA undergraduate students. Nisbet and Vakil (1972) conducted surveys of UCLA students and inquired about their prevalence and frequency of marijuana use in the past 30 days. Their estimates of the price elasticity of marijuana participation for this group ranged from -0.7 to -1.0, when the students were told to report the difference in their consumption in response to a real price change. Nisbet and Vakil (1972) also considered how total quantity consumed would change with a change in price, not just one's willingness to use any marijuana. Their estimate of the total elasticity of demand, which captures changes in average consumption of those that are already using as well as the decision to use, fall in the range of -1.01 to -1.51, suggesting that the total demand for marijuana is actually quite sensitive to changes in price.⁸

Most of the papers published in the economics literature examining use by young adults following this study by Nisbet and Vakil focused again on issues related to legal risk rather than price, due to the absence of a national data source for marijuana prices. Many studies that only included a measure of decriminalization status and no measure of the monetary price of marijuana or other legal risks associated with possession of marijuana generally generated mixed conclusions. For example Thies and Register (1993) and Pacula (1998) found decriminalization to have no effect on the annual or thirty prevalence of marijuana among young adults from the 1984 and 1988 waves of the National Longitudinal Survey of Youth 1979 Cohort. They also found no statistically significant effect on the frequency of use. However, in a series of papers by Saffer and Chaloupka using the 1988, 1990 and 1991 NHSDA that also includes measures of alcohol, cocaine and heroin prices, they find positive and statistically significant effects of marijuana decriminalization on both past year and past month use (Saffer and Chaloupka, 1999a and 1999b).⁹

⁸ We focus on findings from this study reported for an actual price change rather than responses to a hypothetical price change, as these data are deemed more reliable.

⁹ In their second paper (Saffer and Chaloupka, 1999b) that examines differences across gender and ethnicity in past year participation, they find that the positive effect of decriminalization holds for all subgroups except Native Americans. Living in a decriminalized state increases the probability of reporting use in the past year from 2% (for Asians and African Americans) to 4% for Hispanics and individuals under the age of 21.

Similar to what was reported for youth above, studies that focused more explicitly on the actual penalties imposed for possession of small amounts of marijuana and/or the enforcement risk of marijuana generally found changes in consumption associated with small differences in legal risks. Farrelly et al. (1999) show that both higher average fines and greater enforcement risk are associated with lower past month prevalence rates among young adults using the 1991-1994, 1996 NHSDA. Their models suggest that a 10% increase in the proportion of marijuana users arrested for possession would be associated with a 1.6% to 2.0% reduction in the prevalence of marijuana use among young adults (ages 21-30).¹⁰ Similarly, higher median fines are associated with reduced monthly prevalence, however the effect size is small. A 10% increase in the median fine is only associated with a 0.08% reduction in prevalence. Conditional quantities are not considered in this analysis.

The relatively few U.S. studies that have been able to include a measure of the monetary price of marijuana have found consumption by young adults and adults more generally is sensitive to changes in price. In a series of studies looking at the demand for marijuana among American college students, Williams and her colleagues examine annual and thirty day prevalence measures (Williams et al., 2006; Williams et al., 2004). In the first study annual and thirty day prevalence equations are estimated concurrently with the decision to use alcohol using a bivariate probit technique that accounts for unobserved heterogeneity that could influence the decision to use both substances (Williams et al., 2004). They estimate a past month marijuana participation elasticity for young adults 18-24 of -0.24, suggesting that a 10 percent decrease in the price of marijuana would lead to a 2.4% increase in regular use among college students, controlling for the relationship this use may have with alcohol consumption. They also include a measures of the maximum fine for possession of small amounts of marijuana and find, when state fixed effects are included (their preferred model) the legal penalty had no effect on consumption for this group. In the second study, they examine demographic differences in past year use, accounting for the relationship marijuana consumption might have with alcohol and cocaine through cross-price effects (Williams et al., 2006). Results from these models are consistent with findings from the previous study, although they also examine differential effects by age groups within the college population. They find an annual participation elasticity for individuals 18-20 of -0.16 and an annual participation elasticity among 21 -24 year olds of -0.26, suggesting that the older group is even more sensitive to changes in price.

