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Risks and Prices: The Role of User Sanctions in Marijuana Markets
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ABSTRACT

User sanctions influence the legal risk for participants in illegal drug markets. A change in user sanctions may change retail drug prices, depending on how it changes the legal risk to users, how it changes the legal risk to dealers, and the slope of the supply curve. Using a novel dataset with rich transaction-level information, this paper evaluates the impact of recent changes in user sanctions for marijuana on marijuana prices. The results suggest that lower legal risks for users are associated with higher marijuana prices in the short-run, which ceteris paribus, implies higher profits for drug dealers. Additionally, the findings have important implications for thinking about the slope of the supply curve and interpreting previous research on the effect of drug laws on demand for marijuana.

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Over 25 million Americans consumed marijuana in 2005 and there have been over 4 million arrests for marijuana possession since 2000 (SAMHSA, 2006; FBI, annual). Given its popularity and the widespread belief that its harms are low relative to other illicit substances, a significant debate has continued regarding marijuana policy reform in the United States and abroad (MacCoun & Reuter, 2001). The only successful policy reforms that have come out of the recent debate involve modified sanctions facing users. Canada, Germany, Great Britain, Portugal, and Spain have all recently adopted policies that dramatically reduce the penalties and sanctions faced by users of marijuana (Hall and Pacula, 2003). Even in the United States there has been a softening of sanctions toward individuals caught in possession of small amounts of marijuana in many states (Chriqui et al., 2002; Pacula et al., 2003).

A modest literature has developed examining how these small differences in sanctions observed across states in the United States are correlated with differences in marijuana use (Saffer and Chaloupka, 1999; Farrelly et al., 2001; Pacula et al., 2003; Williams et al, 2004). Many studies find that lower sanctions, typically indicated through reduced jail time and lower fines, are associated with greater use although the effect sizes are small and occasionally insignificant. The small or insignificant effect may be explained by one of three possibilities. First, the policies may truly have little impact on demand, especially if enforcement is negligible. Second, people may not be aware of the sanctions or if they have changed, again suggesting that the policies will not affect demand (Pacula, et al., 2005). Third, if supply is upward sloping as with other normal goods there could be an offsetting price effect that reduces the net effect of the policies observed in analyses.

This paper considers this last possibility by examining the role of user sanctions in marijuana markets and whether changes in these sanctions, believed to shift demand, influence the prices paid by users in local markets. Economic theory suggests that price will be affected by demand side policies if supply is upward sloping, a perfectly reasonable assumption for marijuana. To date virtually no work has been done examining the slope of the supply curve for marijuana, presumably due to lack of reliable data given the illegal nature of the good. However, it is possible to infer basic information on the slope of the supply curve by understanding how shifts in the demand for marijuana influence the equilibrium level of prices observed in the market.

In this paper, we use rich transaction-level information from recent marijuana purchases made by arrestees who are part of the Arrestee Drug Abuse Monitoring (ADAM) Program to estimate the impact of state marijuana policies on self-reported price per bulk gram paid. We first develop a model focused exclusively on proximal measures of transaction risk, and then use natural variation in state marijuana laws over time and within states to evaluate the impact of these demand-side policies on the equilibrium prices of marijuana observed in illegal markets. Because it is possible that demand-side policies influence sellers' risk as well, we test the robustness of our findings with respect to these state-policies by considering the impact of other demand shifters on price, in particular the beer tax. The sensitivity analyses support the interpretation that reductions in user risk raise price. There are three implications of these findings. First, the findings support the conclusion that marijuana use is sensitive to changes in the legal risks targeting users. A reduction in sanctions will increase use of marijuana. Second, the supply of marijuana is upward sloping at least in the short run, implying that temporary shortages caused by a reduction in supply or an increase in demand will impact market price. Third, shortages caused by shifts in demand (such as that generated by a reduction in user sanctions) will raise sellers' profits, *ceteris paribus*.

The rest of the paper is organized as follows. In the next section we provide some background literature about state marijuana laws, the operation of marijuana markets, and marijuana prices. In Section 3 we discuss how policies targeting users of marijuana might influence marijuana prices under alternative assumptions about supply. In Section 4 we discuss the data used for this analysis and present our empirical model in Section 5. Section 6 presents the results from these models and in Section 7 we offer some discussion and conclusion.

1.0 Marijuana Laws, Markets and Price

1.1 State marijuana laws

Even though the U.S. federal government retains a strict prohibition on the possession of even small amounts of marijuana, there is significant variation across the states in the legal penalties associated with this offense (Pacula et al., 2003; Chriqui et al., 2001). Given that the majority of marijuana possession offenses are tried in state courts, state law applies (Ostrom and Kauder, 1999). The proportion of these arrests leading to conviction is unknown, but those convicted of marijuana possession are often sentenced to probation and/or a fine, not jail

(MacCoun & Reuter, 2001; National Research Council, 2001; Office of National Drug Control Policy, 2005).[1] Although twelve states are generally recognized as having "decriminalized"[2] possession of small amounts of marijuana, fifteen states have actually eliminated criminal sanctions associated with it and another twenty-six states have conditional discharge provisions for first time offenders (Pacula et al., 2003).[3]

A significant literature has developed in recent years demonstrating that consumption of marijuana by youths and young adults is sensitive to changes in the legal penalties associated with possession of marijuana (e.g., Farrelly et al., 2001; Pacula et al, 2003; Williams, 2004). Presumably, this effect is due to the fact that lower penalties reduce the legal risk if caught in possession of marijuana. However, implicit in this interpretation is the assumption that people are actually aware of these reduced sanctions and are responding to them. Aggregate data from the 2001 National Survey on Drug Use or Health linked to information on state laws suggests this may not be the case. Pacula and colleagues (2005) show that nearly one-third of household respondents report that they do not know what the maximum penalty is for possession of an ounce of marijuana in their state and just over another third report that mandatory or possible jail time was the maximum penalty when they lived in a state that did not impose any jail for offences involving small amounts of marijuana. The authors could not examine knowledge of laws by use rate using the aggregate data so it is not entirely clear that these low correlations are indicative of a lack of knowledge among users. Nonetheless, they clearly indicate a lack of knowledge in the general household population and suggest that an alternative interpretation for the negative correlation between severity of penalties and use may be warranted. For example, it may be the case that states that have adopted relatively lower penalties all share some unobserved characteristics, such as a strong belief in personal liberties or normative values, which are more favorable toward using marijuana. Alternatively, it may be the case that these policies targeting users also inadvertently influence the risk to sellers so that lower penalties facing users translates into a reduced risk to sellers and thus lower marijuana prices. Given that

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[1] MacCoun and Reuter make this claim and footnote: "This statement is a conjecture since no data sets allow the tracking of misdemeanor arrests to sentence. It accords with the impressions of officials and researchers in many jurisdictions" (343).

[2] While decriminalization is common in the literature, we think depenalization is the more accurate term to describe these legal changes. See MacCoun and Reuter (2001, Chapter 5) and Pacula et al. (2005) for expositions of the distinction.

[3] Appendix I presents the depenalization and medicalization policies for the 29 states included in our analysis.

our information on marijuana prices is relatively poor, many studies have not controlled for marijuana prices when evaluating the effect of these policies on demand and thus the coefficient on the policy variable reflects the net effect (direct effect and potentially off-setting indirect effect).

Medical marijuana provisions represent another area of state policy in which there has been substantial change in recent years (see Appendix I). As is the case with sanctions targeting users, state medical marijuana laws have the potential of influencing both the supply and the demand for marijuana within the state. Although it is believed that the medical marijuana market is relatively small (GAO, 2002; MPP 2006, Appendix F) and diversion from a relatively small medicinal market to a very large recreational market would normally not be expected to have any real impact on black market supply, current provisions for medicinal marijuana are extremely vague in terms of how patients are allowed to obtain marijuana. Nine state statutes allow for home cultivation, while several others remain silent or allow patients to obtain marijuana through "any means necessary" (Pacula et al., 2002). Large-scale diversion can easily occur in environments such as these where the government or some other oversight agency does not closely monitor the production and distribution of marijuana for medicinal purposes. More importantly, such ambiguity regarding source of supply creates legitimacy for illegal suppliers, who become the only source of marijuana for individuals unable or unwilling to grow their own. This legitimacy may translate into a reduction in the risk of supplying marijuana to the black market and a reduction in the monetary price.

