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Why Changes in Price Matter When Thinking About Marijuana Policy: A Review of the Literature on the Elasticity of Demand

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Abstract

Recent debates regarding liberalization of marijuana policies often rest on assumptions regarding the extent to which such policy changes would lead to a change in marijuana consumption and by whom. This paper reviews the economics literature assessing the responsiveness of consumption to changes in price and enforcement risk and explicitly considers how this responsiveness varies by different user groups. In doing so, it demonstrates how most of the research has examined responsiveness to prevalence of use, which is a composite of different user groups, rather than level of consumption among regular or heavy users, which represent the largest share of total quantities consumed. Thus, it is not possible to generate reliable estimates of the impact of liberalizing policies on either tax revenues or harms, as these outcomes are most directly influenced by the amounts consumed by regular or heavy users, not prevalence rates.

Keywords

Marijuana; Price; Price Elasticity of Demand

INTRODUCTION

A vast literature has developed over the past twenty years examining the etiology of and factors influencing marijuana consumption. Economists have contributed to this literature by demonstrating the relative importance of changes in the full price of marijuana on marijuana use and drug use careers. The typical approach used by economists to describe how sensitive a user is to changes in the price of a good is the “price elasticity of demand.” The price elasticity of demand measures how much consumption of a good changes (in percentage terms) in response to a one percent change in the price of that good holding all other factors constant. As demand for most goods is downward sloping, the price elasticity of demand is generally negative indicating that when price goes up consumption goes down. A value less than one in absolute value (that is, between 0 and 0.99) is generally considered to be “inelastic” or less responsive to price changes because consumption changes (in percentage terms) less than price changes (in percentage terms). A value greater than one in absolute value is generally considered to be “elastic”, because the percentage change in consumption observed with a one percent change in price is greater than that for price.

Discussion of the price elasticity of demand for marijuana has grown recently in light of debates about marijuana legalization in the U.S. and abroad. However, many who draw on this literature to substantiate a particular position regarding legalization do so naively, unaware that the responsiveness of consumption to price can depend on where in the distribution of marijuana users the sample is drawn. Marijuana markets, like markets for other goods, are characterized by a number of different types of consumers, all of whom contribute in varying amounts to the total amount consumed in the market¹⁻³ and researchers have been careful to consider the type of user in constructing estimates of use.^{4,5} Yet, reviews of the literature on the price sensitivity of demand often ignore these important differences.

This paper contributes to the existing economic and policy literatures on the demand for marijuana and the probable impact of policy on consumption by clearly differentiating the findings from the literature regarding the price elasticity of demand by different types of user groups. In doing so, it becomes readily apparent that various groups might respond differentially to a policy change. In particular, this paper considers how responsive consumption has been to various components of the full price of marijuana, which captures both the monetary aspect of price as well as the non-pecuniary aspects of price, such as the legal risk of using it and/or the perceived health risks. The four user groups considered are (a) initiators and light users – new users who are experimenting with marijuana or consuming small doses on a very infrequent basis; (b) regular users – individuals who consume in relatively small or moderate doses on a more frequent basis; (c) heavy users – individuals who consume on a near daily basis or who meet Diagnostic and Statistical Manual of Mental Health (DSM-IV) criteria for dependence or abuse; and (d) quitters – individuals who are deciding to no longer use marijuana.

Our thesis is that consumption by each of these groups will be differentially impacted by price changes and thus prevalence rates by themselves are imperfect indicators of real consumption changes caused by price changes. Prevalence rates conflate changes in the behaviors of new initiates and casual users with the behaviors of regular or heavy users. Although new initiates and casual users represent a large proportion of the total number of users, they represent a very small amount of the total quantity of the drug consumed.^{1,3,5} Estimates of a price decrease of more than 80 percent^{6,7} would have very different implications for light users, who spend a very small share of their income on marijuana, than on more regular or heavy users, who spend more of their disposable income on the good.

DISCUSSION

The Responsiveness of Initiation

If the goal is to understand factors influencing marijuana initiation, then one must start by looking at use among adolescents. While not all individuals who initiate marijuana are adolescents, the average age of initiation of marijuana among those reporting in the household population is just under the age of 18.⁸ Thus data on adolescent marijuana initiation can contribute insights into initiation generally.