DeSimone and Farrelly (2003) estimate models of annual prevalence and frequency of marijuana use among 18-39 year olds from the 1990-1997 NSDUH, which they compare to results for 12-17 year olds from the same survey years. Their models include measures of the monetary price of marijuana in addition to enforcement risk, represented as the number of marijuana arrests divided by the number of marijuana users within the state. They find very clear negative effects of marijuana enforcement on both prevalence and frequency of marijuana use, suggesting that greater enforcement reduces marijuana use above and beyond any effect this might have on marijuana prices. They also find a negative relationship between marijuana prices and marijuana use, although the results are extremely sensitive to the inclusion of additional variables and controls for unobserved fixed heterogeneity. When fixed effects are included for the same geographical areas as the prices are constructed from (division), price is negative and statistically significant, although very large relative to the other estimated effects. The

¹⁰ It is interesting to note that the results for youth (< 18) in this analysis are different from those published by a subset of the group in 2001. The differences are likely due to changes in the exact specification of the model, but again raise the sensitivity of drawing firm conclusions from any one particular study.

inconsistency in findings is not surprising given the limited variation that is available in the price series used in this (and other) studies, which represents variation across only 19 divisions of the United States.

There is also evidence from international work demonstrating the sensitivity of consumption to changes in the price of marijuana. Studies exploiting variation in state-level marijuana prices identified through law enforcement activities in Australia have generally shown demand to be sensitive to these variables, although in many cases there is important variation across subgroups of the population by gender and other substances used (Clements and Zhao, 2009; Ramful and Zhao, 2009; Williams and Mahmoudi, 2004; Williams 2004; Cameron and Williams, 2001). In all of these cases, prevalence is estimated in terms of annual prevalence rates, which is a bit inconsistent with our definition of regular user. However, in several of the studies they consider the frequency of use in the past year, which allows one to capture the more involved user from the less involved user. Other studies are able to look at selective subgroups of users. For example, Ramful and Zhao (2009) find that marijuana prices are significantly associated with the probability of using marijuana for individuals who also use cocaine and heroin, not for the unconditional sample of marijuana users. It is possible that this represents compositional effects of the population that reports having used marijuana in the previous year (which is what they estimate). Similarly Williams and Mahmoudi (2004), using earlier waves of the Australian Household Survey, finds that while annual prevalence of marijuana is statistically and negatively associated with price, it is driven by the group of individuals who report using both marijuana and alcohol (polydrug users). Findings estimating the level or frequency of marijuana use among current Australian users generally find the level of use conditional upon any use to be unaffected by changes in price (Williams 2004; Zhao and Harris, 2004). The lack of a significant effect of price on the frequency of consumption is surprising, but it may have more to do with the fact that frequency of use is not perfectly correlated with quantities consumed (and a true conditional demand elasticity would be sensitive to changes in average quantities consumed).

The literature examining the association between prices and quantities consumed among marijuana users (conditional demand) is significantly limited, due in part because information is only available on frequency of use occasions not actual quantities consumed. However, in the tobacco and alcohol literatures there are a number of studies that tend to demonstrate the same basic pattern: consumption among current users is at least 50% as responsive as the decision to use and for some age groups it is even higher (Lewit and Coate, 1981; Hu et al., 1995; Manning et al., 1995; Chaloupka and Grossman, 1996; Chaloupka and Wechsler, 1996). Lewit and Coate (1981), for example, used data from the Third Cycle of the Health Examination Survey and were the first to notice the relationship between participation elasticities and conditional demand elasticities, estimating an elasticity of smoking participation of -0.26 and on overall price elasticity of demand of -0.46. Using the same data in a different published study they also showed that there was an inverse relationship between the absolute value of the price elasticity and age (Lewit and Coate, 1982). Specifically, they found that the total price elasticity of demand for 20-25 year olds was more than double that for individuals ages 26 and over. In a later study, Harris and Chan (1999) demonstrated using data from the 1992 and 1993 Current Population Survey that the relationship between the size of the participation elasticity and the unconditional demand elasticity varied by age. For youth (ages 15-17 and 18-20) the participation elasticity for smoking was found to be more than half of the unconditional demand elasticity, suggesting that prevalence rates were important predictors for demand by these age

groups. For older cohorts, however, the participation elasticity was less than a third of the total unconditional demand elasticity, suggesting that the influence of price on quantity consumed becomes more important than participation as people age.

If marijuana is used recreationally in a fashion similar to that of alcohol and/or cigarettes, then it is plausible that the price sensitivity of conditional demand among regular users is at least 50% and possibly as large as 100% the size of the participation elasticities estimated thus far. The implications of this for projections of the effects on legalization could be substantial, as discussed in the next section.