Medicinal marijuana laws could also influence the demand for recreational marijuana through one of three alternative mechanisms: (1) a change in the legal risk to users of marijuana, (2) a change in the perceived harm associated with using marijuana, and (3) an increase in the social availability. States with medical necessity defenses allow individuals who have received permission from a physician to use marijuana for medicinal purposes without risk of prosecution. Thus, these policies directly influence the legal risk of users who obtain medicinal allowances, although this is expected to be a very small segment of the population (GAO, 2002). Second, attitudes and perceptions of marijuana as a harmful drug, which numerous studies have identified as an important correlate with drug use (Bachman et al., 1998; Pacula et al., 2001), are likely to be diminished by policies recognizing its medicinal value because these allowances formally recognize that marijuana can have a beneficial impact on one's health, at least in some circumstances. Finally, medicinal allowances might also influence the social availability of marijuana by increasing the number of social encounters in which youths are around individuals who have used or are using marijuana. Social availability can be further increased if teenagers live in households or near homes where patients and/or their caregivers are growing marijuana, as it is possible for them to share or steal the drug.

1.2 Marijuana Markets

Unlike the markets for cocaine and heroin, marijuana markets are relatively understudied and not well understood. Although ethnographic information provides insights about how particular markets operate (ONDCP, 2004), very little work has been done modeling marijuana markets in general and virtually nothing is known about supply. This is perhaps due to the fact that the primary source of information used to evaluate other drug markets, the Drug Enforcement Agency's System To Retrieve Information from Drug Evidence (STRIDE), is severely limited in two important ways when it comes to marijuana markets. First, unlike observations for cocaine, heroin and other drugs included in the STRIDE database, marijuana is not chemically assayed when purchased or seized by agents. Thus, the STRIDE database does not contain any information on marijuana purity or quality. Second, marijuana purchase observations in STRIDE are highly concentrated in a single city, Washington, DC. These two factors make the STRIDE data relatively less useful for examining the dynamics of these markets.

Data sources providing systematic information on markets geographically dispersed across the nation have begun to emerge, although none contain information on purity and all of the information is obtained from a buyer's perspective. The National Survey on Drug Use and Health (NSDUH; formally, the National Household Survey on Drug Abuse (NHSDA)) has been collecting information from marijuana users on their experiences in marijuana markets since 2001 and the Arrestee Drug Abuse Monitoring (ADAM) Program has been asking arrestees about their last purchase since 2000. Both surveys ask respondents about their drug use behavior, and among recent marijuana users, their methods and circumstances for procuring the drug. In a recent analysis of the 2001 NHSDA data, Caulkins and Pacula (2006) show that most respondents who report use of marijuana in the past year obtain marijuana indoors (87 percent), from a friend or relative (89 percent), and for free (58 percent). Among those who do buy their marijuana, these purchases generally involve small quantities (less than 10 grams), are acquired from a friend (79 percent), and are exchanged indoors (62 percent). Similar transaction characteristics are reported by youth (SAMHSA, 2003) and arrestees (Taylor et al., 2001) and are consistent with evidence obtained from ethnographic studies (ONDCP, 2004). Thus it seems clear that marijuana markets function differently than that of cocaine and heroin markets (Caulkins et al., 1999; Caulkins and Reuter, 1998; Caulkins, 1997). Most notably, open air markets and purchases from strangers are generally rare as compared to other drugs (ONDCP, 2004), suggesting that standard street methods of drug enforcement (undercover buys and patrolling the streets) might not be as effective at deterring marijuana transactions. However, Caulkins and Pacula identify at least two similarities between marijuana markets and other illicit drug markets. First, they find evidence of quantity discounts in marijuana markets, so that people who buy in larger quantities pay less per gram than those who buy in smaller quantities. Second, they find that a minority of users account for the vast majority of purchases.

1.3 Marijuana Prices

There is substantial ethnographic evidence of large geographic differences in the black market price of marijuana (ONDCP, 2002; 2004). For example, information reported in a recent summary of ethnographic studies conducted by the Office of National Drug Control Policy (ONDCP) shows that an ounce of commercial-grade marijuana in Phoenix, Arizona and San Diego, California sold for between $60-$100, while an ounce of commercial-grade marijuana in New York City and Philadelphia, Pennsylvania sold for between $100-$200 in Fall 2002 (ONDCP, 2004). A number of factors could generate this sort of variation including differences in the cost of production (particularly labor, given that this is a labor-intensive commodity), regional differences in quality, transportation costs, imperfect information, search costs, and differential risks to buyers and sellers participating in the market.

Only two studies empirically examine the role of specific factors on the prices paid for marijuana. In an early study, Caulkins (1995) examines data from nine states reported in the Middle Atlantic-Great Lakes Organized Crime Law Enforcement Network (MAGLOCLEN) and tests two conjectures about how prices vary from location to location within the United States. The first conjecture is that prices increase as one moves away from the source, which in the case of marijuana is largely domestic. The second conjecture is that prices are lower in larger markets, as proxied by population. He examines these hypotheses by evaluating prices for cocaine, LSD, and marijuana. In the case of marijuana, Caulkins only finds support for the first hypothesis. The mean price per bulk gram paid for marijuana got statistically higher as the cities got more distant from the mid-west /Appalachian growing region. These results, however, are based on a very limited number of price observations (fewer than 60 in total) that were not representative of all transactions within these states. Thus, although they are suggestive that transportation costs might explain some of the geographic variation in marijuana prices, the evidence cannot be viewed as definitive.

Caulkins and Pacula (2006) evaluate how differences in transaction-level characteristics influencing individual buyers' and sellers' risk correlate with the self-reported price paid per bulk gram of marijuana using data from the 2001 NSDUH. Transaction-specific characteristics evaluated in the models include from whom they purchased (a friend, relative or stranger), where they purchased (inside a private dwelling, inside a public building, outside, or some other location), and proximity to home (near where they live). They find that, contrary to intuition, the quantity-adjusted self-reported price per bulk gram is *positively* associated with purchases made in private dwellings. Purchases made outside or inside public buildings were associated with lower prices on average. They also find no association between whom they purchased from and price paid. Given that the public use data contain no geographic information, their analyses could not account for location-specific factors. Thus, the authors interpret this counter-intuitive finding as potentially reflecting omitted variable biases caused by unmeasured quality or local intensity of enforcement.

Although it is possible that imperfect information and variation in search costs, transportation costs, production costs and quality generate some of the geographic variability in price, it seems implausible that variation in any of these factors could generate the substantial differences in marijuana street prices that are currently observed across cities. To understand the relative importance of geographic differences in production/distribution costs versus the economic value of risks incurred, it is useful to consider the cost of producing a pound of marijuana in a legal market. If marijuana were legal, then the cost of producing a pound of dried marijuana, which according to federal agents is approximately equivalent to the yield of a single plant during one growing season, would simply be the fixed cost of obtaining the plant (depreciated over the lifetime of the plant) plus the maintenance cost of caring for the plant (labor, soil, good lighting, water, and nutrients or pesticides if grown outside). These are the exact same inputs needed to grow any other agricultural product, such as tomatoes or oranges, which can be grown in a home garden or through mass production in certain areas.[4] The trick with growing marijuana is identifying and separating the female plants from the male plants. Female plants, which contain the more potent THC, can be easily determined once a plant matures to a certain stage (e.g. it starts to bud).

Given that mass production of marijuana is not allowed today, we will consider the cost of producing marijuana in a small home garden to keep the comparison fair, although it should be recognized that mass production would allow for economies of scale that are not achieved through home production.[5] Today, a young fruit tree (showing buds) can be purchased at a nursery for approximately $50 while sufficient soil, nutrients, pesticides, and water for a single growing season could be purchased for less than $25. Carrying this analogy forward and assuming that marijuana plants produce buds only once (one growing season) and the total labor cost involved in caring for the plant is slightly more than $100 (a maximum of 20 hours of labor x $5.15 minimum wage), we estimate that the maximum legal price for a pound of marijuana would be less than $200.[6] Ethnographic data suggest that a low-end price for a pound of commercial grade marijuana fell in the range of $500-$700 (ONDCP, 2004). Thus, even relatively low prices of marijuana are substantially higher than the back-of-the-envelope production cost estimate for a product being produced in a relatively low-scale effort. Even if we add to this the cost of transporting the drug, it is improbable that the cost of legal marijuana would come anywhere near its black market price (Kleiman, 1989; 1992).

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[4] It is important to note that marijuana is a weed that grows naturally in several parts of the country, and hence the analogy to a home garden is not as far a field as might otherwise be considered. Of course the quality of THC from a female plant grown in the wild is likely to be inferior to plants that receive special care and attention.

[5] We owe credit for insights regarding the differentiation of growing at home versus in mass production to Jonathan Caulkins.

[6] The total labor time involved may be greater than twenty hours, and larger estimates could be inserted without detracting from the point of the argument. This estimate assumes that the opportunity cost of someone’s time is the federal minimum wage, which may under estimate the opportunity cost of some individuals with better employment opportunities.