Research into factors associated with marijuana initiation and use by adolescents has generally focused on non-monetary aspects of price, including perceived harm and disapproval.^{9,10} However, monetary price is also important. Pacula et al. (2001) examined the relative importance of price and non-monetary harms in predicting trends in use over time.¹¹ While perceived harm and disapproval were important, and played a larger role in the period of expanded use, changes in purity-adjusted price contributed significantly to the trends in youth annual and thirty-day use rates from 1982 to 1998, and particularly in the contraction of use from 1982 to 1992. Annual participation elasticities from this study fell in the range of -0.06 to -0.47, while thirty day participation elasticities generated a wider range of -0.002 to -0.69. Their preferred specification identified a price elasticity for both annual and thirty day prevalence of -0.30, implying that a 10 percent reduction in the price of marijuana would lead to a 3 percent increase in the number of high school seniors reporting past year and past month use.

Other studies have looked at the impact of price on annual and thirty day prevalence of use among high school or elementary students and found negative and statistically significant relationships, but the effect sizes have been small and participation elasticities are not reported.^{17,18, 20} Two Australian studies look more directly at the impact of price on initiation using duration models. Van Ours and Williams (2007) and Bretteville-Jensen and Williams (2010) both examined initiation among youth and young adults in Australia and found marijuana price to be negatively associated with initiation.^{21,22} In Van Ours and Williams (2007), the initiation elasticity ranged from -0.31 to -0.70, with their preferred specification generating a past year initiation elasticity of -0.50. Bretteville-Jensen and Williams (2010) built on this work and found that initiation was driven by the sample of youth under the age of 18 and the monetary price of marijuana was not statistically significant for predicting initiation of marijuana for individuals after age 18.

As economists interpret price more broadly to also include the non-pecuniary aspects of using a good (e.g. the legal risks, the health risks, the search costs), many studies have considered the responsiveness of consumption to decriminalization status and legal risks of using marijuana. In one of the earliest studies of the effects of state decriminalization policies, Johnston et al. (1981) compared marijuana use in the 1970's across states and found no evidence that the decriminalization of small amounts of marijuana in California in 1976 increased use.¹² DiNardo and Lemieux (2001) found a similar null effect of decriminalization in thirty-day prevalence rates for high school seniors in the 1980s.¹³ However, these two studies did not include any additional measures of legal risk in their models, which is problematic as subsequent papers found that the effects of decriminalization are only apparent when additional measures of legal risk or monetary price of marijuana are included.^{14,15}

Studies that included additional measures of the legal risk of consuming marijuana or the monetary price of marijuana have generally found that marijuana decriminalization has a positive and statistically significant effect.¹⁶⁻¹⁸ Using data from the Monitoring the Future Survey, Chaloupka, Grossman and Tauras (1999) found that decriminalization was associated with higher prevalence of marijuana in the past year but not in the past month when state-level fines were also included.¹⁶ Additionally, they found that among those who

report some use, decriminalization was not associated with frequency of use, suggesting that the legal risk deters initiation but does not deter consumption once someone starts to use. Chaloupka et al. (1999) found broader effects when including an additional measure of median jail time served,ⁱ with decriminalization status coming in positive and statistically significant in both the thirty-day prevalence and conditional frequency equations.¹⁷ Finally, Pacula et al. (2003), in an examination of 10th grade students, found decriminalization to be statistically significant above and beyond actual penalties (such as changes in criminal status, reduced time in jail, lower fines, and relative enforcement).¹⁸

In addition to the effects of general decriminalization are the costs of the expected punishment. The expected punishment depends on both the severity of a punishment and the likelihood that the punishment will be carried out. In marijuana policy research, severity is often measured using fines or time in jail while the likelihood of punishment is often associated with the intensity of police enforcement. Chaloupka, Grossman, and Tauras (1999) found fines to be associated with lower annual and thirty day prevalence of marijuana and lower frequency of use among users,¹⁶ while Chaloupka et al (1999) found statistically significant effects only with regards to fines¹⁷ and Pacula et al. (2003) found them only with regards to jail time.¹⁸ Farrelly et al. (2001) examined the effect of average fines and without consideration of decriminalization in a nationally representative sample of youth between the ages of 12 to 20.¹⁹ They found that youth living in states with higher average fines had lower rates of use, but not lower levels of use among those who used marijuana already, suggesting the deterrent effect was on the decision to use not the quantity consumed.