III.C. Implication of findings in terms of potential effect of legalization

Results from these studies suggest that regular use of marijuana will increase both in prevalence and in terms of average level of use with a fall in the monetary price of marijuana and a reduction in the enforcement risk of using marijuana. The precise increase in use, particularly in terms of average quantities consumed among users, remains unclear because of inadequate analyses of conditional demand. However, it is clear that the number (prevalence) of regular users will rise in response to both. As the primary user group appears to be young adults ages 18-25, then it is possible that use will rise among a group (18-20) that is deemed too young to be using marijuana, raising questions as to whether and to what extent enforcement against use by minors will be invoked.

IV. Responsiveness of heavy use

Very little work has been done explicitly examining the sensitivity of heavy or dependent users to changes in prices and other economic variables. So, unlike the previous sections, we simply briefly review here the two studies that provide insights as to the responsiveness of heavy use to changes in the monetary price and/or legal risk associated with marijuana.

In an early study of the impact of marijuana decriminalization on marijuana use, Model (1993) evaluated the impact of a reduction in legal penalties on marijuana-involved emergency room department episodes using quarterly data from the 1975-1979 Drug Abuse Warning Network. The data were collected in 24 metropolitan statistical areas, of which several resided in states that adopted decriminalization policies. As data were available both pre and post the policy changes, Model (1993) was able to identify the impact of the policy on trends and determines that states that adopted decriminalization policies experienced a 56 to 64 percent increase in marijuana-involved emergency department visits than states who did not adopt these policies. She also found a significant decline in the number of emergency department episodes involving other illicit drugs in states that adopted these policies, suggesting a possible substitution of marijuana for these harder substances (DAWN does not record alcohol in all cases, so the substitution was only found with respect to harder substances). As a marijuana-mention in an emergency room episode does not indicate that marijuana was the cause of the episode, Model (1993) was careful to interpret her results as suggestive that a reduction in legal penalties would lead to an increase in either the number of marijuana users (and hence marijuana-involved episodes due to there just being more users in a given population) or more harmful use of marijuana among those that decide to use. Measures of marijuana prices and enforcement risk were not captured in her model.

In a different study, Pacula and Kilmer (2003) examine the association between marijuana use and marijuana-involved crime using a sample of arrestees from the Arrestee Drug Abuse Monitoring (ADAM) program. Arrestees are a population that is widely recognized as being heavily engaged in drug use, with over 60% of arrestees testing positive for marijuana use via urine samples in the United States, the UK and Australia (Makkai et al., 2000). As part of their analysis of the effect of consumption on crime, Pacula and Kilmer (2003) showed that self-reported use in the past thirty days and use in the previous 72 hours before the crime was committed (determined through self-report and urine analysis) were both negatively associated with self-reported price, meaning that lower prices were associated with more use for this group. A specific price elasticity of demand was not provided, given that the measure of price was not adjusted for potency, but the data were indicative of a strong association suggesting that even in a group of heavy users, consumption is sensitive to changes in price.

The idea that heavy use is at least as responsive to price (and other economic variables) as prevalence of regular users is not all that shocking when considered within the context of what is known about consumption of similarly intoxicating or addictive goods, in particular alcohol and cigarettes (Chaloupka and Warner, 2000; Manning et al 1995; Grossman et al., 1994). Manning et al (1995) was the first to carefully document how the price elasticity of demand changes over the distribution of consumption among drinkers. They found that drinkers' responsiveness to prices varied along with the different types of consumption in a U-shaped manner. Abstainers and extremely heavy drinkers were found to be the least responsive to changes in price, while light and moderate drinkers were more responsive. Their study did not suggest that heavy consumers were completely non-responsive. In fact, drinkers consuming in the 80th percentile of total consumption were significantly responsive to price, with a price elasticity of -0.74. However, drinkers in the further tail of the distribution (90th percentile) were not responsive to higher prices and behaved more like abstainers and light drinkers. Prior to this study, most analyses simply considered dichotomous indicators of heavy users, typically defined as drinkers who consume five or more drinks in a single drinking occasion, and found that these binge drinkers and/or binge drinking days were more responsive to changes in price than light or infrequent drinkers (Kenkel 1993; Grossman et al., 1994).

V. Impact of legalization and regulation on quit behavior

Economists have only recently begun to get interested in modeling the decision to quit marijuana use and examine the sensitivity of this decision to economic variables. The only published work including measures of the monetary price on the decision to quit is the work by van Ours and Williams (2007) using the 1998 Australian National Household Survey on Drug Abuse. In their models of the conditional likelihood of quitting marijuana use within the past year, they find that the monetary price of marijuana generally has a positive, although statistically insignificant, effect on the proportional hazard model for use among young users (\leq age 22). The models of quit behavior did show, however, that youth who initiate at an earlier age are less likely to quit use of marijuana, which is a result that is consistent with work from several other researchers using data from various countries but not including measures of the monetary price (van Ours, 2006; Pudney, 2004). Because marijuana prices are highly correlated with the decision to initiate early, then one can infer from these combined studies that higher marijuana prices reduce the duration of the typical use career.