2.0 Theoretical Framework

2.1 Supply and Demand Analysis

The impact of changing user sanctions on price depends on how it influences user and seller risk as well as one's assumptions about supply. Assumptions about supply are necessary as no empirical analyses examining the elasticity of supply have been conducted, so theories develop based on alternative plausible assumptions (e.g. Becker, Murphy, and Grossman, 2006).

If the *supply of marijuana is perfectly competitive* or one presumes a relatively short run adjustment period, then it is appropriate to think of the supply function as infinitely elastic. If state depenalization or medicalization policies truly only affect the user's risk of using marijuana and not the enforcement or risks to sellers, then adoption of these policies should not influence the monetary price of marijuana.

If we assume *supply is upward sloping*, there are two mechanisms by which lowering the user sanctions could increase the retail price. First, increase use due to lower penalties could shift the demand curve to the right and subsequently increase the price at least in the short run. Second, if relaxing user sanctions causes police officers to spend more time targeting marijuana sellers, then the subsequent increase in seller risk could cause the supply curve to shift in, resulting in higher prices. However, there is also reason to believe that relaxing user sanctions will actually lower the legal risk to sellers. This could happen if, for example, marijuana depenalization policies reduce the likelihood that police pursue low-end marijuana transactions or if sellers are able to pass themselves off as users rather than sellers (by carrying less with them and selling smaller consumption bundles). There is some evidence suggesting that retail dealers are aware of the differential penalties and willing to use them to reduce their own legal consequences. Sevigny and Caulkins (2004) report that 20% of state inmates in prison on charges for drug possession (or possession with intent to sale) actually self-report being retail sellers[7] Thus, the net impact of lower sanctions on equilibrium prices is theoretically ambiguous.

If we assume *supply is downward sloping*,[8] lower user sanctions can only lead to higher retail prices if it leads to a net increase in the legal risk to sellers. Therefore, if we hold the legal

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[7] From authors' calculation of numbers presented in Table 1b.

[8] It has been argued that for a given level of enforcement, an increase in the number of suppliers reduces the relative risk facing any single supplier in the market, suggesting that the supply curve for any illicit substance is actually downward sloping rather than upward sloping (Reuter and Kleiman, 1986).

risk to sellers constant we should anticipate that a reduction in penalties should lead to a lower equilibrium price.

Findings of the impact of relaxing user penalties on equilibrium prices can therefore provide insight into the slope of the marijuana supply curve. If relaxing penalties leads to no change in prices, then the supply curve is either perfectly elastic or upward sloping (assuming seller risks are also affected by this change). If relaxing penalties lowers equilibrium prices, supply is either downward sloping or upward sloping (which assumes the decline in sellers' risks is greater than the decline in buyers' risks). If relaxing penalties leads to a higher equilibrium price, then the supply curve for marijuana must be upward sloping.

2.2 Modeling the Price of Marijuana

We begin with a simple model of the market price for marijuana (P_{jt}):

(1) $P_{jt} = P(D_{jt}, S_{jt})$,

where D_{jt} and S_{jt} represent local market demand and supply in jurisdiction j at time t. Both supply and demand will depend on the legal risk in the jurisdiction (L_{jt}) as well as other factors. The supply of marijuana, for example, will depend on the legal risk of selling marijuana in jurisdiction j at time t (L^S_{jt}), the cost of producing and transporting the marijuana (X_{jt}), and the size of the market (C_{jt}): [9]

(2) $S_{jt} = S(L^S_j,(AC_{jt}, SP_{jt}), X_{jt}, C_{jt})$.

The legal risk of selling marijuana in jurisdiction j at time t is presumed to be a function of the risk of getting caught (AC_{jt}) and the penalties imposed on sellers if caught (SP_{jt}). Because information on the size of the marijuana market is not readily available, we will approximate the size of the market (C_{jt}) using a vector of community-level demographic and socio-economic variables that are known to be correlated with demand. Demand for marijuana in jurisdiction j at time t can be further specified as:

(3) $D_{jt} = D(P_{jt}, L^D_{jt}(AC_{jt}, PP_{jt}), C_{jt})$,

[9] Supply is currently specified presuming that individual firms are not price takers (i.e., it is not a perfectly competitive market). Given the barriers to entry in the market and the ability to differentiate products, this seems plausible although we recognize it is an empirical question that is currently unanswered due to insufficient data on all aspects of production and the number of firms.

where L^D_{jt} represents the legal risks facing the user of marijuana in jurisdiction *j* at time *t*, which is itself a function of the probability of getting arrested and the severity of penalties facing buyers if caught (PP_{jt}). The vectors P_{jt} and C_{jt} are defined above.

A unique feature of drug markets, however, is that a single market price is never observed in a given jurisdiction, as currently indicated by equation (1). One reason for the lack of uniformity in price within particular markets is that there are unique risks associated with each individual transaction (R_{ijt}) generated by particular decisions made by the buyers and sellers. Although the transaction-specific risks may be associated with the legal risks of buying or selling a drug in market *j*, there are some independent factors that can be represented as follows:

(4) $R_{ijt} = R(T_{ijt}, I_{ijt}, L^S_{jt}, L^D_{jt})$,

where T_{ijt} is a vector of variables capturing where and how the transaction took place (e.g. indoors, outdoors, contacted by phone, contacted on the street) for bundle *i* in jurisdiction *j* at time *t*, and *I* represents the information that the buyer and seller have about each other (strangers, friends, acquaintances), including observable characteristics of each other. In addition to capturing an important part of the legal sanction associated with the transaction, vectors *T* and *I* reasonably capture the non-legal risks associated with a black market transaction (e.g., risk of robbery, risk of being swindled). To reflect this idiosyncratic risk associated with individual exchanges, we modify equation (1) as follows:

(5) $P_{ijt} = P(R_{ijt} D_{jt}, S_{jt})$.

Substituting Eqs. (2) - (4) into Eq. (5) gives us the following reduced form equation for the price of marijuana for a specific transaction:

(6) $P_{ijt} = P(T_{ijt}, I_{ijt}, AC_{jt}, SP_{jt}, PP_{jt}, X_{jt}, C_{jt})$.[10]

Fundamentally, we are interested in determining whether the vector of penalties that are intended to influence users (PP_{jt}) are found to be important attributes of the monetary price of marijuana after controlling for all of the other factors that can influence the price for a specific bundle. In this analysis, we have several different measures of the penalties that we wish to consider. First, we will examine the fines and allowances for conditional discharge associated

[10] An implicit assumption of this model, as specified here, is that the risk of arrest is the same for the buyer and seller. In the empirical analysis, we will approximate the buyers' and sellers' risks of arrests separately, but for ease of exposition we group them together here.

with possession of small amounts of marijuana. Then we will examine the penalties associated with the use and provision of medical marijuana.

3.0 Data

Information about marijuana transactions is obtained from the Arrestee Drug Abuse Monitoring (ADAM) Program (formerly Drug Use Forecasting System). From 1987 to 2003, the U.S. Department of Justice interviewed arrestees in urban booking facilities about their drug use patterns as well as tested them for drug use.[11] The purpose of the study is to provide local law enforcement and other local officials with reliable estimates of the prevalence of drug abuse and related problems in the population of arrestees in their jurisdiction. ADAM sites were originally selected through applications from those jurisdictions interested in participating, but the number of sites increased substantially from 24 in 1996 to 43 in 2003. ADAM data collection takes place four times a year at each site, usually for one or two weeks per calendar quarter. Arrestees are approached within 48 hours of their arrest and asked to participate in the study. Although participation in ADAM is strictly voluntary, response rates hover around 80 to 90 percent (U.S. Department of Justice, 2000).

From 2000 to 2003, questions about recent drug purchases (i.e., how the dealer was contacted, relationship with dealer, location of transaction) were included to capture information about local drug markets. To isolate the effect of penalties on the price paid for marijuana, we limit the analysis sample in three important ways. First, we exclude transactions where the marijuana was obtained with means other than cash, such as property or sex. Second, because the penalties we are examining are only for possession of small amounts of marijuana, we only include transactions where an ounce or less was purchased. In this way, we are able to isolate the effect of penalties on the retail transactions they are meant to influence. Third, we only consider transactions where the amount purchased was reported in grams and ounces since we have no way of converting “joints”, “bags”, and “packets” to grams.

State-level data on marijuana penalties and medicalization laws were collected by lawyers and policy analysts at The MayaTech Corporation (See Pacula, Chriqui, & King, 2003 for a detailed description of the data collection procedures).[12] Detailed information on the

[11] Most of these individuals were arrested for non-drug offenses.
[12] We also used data Marijuana Policy Project (2006) for information about the implementation of medicalization laws in 2002 and 2003.

statutory implementation of the depenalization policies is available for the first three quantity amounts specified in each law. In this analysis we use information on state statutory fines and conditional discharge provisions for possession offences involving 10 grams or less of marijuana.[13] We limit our analysis to those arrestees who live in states where the maximum fine for possessing and selling marijuana is statutorily defined.