Table 1 summarizes the findings with respect to the effects of the monetary price, decriminalization, and the legal risk (penalties and police enforcement) of marijuana on the decision to use marijuana among youth. Marijuana initiation among youth is very sensitive to changes in the price of marijuana with plausible initiation elasticities from -0.3 (in Pacula et al., 2001) to -0.5 (in Van Ours and Williams, 2007). The literature suggests that policies that reduce the price of marijuana by 10 percent therefore, will lead to a 3-5 percent 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, although there is some inconsistency from study to study as to whether it youth prevalence rates are more sensitive to jail sentences or fines. In most cases, the impact of the legal risk on prevalence is generally small, and when frequency of marijuana use is examined, legal risks are generally insignificant. The effects of decriminalization are less clear from the literature, 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 knowledge about these policies.^{18,23,24} As there has been very little variation in decriminalization policies in the U.S. between the early 1980s and mid-2000s, it is difficult to infer anything from studies relying on variation in state policies.¹⁸

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

The Responsiveness of Regular Use

The economics literature typically defines “regular users” as individuals who report use on a monthly basis (so reporting that they used 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 and could easily capture new initiates as well. However, nationally representative data provide no other, more reliable measure. As with initiation, regular use is also associated with a specific age group, as epidemiological data consistently demonstrate that regular use of marijuana peaks during young adulthood. According to the 2008 National Survey of Drug Use and Health (NSDUH), the rate at which people report using marijuana in the past month more than doubles from teens under 18 to adults ages 18-25, and then declines with age after age 30. Therefore, we focus on studies of young adults in particular when trying to understand the responsiveness of behavior among “regular users.”

The literature examining the consumption behavior of regular users is larger than that for any other user group, however the vast majority of the work focuses on prevalence, not frequency of use. Table 2 provides a summary of some key studies that have considered various components of the full price on consumption among young adults. Several more studies reviewed herein consider changes in annual prevalence rates or apply to the general adult population, but these studies are excluded from the summary table so as to focus attention on studies targeting regular users, as defined above. As age still varies considerably even among the regular user population, we indicate in an extra column of Table 2 the age of the sample considered.

The first study to examine the price elasticity of demand for marijuana examined a population of American undergraduate students. Nisbet and Vakil (1972) inquired about students’ marijuana use in the past 30 days to estimate the effect of price both on the decision to use and the amount consumed.²⁵ Their estimates of the price elasticity of marijuana participation for this group ranged from -0.7 to -1.0, while the total elasticity of demand, which captures changes in average consumption among those already using as well as the decision to use, ranged from -1.01 to -1.51. The elasticities derived from this study suggest that the total demand for marijuana is actually quite sensitive to changes in price.ⁱⁱ Two other papers focused on the behavior of college students and found statistically significant price elasticities. Williams et al. (2004) estimated a past month marijuana participation elasticity for a nationally representative sample of American college students age 18-24 of -0.24, controlling for alcohol use as well as unobserved heterogeneity.²⁶ They also included a measure of the maximum fine for possession of small amounts of marijuana and found when state fixed effects were included the legal penalty had no effect on consumption for this group. In a follow-on study in which younger students were differentiated from older students and cocaine use was also accounted for, Williams et al. (2006) found a lower annual participation elasticity for young college students less than 21 of -0.16 and a higher participation elasticity for older students of -0.26.²⁷

ⁱⁱWe 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.