While there is limited information available from the marijuana literature, there is a growing literature on tobacco examining the decision to quit. The tobacco literature demonstrates consistently that economic variables, including prices and perceived health risks, are important and statistically significant factors for deciding to quit (Jones 1994; Hymowitz et al., 1997; Tauras and Chaloupka, 1999; Forester and Jones, 2001). Again, if recreational use of marijuana is behaviorally similar to that of tobacco, then policies that lower the price of marijuana make it more difficult for individuals to decide to quit using it, thereby extending the duration of their use career.

VI. Implications and conclusions regarding probable effect of legalization on consumption of marijuana

The literature just reviewed demonstrates a number of limitations in our current understanding of the impact of price and policy variables on marijuana use. First and foremost, while a growing literature has developed analyzing the prevalence of any use, particularly use in the past month and the past year, very little work carefully considers the impact of economic variables on the level of marijuana use. This is a major limitation in efforts trying to ascertain the impact of marijuana legalization on overall use (and harms from use) as very little work explicitly considers this. Findings from the alcohol and tobacco literature consistently demonstrate that quantities consumed among existing users are sensitive to changes in the monetary and non-pecuniary components of price (Chaloupka and Pacula, 2001; Grossman et al., 1994) and it is changes in these types of users that are likely to be the most relevant for understanding the impact on total consumption (and hence total revenue). But without a specific understanding of how the level of use would change in response to price changes, any estimate of the effect of consumption due to a change in legalization will grossly understate the effects on total consumption.

Second, while changes in the monetary price of marijuana may be important for understanding how much consumption will change, other aspects of the change in policy including the reduction in the legal risk of using and perceived harm of use, will also be important predictors of how much consumption actually changes. Thus, models attempting to project the impact of a change on consumption associated with legalization must make assumptions regarding the anticipated change in perceived norms and harms in addition to assumptions regarding the change in price and legal risk. Ignoring these factors would again lead to an understated estimate on consumption.

Third, evidence presented here suggests that the entire etiology of marijuana use could change in a response to changes in consumption, as there is evidence that initiation, escalation and duration of use will all be impacted by elements of this policy change and in each case the effect is reinforcing: more new initiates, more regular users, and people using for longer periods of time. Summary measures from initiation suggest that for every 10% decline in the monetary price of marijuana, there will be an increase of 3 to 5% in new marijuana users prior to the age of 18, an increase of 2.5% in regular users, and because of the rise in early initiation among youth, an increase in the duration in which marijuana is used during adulthood. The implication will be an expanding market, both in terms of the number of users and in the total quantity consumed by the market. While various efforts might be used to try to counter these efforts, such as targeted prevention, these efforts are already in place in schools, communities, health care settings and even criminal justice settings, and are embedded in the estimates drawn from

these studies. Prevention would have to become even more effective than it already is to actually counter the trends suggested by the literature.

Finally, the research reviewed in this chapter focuses on the impact of small changes in marijuana prices or enforcement risk associated with marijuana use in a prohibition regime. While insightful, none of this work provides anything more than simple insights into how consumption might change in response to large changes in the price, perceived harm, or enforcement risk that could accompany a policy change like legalization as these are changes outside the scope of the models being empirically estimated. While we do not know what legalization would look like in California, it will not be a marginal change and hence reviews of the literature such as these can only be suggestive of directional changes rather than precise measures of changes in terms of order of magnitude.

Even given these caveats, it is clear that consumption is likely not to be unchanged in response to legalization. Both the numbers of users and the average quantity consumed among existing users (regular or heavy users) will likely go up in response to this policy. How much will completely depend on the following factors: the decline in price caused by the removal of prohibition of supply, the extent to which the new laws prohibiting use among youth and young adults less than 21 are enforced, and the changes in perceived harm and social norms related to marijuana use. In other work, we put together our best guesses of how much each of these will change to evaluate what the probable total effect of legalization would be on consumption and revenues (Kilmer et al., 2010). We use findings from this review, however, to inform our best guesses regarding how much consumption will change in response to a decline in the monetary price of marijuana (-0.3 for change in prevalence and -0.225 for conditional quantity consumed for a total elasticity of demand of -525). The change in conditional quantity demand is guesstimated by approximating the relationship between elasticities and conditional demands observed in the alcohol and tobacco literatures cited above.

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