The type of medicalization provision is important because it indicates the number of patients likely to be affected by the provision as well as the legal rights. Therapeutic research program provisions and rescheduling laws are generally viewed as more restrictive as they are passive laws and do not provide active defenses to patients except if use is federally sanctioned. The physician recommendation laws and medical necessity defenses provide greater protection to patients and potentially a larger number of patients might be affected.

These statutory laws represent one dimension of the legal risk of buying and selling drugs. Another dimension is the degree of law enforcement in the area in which the drugs are sold. To proxy this enforcement risk, we divide the number of marijuana arrests (for possession and sales separately) by the total number of arrests at the county-level. These arrest data are pulled from the FBI's Uniform Crime Reports (UCR), which collects and reports information on the number of arrests and crimes reported to the police for every city in the country. While the shortcomings of these data are well documented (e.g. O'Brien, 1985; Maltz and Targonski, 2002), they remain the only national source of geographically disaggregated crime and arrest data in the United States.[14]

These ratios capture the relative importance of marijuana enforcement to police officers in the county and have been used in other studies (e.g., Farrelly et al., 2001; Pacula et al., 2003). While the ideal measure to capture enforcement would be possession arrests per unit of consumption, annualized consumption information is not available at the county level. DeSimone and Farrelly (2003) demonstrate with data from the 1990-1997 National Household Surveys on Drug Abuse that the effect of the probability of arrest on self-reported use rates for

[13] States are classified as allowing conditional discharge if completion of the terms or conditions translate into a complete dismissal of charges.

[14] Despite problems with county-level UCR data from ICPSR and how they have been used (Maltz & Targonski, 2002), we are comfortable using them for this analysis of large urban counties. Not only do we only consider the period after the ICPSR changed the imputation strategy, we also exclude observations from jurisdictions with a coverage indicator score less than 70. The coverage indicator is an indicator of the quality of the data made available to the FBI and ranges from 0 (no information) to 100 (complete information).

adults is negative regardless of whether they denominated by number of users or number of Index I arrests. Thus, we believe marijuana arrests as a fraction of all arrests in a county is a reasonable proxy for the probability of being arrested for possession.

To capture differences across counties in the demand for marijuana and size of the market (Jacobson, 2005), we merge data about county demographic and socio-economic characteristics. Information on the demographics of the county population, such as age, race/ethnic categories, percent male are obtained from the U.S. Census. Information pertaining to per capita income and local unemployment rates are obtained from the Bureau of Economic Analysis and Bureau of Labor Statistics, respectively.

Descriptive statistics about these enforcement variables, as well as information about marijuana transactions and state penalties for the analytic sample employed here are reported in Table 1. Because of the geographic dispersion of the ADAM sites, we see that the maximum fine for possessing 10 grams of marijuana ranges from $100 to $150,000 in our analytic sample.[15] For this sample, the average nominal maximum fine is $16,401 and the median is $500.[16] Almost 88 percent of arrestees in the analysis sample live in states where possession of 10 grams can be conditionally discharged. We focus on fines and allowances for conditional discharges because they have been shown to be correlated with demand in previous studies (Farrelly et al., 2001; DeSimone and Farrelly, 2003; Pacula et al., 2003).

Approximately 36 percent of the arrestees in the analysis sample live in states where there is either a provision for physicians to recommend marijuana or allowance for a medical necessity defense for those who use marijuana for medicinal purposes. There also appears to be tremendous variation in the enforcement of marijuana laws across the ADAM counties. For example, in 2000 over 10.5 percent of all arrests made in Douglas County, NE were for marijuana possession; the equivalent figure for Bernalillo County, NM was less than 0.4 percent (UCR, 2001).[17]

With respect to the last marijuana purchase, roughly 49 percent of the sample bought from their regular source, 35 percent bought from an occasional source, and 16 percent made the

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[15] Oklahoma does not have a maximum fine for possessing 10 grams and is not included in these calculations.
[16] The average maximum fine decreases to $1,059 when observations from Arizona (where the maximum fine is $150,000) are omitted.
[17] These figures come from UCR, not ADAM. Surprisingly, ADAM does not report arrests by specific drug.

purchase from a new source. Most buyers contacted the dealer by making a phone call or going to a house or apartment building. Approximately 60 percent of the transactions occurred in a house, apartment, or public building and this is consistent with the claim that most marijuana transactions do not occur in bustling street markets (Kleiman, 1992). The price paid per bulk gram ranges from approximately $0.10 to $680, with the median and mean values being $4.44 and $10.19, respectively ($2004). This is strikingly similar to the price per bulk gram derived from the Drug Enforcement Administration's System to Retrieve Information from Drug Evidence (2000-$9.21, 2001-$10.06, 2002-$11.65, 2003-$11.94; Caulkins et al., 2004).[18]

Table 2 displays the mean prices paid per bulk gram by marijuana policy. Using data from the entire sample, Panel A suggests that in states with more liberal marijuana laws (conditional discharge, physician recommendation, decriminalization), arrestees pay more per bulk gram for marijuana. Panel B examines the arrestees from three states that changed medical marijuana policies during the sample period (Colorado, Hawaii, and Nevada). In almost every case, the mean price paid was higher after the physician recommendation or medical necessity law was enacted. But since only one of the three pairwise comparisons is statistically significant at the 10 percent level, we cannot rule out that these differences are simply attributable to chance. We also cannot rule out whether these differences are attributable to some other confounding factor. This motivates the multivariate analyses.

4.0 Empirical Specifications

To ensure the proper specification of our models with a skewed dependent variable (See Figure 1), we adopt a strategy that involves the testing of both the conditional mean and mean-variance relationship of our dependent variable (Deb, Manning and Norton, 2003). A Box-Cox test is first used to determine the appropriate transformation of the dependent variables dependent on our controls, and findings from these tests are confirmed using Pregibon's link test (Pregibon, 1980).[19] Following these, we use a general linear model with a log link function:

(7) $$\mathbf{E}(PPG_{ijt}) = exp(\delta_0 + T_{ijt}\delta_1 + I_{ijt}\delta_2 + AC_{jt}\delta_3 + SP_{jt}\delta_4 + PP_{jt}\delta_5 + C_{jt}\delta_6 + Year_t\,\delta_7 + Quarter_t\,\delta_8 + State_j\delta_9 + \mu_{ijt})$$

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[18] The average per bulk gram price for those responding to the National Household Survey on Drug Use was $5.45 in 2001 ($2004); Caulkins and Pacula, 2006). Since our ADAM analysis is limited to transactions <=1 ounce and the NHSDA is not, we attribute this discrepancy to quantity discounting.

[19] It is important to note that in running "linktest" in Stata is not always instructive. In these instances we rely completely on the theta from the Box-Cox test, which for this analysis is always close to 0 (link=log).

where *PPG* is the real price per bulk gram paid at the last transaction, *Year*, *Quarter*, and *State* represent a vector of dummy variables noting the year and quarter of the transaction and state where it occurred, and μ is the residual. All other variables are as specified in Section 3.2.

Once we identify the proper transformation of our dependent variables, we then determine the relationship between the transformed dependent variable's mean and its variance using a modified Park test (1966).[20] Based on the size of gamma (which is reported in the tables), we specify the mean-variance relationship with the Gamma distribution:

(8) $V(PPG_{ijt}) = E(PPG_{ijt}^2)$.

Since we are primarily interested in the significance of state policy variables, we cluster the standard errors at the state-level to account for correlation among the residuals for arrestees in the same state.

5.0 Results

Table 3 models the real price per bulk gram of marijuana as a function of transaction-level variables while controlling for time-invariant state-level characteristics. One main finding is that arrestees who contact dealers by going to a private dwelling (house or apartment) generally pay lower prices than those who contact a dealer in public (the omitted category). This may represent differences in search costs in that people going to private dwellings may have a particular dealer in mind, while those buying in public may be looking for an available dealer (73% of those who contacted a dealer in public make the exchange outdoors). The coefficient on contacting the dealer by other means is also negative and statistically different from zero.

We find no association between the price paid per bulk gram and whether the sale took place in the buyers' neighborhood, contrary to results presented in Caulkins and Pacula (2006). The differential results may be due to a difference in the populations examined (arrestees versus a household sample) or may be due to our ability to account for regional market differences in this analysis which went unaccounted for in the previous analysis.