Other studies examining demand responsiveness using U.S. populations of regular users have examined non-monetary aspects of price. Studies that only include a measure of decriminalization status generated mixed conclusions. For example Thies and Register (1993) found decriminalization to have no effect on the annual or thirty day prevalence of marijuana or the frequency of use among young adults,²⁸ while a series of papers by Saffer and Chaloupka found positive and statistically significant effects of marijuana decriminalization on both past year and past month use.^{29,30ⁱⁱⁱ} However, studies that included actual penalties and/or enforcement risk instead of decriminalization status found that consumption is sensitive to small differences in legal risks.^{15,31} Farrelly et al. (1999) suggested that a 10 percent increase in the proportion of marijuana users arrested for possession would be associated with a 1.6 percent to 2.0 percent reduction in the prevalence of marijuana use among young adults.^{31,iv} Higher median fines were also associated with reduced monthly prevalence, although the effect size is small— a 10 percent increase in the median fine is only associated with a 0.08 percent reduction in prevalence. Conditional quantities consumed were not considered in this analysis.

Several studies have examined the responsiveness of annual prevalence rates and frequency of use (i.e. “conditional demand”) to changes in the full price of marijuana. The problem with using annual prevalence rates rather than past month prevalence rates to consider the responsiveness of regular users is that annual prevalence rates combine the behavior of new initiates and more persistent users, particularly for individuals past the age of initiation. Nonetheless, the general findings even for these models are supportive that consumption is sensitive to changes in the full price of marijuana. DeSimone and Farrelly (2003), for example, estimated models of annual prevalence and frequency of marijuana use among 18-39 year olds.³² They found 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 sensitive to the inclusion of state geographic fixed effects which is not surprising given the limited variability they have in price over the short period of time examined. Rhodes et al. (2000) also estimated a negative price elasticity in their models employing the entire household population (ages 12 years and older) using the National Household Survey on Drug Abuse (NHSDA). Their estimate of the annual price elasticity of demand was -0.33.³³

There is also evidence from international work demonstrating the sensitivity of consumption to changes in the price of marijuana when annual measures of use are used.³³⁻³⁸ For example, Ramful and Zhao (2009) found that marijuana prices were significantly associated with the probability of using marijuana for individuals who also use cocaine and heroin, but not for the unconditional sample of marijuana users.³⁴ Similarly Williams and Mahmoudi

ⁱⁱⁱIn 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.

^{iv}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.

(2004), using earlier waves of the Australian Household Survey, found that while annual prevalence rates were negatively associated with price, it was the group of individuals who report using both marijuana and alcohol (polydrug users) that drove that result. Studies examining the level or frequency of marijuana use among past year users generally found that these measures were unaffected by changes in price.³⁸⁻³⁹ The lack of a significant effect of price on the frequency of consumption in these Australian samples differs from findings using U.S. data.

In an effort to understand the extent to which population differences drove differences in findings regarding price elasticities, Gallet (2013) conducted a meta-analysis, building a model based on findings from 82 estimates from 13 studies of Australia and India as well as the U.S.⁴⁰ Gallet did not attempt to distinguish between different types of users, as we do here, but he still generates non-zero estimates of participation elasticities based on his meta-analysis in the range of -0.28 to -0.31. Follow up discussions with the author revealed that the conditional demand elasticity generated from the model for marijuana was estimated to be -0.15. Thus the findings from the meta-analysis reinforce the conclusion that in the U.S. changes in the monetary price of marijuana do influence both the prevalence of marijuana use and conditional quantity consumed.

Responsiveness of Heavy Use

Little work has been done explicitly examining the sensitivity of heavy or dependent use to changes in the full price of marijuana. In an early study of the impact of marijuana decriminalization on marijuana use, Model (1993) identified that states that adopted decriminalization policies experienced a 56 to 64 percent increase in marijuana-involved emergency department episodes compared to states who did not adopt these policies.⁴⁶ However, she also found a significant decline in the number of episodes involving other illicit drugs in states that adopted these policies, suggesting a possible substitution of marijuana for these harder substances. Measures of marijuana prices and enforcement risk were not included in her model, however.