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[20] To perform a modified Park test, one runs a generalized linear model of raw y on x with link(log) and family(gamma), keeping both the residuals and the predicted value of y. Then one regresses the ln(residuals squared) on ln(yhat) and a constant. The value of the coefficient on the ln(yhat) term, referred to here as "gamma", gives information regarding the nature of the relationship between the variance and the mean. For example, if the coefficient is 0 (or not significantly different from zero), then it implies a Gaussian distribution (which has constant variance). See Deb et al. (2003) for more.

Table 4 presents the results from models that include penalties for possessing small amounts of marijuana. Because we have virtually no variation in these penalties within states during the time period being examined, state fixed effects are not included in the model and results should not be interpreted as causal. Further, the first two columns exclude the vector of county-level variables which 1) do not change much from 2000-2003 and 2) effectively identify many of the states in our analysis sample since most states only include one ADAM site. Column 1 begins by specifying the model without factors that may be correlated with the risks buyers and sellers face, such as arrest rates and sales penalties. We find that higher maximum fines (which indicate higher legal costs to buyers and are associated with less use) are indeed associated with lower prices. Furthermore, states that allow for dismissal of charges for first time offenders (conditional discharge provisions that have been shown to be positively associated with consumption among youth and young adults) are associated with higher prices. These preliminary findings suggest that the legal risks to buyers may be important correlates of price.

In Column 2 we include a measure of the real maximum fine associated with selling small amounts of marijuana. It may be the case that states with tougher penalties on users are also tougher on sellers, and hence associations in the previous two regressions merely reflect unaccounted variation in sellers' risks. However, the results in Column 2 suggest that this is not the case as the inclusion of penalties for the sale of marijuana does not change the principal findings for our possession penalties and the transaction-level variables. Columns 1 and 2 still indicate that those who contacted the dealer at an apartment or home paid less while those who made the purchase in a residence paid more than those who made the exchange inside a public location.

Column 3 includes the vector of county-level covariates along with the user penalties and the maximum fine for selling. While the coefficient on conditional discharge remains positive and highly significant, it becomes roughly 50 percent smaller. It is also important to note how the coefficients on the maximum fines essentially change from Column 2 to Column 3. In Column 2, the coefficient on the log of the real maximum fine for possession is -0.125 and statistically significant while the coefficient on the log of the real maximum fine for selling is statistically indistinguishable from 0. In Column 3, which includes the vector of county-level variables, the possession fine increases to almost 0 (-0.008) and the selling fine is now -0.16 and statistically significant at the one-percent level. The instability in the coefficients on these fine measures is likely attributable to the fact that they do not vary and are correlated with the county factors that also do not really change during our sample period.

The ideal measure of the monetary fine associated with marijuana possession would be a statistic generated from assigned fines instead of statutory maximums. However, geographically-disaggregated data about conviction rates and assigned fines for marijuana possession are simply not available. We use the statutory maximum as a proxy for the expected fine associated with using and buying marijuana, but realize the limits of this approach when using data from Arizona—which has a statutory maximum of $150,000 and accounts for almost 10% of our ADAM sample. Column 4 of Table 4 drops the 1,000 observations from Arizona and not surprisingly, the maximum fine is no longer significant. Despite the smaller sample, the coefficient on conditional discharge is still positive and significant. The remaining columns in Table 4 exclude observations from Arizona.

Next, we introduce an indicator variable for the 11 "decriminalization" states that reduced criminal sanctions for marijuana possession in the 1970s.[21] While recent research suggests the traditional interpretation of this variable as a measure of the legal risk is wrong, decriminalization status remains an important correlate of demand even when measures of the legal risk are included in the analysis (Pacula, Chriqui, & King, 2003). One interpretation of the robustness of the decriminalization variable to the inclusion of other measures of legal risk is that this policy more accurately reflects unobserved differences in the enforcement of the policy or differences in unobserved state sentiment toward marijuana. Another interpretation is that it is an information effect in that users/potential users may see decriminalization as a clear signal of weaker penalties, even if the penalties are not that different from states that have not decriminalized. The coefficient on decriminalization in Column 5 is positive and significant and does not minimize the practical and statistical significance of the conditional discharge variable. In fact, the inclusion of decriminalization actually *increases* the coefficient on conditional discharge. The fact that both conditional discharge and decriminalization are positively associated with price lends further support to the conclusion that shifts in demand will influence price. However, one cannot rule out the possibility that these policies might also influence risk to sellers because of corresponding shifts in enforcement that accompany the policy itself.

[21] While Arizona is often referred to as a decriminalization state because of policy changes in 1996, it does not matter for Columns 4-6 since observations from Arizona are excluded.

Column 6 includes county-level enforcement measures from the Uniform Crime Reports. These enforcement measures should provide a better approximation of the general enforcement risk, and hence expected penalty, associated with any transaction. In addition, by including measures of enforcement risk in the model, we can evaluate the impact of the demand-side policies holding enforcement (at least arrest rates) constant. After including these variables, the coefficients on conditional discharge and dealer contact remain statistically significant with smaller absolute values. The negative sign on the ratio of marijuana possession arrests to all arrests is consistent with the hypothesis that as expected sanction for possession increases, price decreases via a shift in demand. While we find no significant association between sales arrests on price per gram, it does make sense that the coefficient is positive.

In general, Tables 3 and 4 support the notion that the market prices for marijuana are sensitive to transaction risks. Moreover, the results in Table 4 are consistent with the hypothesis that users' risks, which are at least partially determined by demand-side policies regarding possession penalties for marijuana, are also important correlates of equilibrium price. However, there are at least two limitations of the analyses presented thus far. First, the results presented in Table 4 are based entirely on cross-sectional variation in policies. Thus, unobserved state factors that are correlated with penalties for possession of marijuana may be driving the associations in Table 4 rather than a real penalty effect. Second, all of the state laws evaluated thus far could also influence the risk faced by sellers if dealers can effectively hide themselves as users or if enforcement of low-end marijuana transactions changes as a result of these policies.

In light of these limitations, we also consider the influence of state medical marijuana laws on equilibrium prices in Table 5. Unlike the penalties for possession, there has been some variation in state medical marijuana laws within the states even within our short time period being examined; thus, it is possible to include state fixed effects in our models that account for other unobserved state factors that might be associated with the policy and price. Moreover, state medical marijuana laws are supposed to create protection for medical users, but not provide protection to drug dealers and organized marijuana sellers.

Columns 1 through 7 of Table 5 include an indicator variable that equals 1 if the state actively allows physician recommendation and/or medical necessity defense.[22] This measure

[22] See Appendix I for the list of states that allow physician recommendation and/or medical necessity defense.

captures policies that protect physicians and/or their patients from state prosecution for discussing, recommending, or using marijuana as medicine. The models are first evaluated excluding state fixed effects so that comparison with results in Table 4 can be directly made. In Columns 3-4 other state penalty measures are included and in Columns 5-7 the enforcement measures are incorporated. Across the board, the coefficient on physician recommendation/ medical necessity defense is positive and statistically significant. In the specification with state fixed effects, enforcement controls, county-, transaction-, and individual-level characteristics (Column 6), the results suggest that arrestees in states with active medical marijuana programs pay $1.40 more for a gram of marijuana compared to arrestees in non-medical states.[23]

In Column 7, the natural log of the county population is included as a regressor. This provides another proxy for market demand and allows us to test Caulkins's conjecture (1995) and Jacobson's (2005) finding that the price is lower in larger markets. The coefficient and standard error on physician recommendation/medical necessity defense remains virtually unchanged. The coefficient on county population is negative and statistically significant, thus confirming the hypothesis that price per gram in lower in larger markets.

Since laws that allow physicians to recommend marijuana or patients to use a medical necessity defense will primarily influence consumers (rather than dealers),[24] the positive association with price suggests that the market supply curve for marijuana is upward sloping because a change in demand leads to an increase in equilibrium prices. It is important to note, however, that all states with recommendation/medical necessity laws also have provisions for home cultivation. If allowances for home cultivation reduced the risk to sellers of producing marijuana, then prices should fall holding other factors constant. But because we see an overall positive effect of these policies on price, it suggests that the shift in demand exceeds the shift in supply that could occur with a reduction in risk to sellers.

Finally, to address any remaining concerns that sellers' risk—instead of buyers' risk—is driving our results, Table 6 reports how the state beer tax is related to the price paid by arrestees. Previous research finds a negative relationship between the beer tax and marijuana prevalence (e.g., Pacula, 1997) and several studies find alcohol and marijuana to be economic complements

[23] $2004. This marginal effect was calculated with the *mfx* command in State 9.2.
[24] It could reduce the risk to suppliers (e.g., of being informed on by users trying to reduce their legal costs) which could again lead to an increase in supply and lower price, making the net price effect ambiguous.

in the United States (Farrelly et al., 1999; Pacula, 1998; Saffer & Chaloupka, 1999; Williams et al., 2004). Since there is variation in the state beer tax during our analysis period, we can use state-fixed effects to control for the unobservable state-level characteristics that influence marijuana prices and do not change over time.[25] In Column 1 we find a negative and statistically significant relationship between the real beer tax and the real price paid per bulk gram, suggesting that reducing demand for alcohol, and subsequently marijuana, reduces the equilibrium price for marijuana. In Column 2 we include the marijuana enforcement variables and the results do not change.

In Column 3 we add in a vector of county-level demographic and economic characteristics, and not surprising, the coefficient on the state beer tax is no longer significant (the t-statistic is -1.25). As mentioned before, many of the states in our analysis sample only include one ADAM site; thus, saturating the model with too many state- and county-level variables will increase the standard error on the coefficient for the state beer tax (especially given our short time frame and the minimal variation). It is reassuring, however, to note that the beer tax coefficient remains negative as we would expect. So although not definitive, Table 6 does provide additional support for the claim that the supply curve for marijuana is upward sloping.

6.0 Discussion

This paper finds that variations in policies associated with user risk are associated with variations in self-reported marijuana prices per gram. Results exploiting cross-sectional variation in possession penalties suggest that states with lower penalties have higher prices due to increased demand that more than offsets the effect on price of any increase in supply. This provides new evidence that user sanctions can influence demand. Given the variation examined is purely cross-sectional, the direction of causality is not entirely certain. Thus, we also examine state medical marijuana laws and using within state temporal variation in the adoption of liberal marijuana policies, we find evidence that policies aimed at users do in fact lead to changes in prices in a fashion that is consistent with anticipated shifts in demand. Robustness checks that examine changes in beer taxes generally, but not definitively, support the conclusion that supply is upward sloping in these markets.

[25] Changes in Alaska in 2002, Nebraska in 2003, Nevada in 2003, New York in 2001 and 2003, Tennessee in 2002, Utah in 2003 (Brewers Almanac)

There are a number of plausible explanations for an upward sloping supply curve for marijuana even in the long run. As was discussed previously and has been published elsewhere (Kleiman, 1990; Reuter and Kleiman, 1986), a substantial fraction of the monetary price of marijuana represents the economic value of risk associated with engaging in an illicit market. Although it is frequently presumed in other areas of economics that producers are risk-neutral, such a notion is inconsistent with empirical evidence showing that marijuana sellers receive large compensation for incurring risk in bringing the drug to market. A more plausible assumption is that producers of marijuana are not risk-neutral.[26] If we further presume that the population of potential suppliers to the market has heterogeneous risk preferences, it is easy to identify a potential barrier to entry into this market - the risk premium. If the current monetary compensation for incurring risk is relatively low, then some potential suppliers may choose to stay out of the market. Only by increasing the risk premium (and hence monetary price of supplying the good) will new suppliers decide to enter the market.

An upward sloping supply curve could also exist if input prices rise with increases in output. Although in legal markets rising input prices are relatively less common for agricultural products, the illicit nature of the marijuana market means that suppliers need to compensate field workers for the risk they incur participating in the production of an illegal good. If individuals who make up the potential pool of laborers have heterogeneous preferences in risk, then it is possible that input costs could rise with the level of production as those with the lower risk preference will have to be paid a higher premium to be enticed to work in this market versus a legal market. The extent to which heterogeneous risk preferences among potential laborers could influence the cost of production depends on the distribution of high and low risk preferences in the population of workers and the relative tax imposed on legitimate wages.

There are a number of important caveats that need to be considered when interpreting these results. First, the data that are employed in this study are drawn from a convenience sample of what is presumed to be heavy and/or regular users who are frequently engaged in the marijuana market. We do not know to what extent purchases described here are representative of the full population of purchases made in the market. Furthermore, we only observe purchases over a small window of time (16 quarters over the course of 4 years). However, these ADAM

[26] Even if all suppliers are risk averse, the supply function will slope upwards if their risk premiums vary.

data do represent a very good source of information on marijuana prices in the U.S., as it is clear that arrestees are frequent users who engage regularly in the market (Caulkins and Pacula, 2006).

A second and perhaps more important limitation of the study is the lack of information on the quality of marijuana. The omission of information on quality is clearly important because it is possible that several transaction-specific characteristics that we interpret as indicative of risk are also highly correlated with quality. To the extent that certain transaction patterns are highly correlated with the quality of marijuana (e.g. high quality marijuana purchased indoors and only sold to regular customers), then there may be some bias in interpreting the transaction coefficients as measuring differences in risk. However, unless the quality of marijuana is systematically correlated with state-level policies, it is not clear how the omission of quality from this analysis could potentially bias the findings regarding the effect of state policies.

While the finding of an upward sloping supply curve in marijuana markets may not be surprising, it does have important implications for thinking about the impact of changing user sanctions in illegal drug markets. First, it suggests that price effects may offset some of the policy effects of reducing legal risk to users on demand. This helps us better understand the small and sometimes statistically insignificant coefficients on policy variables in previous demand analyses. Second, it suggests that lowering legal risks for users are associated with higher marijuana prices, which *ceteris parabis*, implies higher profits for drug dealers in the short-run. Evaluating the welfare and moral implications of increasing profits for dealers is beyond the scope of this paper, but it is important to note that the increase in profits could lead to a rise in the number of dealers in the long run if barriers to entry, such as heterogeneous risk preferences across sellers, do not exist.

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Table 1.
Summary statistics for ADAM arrestees who purchased <=1oz marijuana with cash only

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Conditional discharge allowed for possessing 10g	10370	0.879267	0.325832	0	1
Nominal maximum fine for possessing 10g	9708	16401.29	45297.62	100	150000
Classified as a "decriminalization" state	10370	0.506461	0.499982	0	1
Nominal maximum fine for selling 10g	9984	49410.8	106000.7	100	500000
Physician recommendation or medical necessity	10370	0.355641	0.47873	0	1
Current Therapeutic Research Program	10370	0.422758	0.494022	0	1
Nominal beer tax	10370	0.25068	0.184921	0.06	1.07
MJ possession arrests/All arrests (FBI-CI>=70)	8579	0.046083	0.024306	0.001656	0.123499
MJ sales arrests/All arrests (FBI-CI>=70)	8579	0.004946	0.003898	0.0003	0.027496
Nominal transaction cost	10370	46.14262	78.58991	1	4500
Total grams purchased	10370	10.23567	9.380081	0.05	28.35
Real price per bulk gram (1982-84=100)	10370	5.393351	15.58225	0.059752	361.3777
Purchased in buyer's neighborhood	10370	0.400675	0.490059	0	1
Purchased from regular source	10370	0.487175	0.49986	0	1
Purchased from occasional source	10370	0.34783	0.476305	0	1
Purchased from a new source	10370	0.164995	0.371194	0	1
Contacted dealer: By phone or page	10370	0.43163	0.495327	0	1
Contacted dealer: Go to house or apt.	10370	0.236741	0.425102	0	1
Contacted dealer: Approached in public	10370	0.200675	0.400525	0	1
Contacted dealer: Other method	10370	0.130955	0.337367	0	1
Purchase location: In a house or apartment	10370	0.608197	0.488177	0	1
Purchase location: Public--Indoors	10370	0.12189	0.327175	0	1
Purchase location: Public--Outdoors	10370	0.269913	0.443936	0	1
Male	10370	0.923722	0.265455	0	1
Age 20 or less	10370	0.224976	0.417587	0	1
Age 21 to 25	10370	0.282642	0.450306	0	1
Age 26 to 35	10370	0.293057	0.455186	0	1
Age 36 or more	10370	0.199325	0.399512	0	1
White	10370	0.478206	0.499549	0	1
Black	10370	0.295178	0.456145	0	1
Asian	10370	0.00974	0.098213	0	1
Other race	10370	0.216876	0.412137	0	1
Hispanic	10370	0.168081	0.373956	0	1
Married	10370	0.158631	0.365349	0	1
Employed	10370	0.600579	0.489803	0	1
High School Graduate or GED	10370	0.717454	0.450259	0	1
Unemployment rate	10370	5.10082	1.344728	2.5	8.6
Real per capita personal income	10370	19482.71	4807.44	8751.452	49842.63
% Male	10370	0.493118	0.010507	0.464833	0.508659
% Black	10370	0.131806	0.1197	0.004654	0.682782
% White	10370	0.779675	0.128884	0.258181	0.982966
% American Indian	10370	0.01727	0.019336	0.002377	0.151804
% Asian	10370	0.071249	0.099024	0.004632	0.706677
% Hispanic	10370	0.163728	0.136527	0.015745	0.945625
% Age 0 to 17	10370	0.254745	0.023368	0.167865	0.367887
% Age 18 to 24	10370	0.098556	0.009748	0.07286	0.128117
% Age 25 to 34	10370	0.156673	0.01792	0.116671	0.215978
% Over 34	10370	0.490026	0.028068	0.366178	0.5502
County FIPS	10370	25723.81	17332.54	1073	53063
State FIPS	10370	25.66538	17.3278	1	53
Quarter	10370	2.46297	1.090481	1	4
Year	10370	2001.551	1.090885	2000	2003