Other studies have examined marijuana use among arrestees. Arrestees are a population that is heavily engaged in drug use, with over 60 percent of arrestees testing positive for marijuana use via urine samples in the United States, the UK and Australia.⁴⁷ Pacula and Kilmer (2003) found that use both in the past thirty days and in the 72 hours before the crime was committed were both negatively associated with self-reported price.⁴⁸ The lack of a potency-adjusted price limited the ability to create a specific price elasticity of demand, but the strong association did suggest that consumption is sensitive to changes in price even in a group of heavy users. Grossman (2005) linked external price data that adjusted for average potency to arrestee self-reported use data and found statistically significant price effects. His estimates of the price elasticity depended on the specification of the model, but fell in the range of -0.26 to -1.18.⁴⁹ Finally, Rhodes et al. (2000) found a very high elasticity of marijuana demand among arrestees, from -2.65 to -2.79.⁵⁰

Responsiveness of Quit Behavior

Economists have only recently begun to model the decision to quit using. The only published work including measures of the monetary price on the decision to quit is the work by van Ours and Williams (2007).²¹ In their analysis of young users (under the age of 23) in Australia, they found that the monetary price of marijuana generally had a positive, although statistically insignificant, effect on the likelihood of quitting marijuana in the past year. Considered along with other studies that found that marijuana prices were correlated with the decision to initiate drug use early,^{54,55} they suggest their findings suggest that higher marijuana prices still reduce the duration of the typical use career, but they do so by delaying initiation rather than enticing the user to quit.

RECOMMENDATIONS

It is now better understood that marijuana markets share some common characteristics with markets of other intoxicating goods. In particular, like alcohol, the casual user or marijuana represents a relatively large share of the proportion of people who report using any marijuana in the past year, but they represent a very small proportion of the total amount consumed.¹⁻⁵ This realization implies that knowledge of how prevalence rates change in response to a change in price may not be that useful for understanding how total consumption would change with a change in price because of the heterogeneity in users represented by any particular prevalence rate. To understand how total consumption (in terms of volume of the good consumed) changes, one needs to understand how behavior among regular users and heavy users changes. Participation elasticities, generated from studies examining how annual or thirty-day prevalence rates change with a change in the price of marijuana, represent the bulk of the estimates from the literature on elasticities so far. Far less time and attention has been given in the literature to precisely estimating the sensitivity of amount consumed or heavy use.

Manning et al (1995) was the first to carefully document the fact that the price elasticity of demand changes over the distribution of users.⁴³ Their analysis focused on drinkers and they found that the price elasticity of demand followed more of a U-shaped pattern. While, drinkers in the far tail of the distribution (90th percentile) were not responsive to higher prices and behaved more like abstainers and light drinkers, drinkers consuming in the 80th percentile of total consumption were significantly responsive to price, with a price elasticity of -0.74 that was much higher than that of moderate drinkers. Prior analyses that considered dichotomous indicators of heavy users found that binge drinkers and/or binge drinking days were more responsive to changes in price than light or infrequent drinkers.^{52,53}

To what extent might the same logic apply to marijuana? The literature described here suggests that a non-linear relationship is certainly plausible. What little evidence we have on heavy users suggests price elasticities substantially larger than those estimated from past month users. But the literature is thin, due in part to relatively lousy data on potency-adjusted marijuana and due in part to lousy data on how much marijuana is consumed in a single use occasion across different types of users. We do know that regular users are sensitive to changes in the monetary price of marijuana. Prevalence estimates suggest that a 10 percent decline in price could lead to a 2.4 to 2.5 percent increase in rates of use among

regular users. Full consumption effects, which would also capture changes in the amount consumed among existing users (i.e. “conditional demand”) may even be larger, as indicated by the full demand and conditional demand elasticities identified in the U.S. literature. The sensitivity of the conditional demand for marijuana to changes in prices in the U.S. is consistent with findings from the alcohol and tobacco literature, which have consistently shown that quantities consumed among users are also sensitive to changes in price.⁴¹⁻⁴⁵

However, the frailty of the literature understanding the behavior of regular and heavy marijuana users leaves us with little basis on which to answer the most pressing question of our time: how will marijuana consumption change with legalization? However, it is important to keep in mind that even if the literature were more complete, it is not clear that one could infer anything about consumption in a legalization regime based on price elasticity estimates generated from a prohibition regime. Legalization would bring more than just a potential reduction in the price of the substance; it will also bring a reduction in the legal risks of using the drug and the perceived harm, which we have demonstrated here have their own independent effects on demand. Thus, the honest answer is that we simply do not know and will not know until evaluations of the current state experiments in Colorado and Washington are carefully conducted.