*

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Table 2.
Price paid per bulk gram of marijuana by arrestees subject to different policies ($2004)

		No policy	**With policy**	
Panel A: Price paid by arrestees under different state laws				
Conditional discharge	Mean	$6.55	$10.69	***
	N	*1252*	*9118*	
Physician recommendation / Medical necessity	Mean	$6.91	$16.13	***
	N	*6682*	*3688*	
Decriminalization	Mean	$9.54	$10.81	**
	N	*5118*	*5252*	
Panel B: Prices paid by arrestees in states that changed physician recommendation/medical necessity laws since 2000				
Colorado	Mean	$3.59	$4.87	*
	N	*94*	*297*	
Hawaii	Mean	$18.11	$23.44	
	N	*13*	*143*	
Nevada	Mean	$7.78	$9.17	
	N	*233*	*239*	

Note: All figures are adjusted for inflation and reported in $2004. A two-sample t test is used to compare means.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3.
GLM Estimates of Log Real Price Per Bulk Gram: Transaction Information

	(1)	(2)	(3)	(4)
Purchased from occasional source	0.042	0.047	0.028	0.030
	[0.053]	[0.055]	[0.051]	[0.050]
Purchased from a new source	0.027	0.038	-0.014	-0.009
	[0.071]	[0.068]	[0.072]	[0.072]
Purchased in buyer's neighborhood	-0.027	-0.027	-0.023	-0.023
	[0.063]	[0.063]	[0.059]	[0.059]
Purchased in Public--Indoor		-0.022		-0.095
		[0.081]		[0.086]
Purchased in Public--Outdoor		-0.049		-0.124
		[0.061]		[0.079]
Contact dealer: Phone or pager			0.046	-0.014
			[0.051]	[0.073]
Contact dealer: Go to house or apt.			-0.094*	-0.179**
			[0.051]	[0.081]
Contact dealer: Other method			0.287***	0.249**
			[0.085]	[0.097]
Bought directly from dealer				0.076
				[0.090]
Constant	-2.842	-2.715	-5.003	-5.085
	[6.339]	[6.386]	[5.821]	[5.706]
State fixed effects	Yes	Yes	Yes	Yes
County-level variables	Yes	Yes	Yes	Yes
Individual-level variables	Yes	Yes	Yes	Yes
Quarter and year fixed effects	Yes	Yes	Yes	Yes
Observations	10370	10370	10370	10370
Gamma from Modified Park test	1.97	1.97	2.07	2.09
BIC	-85422	-85228	-85339	-85334

Notes: All models estimated using GLM with link(log) and family(Gamma). Individual-level variables include Male, Age 21 to 25, Age 26 to 35, Age 36 or more, Black, Asian, Other race, Hispanic, Married, Employed, and High School Graduate or GED. County-level variables include Unemployment rate, Real per capita personal income, % Male, % Black, % American Indian,% Asian, % Hispanic, % Age 0 to 17, % Age 25 to 34, and % Over 34. Reference groups: Source (Regular source), Contact (Approached in public), Purchase location (In a house or apartment). Standard errors clustered at the state-level in all models. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4.
GLM Estimates of Log Real Price Per Bulk Gram: User Penalties

	(1)	(2)	(3)	(4)	(5)	(6)
Conditional discharge allowed for possessing 10g	0.847***	0.776***	0.370***	0.516***	0.605***	0.390***
	[0.189]	[0.228]	[0.094]	[0.196]	[0.201]	[0.134]
Ln(Real maximum fine for possessing 10g)	-0.156***	-0.125**	-0.008	-0.056	0.004	0.065
	[0.029]	[0.054]	[0.016]	[0.069]	[0.054]	[0.047]
Ln(Real maximum fine for selling 10g)		-0.048	-0.162***			
		[0.051]	[0.012]			
Classified as a decriminalization state					0.257**	0.540***
					[0.131]	[0.149]
MJ possession arrests/All arrests						-8.721***
						[3.038]
MJ sales arrests/All arrests						6.202
						[12.314]
Purchased from occasional source	0.059	0.029	0.002	0.073	0.061	0.120**
	[0.055]	[0.053]	[0.053]	[0.060]	[0.061]	[0.060]
Purchased from a new source	-0.002	-0.012	-0.043	-0.045	-0.046	-0.022
	[0.085]	[0.090]	[0.082]	[0.088]	[0.090]	[0.103]
Purchased in buyer's neighborhood	0.055	0.071	0.025	0.039	0.035	0.010
	[0.065]	[0.068]	[0.062]	[0.059]	[0.062]	[0.058]
Contact dealer: Phone or pager	-0.056	-0.097	-0.102	-0.108	-0.086	-0.034
	[0.088]	[0.088]	[0.073]	[0.076]	[0.076]	[0.077]
Contact dealer: Go to house or apt.	-0.269***	-0.301***	-0.286***	-0.272***	-0.258***	-0.191**
	[0.086]	[0.086]	[0.074]	[0.081]	[0.082]	[0.083]
Contact dealer: Other method	0.141*	0.130	0.122	0.128	0.155	0.190
	[0.084]	[0.090]	[0.089]	[0.098]	[0.104]	[0.124]
Purchased in Public--Indoor	-0.161**	-0.217***	-0.214***	-0.158*	-0.154*	-0.089
	[0.079]	[0.052]	[0.057]	[0.088]	[0.088]	[0.101]
Purchased in Public--Outdoor	-0.105	-0.108	-0.149*	-0.173**	-0.163*	-0.092
	[0.094]	[0.093]	[0.081]	[0.085]	[0.087]	[0.097]
Bought directly from dealer	0.077	0.054	0.103	0.151*	0.152*	0.218***
	[0.103]	[0.102]	[0.091]	[0.083]	[0.082]	[0.073]
Constant	2.032***	2.396***	3.358	5.261	6.676*	13.669***
	[0.281]	[0.265]	[3.247]	[3.939]	[3.509]	[2.815]
State fixed effects	No	No	No	No	No	No
County-level variables	No	No	Yes	Yes	Yes	Yes
Individual-level variables	Yes	Yes	Yes	Yes	Yes	Yes
Quarter and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9708	9322	9322	8708	8708	6917
Gamma from Modified Park test	1.75	1.68	1.85	1.68	1.76	1.82
BIC	-77446	-74107	-75346	-69293	-69341	-53125

Notes: All models estimated using GLM with link(log) and family(Gamma). Columns 4-6 do not include 1,000 observations from Arizona. The sample size decreases by an additional 1,791 observations in Column 6 because enforcement data are limited to jurisdictions with UCR Coverage Indicator scores >=70. Individual-level variables include Male, Age 21 to 25, Age 26 to 35, Age 36 or more, Black, Asian, Other race, Hispanic, Married, Employed, and High School Graduate or GED. County-level variables include Unemployment rate, Real per capita personal income, % Male, % Black, % American Indian,% Asian, % Hispanic, % Age 0 to 17, % Age 25 to 34, and % Over 34. Reference groups: Source (Regular source), Contact (Approached in public), Purchase location (In a house or apartment). Standard errors clustered at the state-level in all models. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5.
GLM Estimates of Log Real Price Per Bulk Gram: Medical Marijuana