SUMMARY AND CONCLUSIONS

The research reviewed here provides insights into discussions regarding legalization. In particular, it is clear from the literature that the demand for marijuana is responsive to changes in both its monetary price and the nonpecuniary aspects of price, particularly those pertaining to legal risk. However, the responsiveness of demand varies depending on the type of policy change (price change versus criminal status change) and varies considerably across the type of user (light, casual, regular or heavy). This knowledge is useful for thinking about the effects of policy changes on consumption overall, as changes in the simple annual prevalence rate will not fully reflect changes in the distribution of users or the amount consumed overall. In particular prevalence rates over represent the behavior of light and casual users and discount the behavior of regular and heavy users, who generally represent a much smaller proportion of the total users even though they represent the majority of quantity consumed.

However, the findings cannot provide any sort of precise insight regarding how much consumption might change in response to a change in price or liberalization policy. A number of limitations remain in our current understanding of the impact of price on marijuana use. First and foremost, while a fairly robust literature has emerged analyzing the impact of price on the prevalence of marijuana use (in the past year or past month), very little work carefully considers the impact of price (and its full components) on the quantity consumed conditional upon using it. This is a major limitation in efforts to ascertain the impact of marijuana legalization on overall use and its effect on harms as those harms will most likely be associated with persistent regular or heavy use, not casual use. Similarly, tax revenue from sales will be more heavily influenced by the change in total amount consumed among existing users than the proportion of the population who decide to use any marijuana. Findings from the alcohol and tobacco literature suggest that quantities consumed among

existing users are sensitive to changes in the monetary and non-pecuniary components of price^{52,56-58} and it is changes in these existing users that are likely to be the most relevant for understanding the impact on total consumption (and hence total revenue). But without an understanding of how much 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 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 not only the change in monetary price but also the anticipated change in perceived norms and legal risk. For example, the results of Pacula et al. (2001) suggest that a 10 percent decrease in the perceived harm of marijuana would generate a 28.7 percent increase in annual prevalence of marijuana use among youth, a change substantially larger than the results of a small change in the monetary price, legal risks or law enforcement.¹¹ Ignoring these factors would again lead to an understated estimate on consumption.

Third, evidence presented here suggests that all aspects of marijuana use could change in response to this policy change, with more new initiates, more regular users, and people using for longer periods of time. Summary measures from initiation suggest that for every 10 percent decline in the monetary price of marijuana, there will be an increase of 3 to 5 percent in new marijuana users prior to the age of 18, an increase of 2.5 percent in regular users, and an increase in the duration in which marijuana is used during adulthood. Absent more vigorous prevention efforts to counter these trends, the implication will be an expanding market, both in terms of the number of users and in the total quantity consumed by the market.

Acronyms List

DSM-IV	Diagnostic and Statistical Manual of Mental Health Disorders, Fourth Edition
NHSDA	National Household Survey on Drug Abuse
NSDUH	National Survey on Drug Use and Health

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Table 1

Findings Related to Impact of Price on Initiation of Marijuana

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 inconclusive	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 results; even significant 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)

Table 2

Findings from the Literature of the Effects of Price on Regular (Past Month) Use

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)	Full population
	-0.28 – 0.31 (30 day participation elasticity)	Gallet (2013)	Mixed populations
Decriminalization	No effect on prevalence or frequency of use	Thies & Register (1993) ; Pacula (1998)	NLSY79 Young adults (ages 19-30)
	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	1991-1994, 1996 NSDUH (ages 21 to 30)
	Median fine insignificant	Williams et al (2004)	College students – HCAS
Enforcement	Crime per officer ratio positive and significant (elasticity not specified)	Pacula (1998)	NLSY79 (young adults ages 19-26)
	Past month participation elasticity for MJ arrests to users: -0.157 to -0.176	Farrelly et al (1999) *Monetary price included	1991-1994, 1996 NHSDA (ages 21 to 30)