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Physician recommendation or medical necessity	0.872***	0.729***	0.669***	0.574***	0.771***	0.165*	0.160*
	[0.133]	[0.160]	[0.172]	[0.136]	[0.118]	[0.086]	[0.086]
Current Therapeutic Research Program			0.139				
			[0.144]				
Conditional discharge for possessing 10g				0.432***			
				[0.138]			
Ln(Real maximum fine for possessing 10g)				0.057			
				[0.043]			
Classified as a decriminalization state				0.155*			
				[0.089]			
MJ possession arrests/All arrests					-7.706***	-1.638	-1.777
					[1.960]	[4.042]	[4.167]
MJ sales arrests/All arrests					14.778	25.282	30.306
					[9.057]	[18.247]	[18.646]
Ln(County population)							-0.119**
							[0.054]
Purchased from occasional source	0.038	0.020	0.018	0.041	0.073	0.072	0.071
	[0.053]	[0.051]	[0.051]	[0.058]	[0.052]	[0.054]	[0.054]
Purchased from a new source	-0.041	-0.054	-0.059	-0.058	-0.033	-0.018	-0.019
	[0.083]	[0.082]	[0.081]	[0.092]	[0.087]	[0.084]	[0.084]
Purchased in buyer's neighborhood	0.000	-0.029	-0.029	0.004	-0.053	-0.050	-0.050
	[0.064]	[0.060]	[0.060]	[0.066]	[0.052]	[0.053]	[0.053]
Contact dealer: Phone or pager	-0.072	-0.051	-0.053	-0.082	-0.002	0.007	0.008
	[0.080]	[0.080]	[0.078]	[0.078]	[0.079]	[0.077]	[0.077]
Contact dealer: Go to house or apt.	-0.263***	-0.233***	-0.234***	-0.245***	-0.162**	-0.133	-0.131
	[0.091]	[0.086]	[0.084]	[0.085]	[0.081]	[0.084]	[0.084]
Contact dealer: Other method	0.166*	0.225**	0.220**	0.168*	0.241**	0.262**	0.265**
	[0.091]	[0.106]	[0.105]	[0.101]	[0.117]	[0.109]	[0.109]
Purchased in Public--Indoor	-0.119	-0.127	-0.130	-0.150*	-0.069	-0.067	-0.067
	[0.090]	[0.087]	[0.086]	[0.085]	[0.099]	[0.101]	[0.101]
Purchased in Public--Outdoor	-0.120	-0.130	-0.128	-0.157*	-0.065	-0.079	-0.077
	[0.098]	[0.087]	[0.086]	[0.089]	[0.089]	[0.088]	[0.088]
Bought directly from dealer	0.119	0.092	0.097	0.146*	0.134	0.126	0.130
	[0.096]	[0.088]	[0.088]	[0.084]	[0.096]	[0.093]	[0.093]
Constant	1.413***	8.293*	6.389	12.968***	16.503***	19.142**	13.379*
	[0.228]	[4.765]	[4.907]	[3.537]	[3.492]	[7.491]	[7.892]
State fixed effects	No	No	No	No	No	Yes	Yes
County-level variables	No	Yes	Yes	Yes	Yes	Yes	Yes
Individual-level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10370	10370	10370	8708	8579	8579	8579
Gamma from Modified Park test	1.64	1.70	1.74	1.77	1.95	2.16	2.15
BIC	-84022	-84686	-84699	-69564	-68280	-68507	-68500

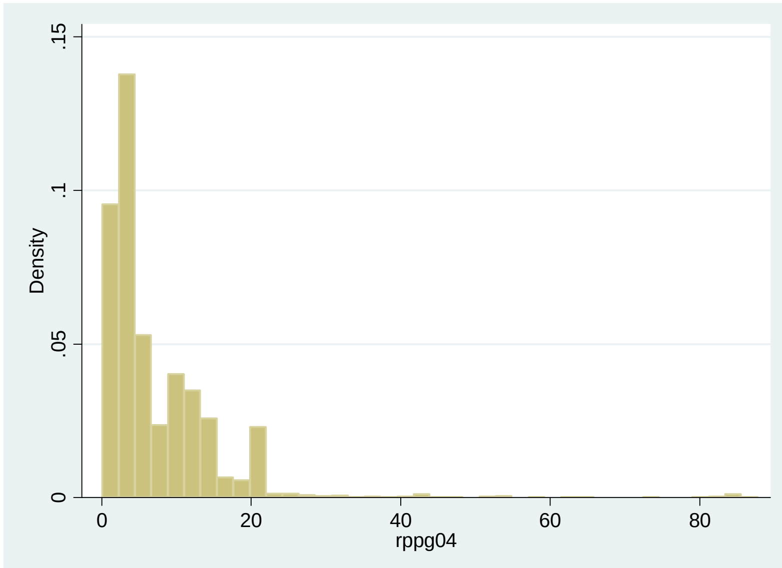
Notes: All models estimated using GLM with link(log) and family(Gamma). Column 4 does not include 1,000 observations from Arizona and 662 observations from states that do not have a maximum fine for possessing 10 grams. The sample size decreases by 1,791 observations in Columns 5-7 because enforcement data are limited to jurisdictions with UCR Coverage Indicator scores >=70. Individual-level variables include Male, Age 21 to 25, Age 26 to 35, Age 36 or more, Black, Asian, Other race, Hispanic, Married, Employed, and High School Graduate or GED. County-level variables include Unemployment rate, Real per capita personal income, % Male, % Black, % American Indian,% Asian, % Hispanic, % Age 0 to 17, % Age 25 to 34, and % Over 34. Reference groups: Source (Regular source), Contact (Approached in public), Purchase location (In a house or apartment). Standard errors clustered at the state-level in all models. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6.
GLM Estimates of Log Real Price Per Bulk Gram: Real Beer Tax

	(1)	(2)	(3)
Real beer tax	-0.742***	-0.704***	-0.486
	[0.153]	[0.211]	[0.388]
MJ possession arrests/All arrests		-2.535	-0.697
		[2.814]	[3.549]
MJ sales arrests/All arrests		43.902**	20.153
		[18.204]	[16.468]
Purchased from occasional source	0.034	0.072	0.073
	[0.052]	[0.054]	[0.054]
Purchased from a new source	-0.014	-0.025	-0.020
	[0.073]	[0.085]	[0.083]
Purchased in buyer's neighborhood	-0.022	-0.051	-0.049
	[0.060]	[0.056]	[0.053]
Contact dealer: Phone or pager	-0.007	0.026	0.007
	[0.074]	[0.077]	[0.077]
Contact dealer: Go to house or apt.	-0.181**	-0.123	-0.133
	[0.081]	[0.083]	[0.084]
Contact dealer: Other method	0.254**	0.283**	0.262**
	[0.104]	[0.115]	[0.108]
Purchased in Public--Indoor	-0.087	-0.057	-0.067
	[0.088]	[0.101]	[0.101]
Purchased in Public--Outdoor	-0.117	-0.063	-0.079
	[0.082]	[0.090]	[0.089]
Bought directly from dealer	0.073	0.129	0.122
	[0.089]	[0.091]	[0.092]
Constant	1.644***	1.590***	20.026**
	[0.179]	[0.321]	[9.491]
State fixed effects	Yes	Yes	Yes
County-level variables	No	No	Yes
Individual-level variables	Yes	Yes	Yes
Quarter and year fixed effects	Yes	Yes	Yes
Observations	10730	8579	8579
Gamma from Modified Park test	2.03	2.08	2.15
BIC	-85326	-68506	-68504

Notes: All models estimated using GLM with link(log) and family(Gamma). The sample size decreases by 1,791 observations in Columns 2-3 because enforcement data are limited to jurisdictions with UCR Coverage Indicator scores >=70. Individual-level variables include Male, Age 21 to 25, Age 26 to 35, Age 36 or more, Black, Asian, Other race, Hispanic, Married, Employed, and High School Graduate or GED. County-level variables include Unemployment rate, Real per capita personal income, % Male, % Black, % American Indian,% Asian, % Hispanic, % Age 0 to 17, % Age 25 to 34, and % Over 34. Reference groups: Source (Regular source), Contact (Approached in public), Purchase location (In a house or apartment). Standard errors clustered at the state-level in all models. * significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1.
Distribution of price paid per bulk gram of marijuana ($2004)



Note: N=10,256. For display purposes we do not include the 114 observation with RPPG>$100.

Appendix I.
Marijuana Penalties and Medicalization Policies for States in our Analysis Sample, 2003

State	Obs.	Conditional Discharge for 10g	Nominal Max Fine for Possessing 10g	Classified as "Decrim" State	Physician Recommendation/ Med. Necessity	Current TRP	Allows for Home Cultivation
Alabama	135	Yes	$2,000			Yes	
Alaska	367	Yes	$1,000	Yes	Yes		Yes
Arizona	1,000	Yes	$150,000	Yes			
California	1,384	Yes	$100	Yes	Yes	Yes	Yes
Colorado	391		$100	Yes	Yes*		Yes*
Wash DC	17	Yes	$1,000				
Florida	172	Yes	$1,000				
Georgia	168	Yes	$1,000			Yes	
Hawaii	156	Yes	$1,000		Yes*		Yes*
Illinois	137	Yes	$1,500			Yes	
Indiana	461	Yes	$5,000				
Iowa	303	Yes	$1,000				
Louisiana	107	Yes	$500				
Massachusetts	15	Yes	$500			Yes	
Michigan	114	Yes	$2,000				
Minnesota	386	Yes	$300*	Yes		Yes	
Missouri	30		$1,000				
Nebraska	329	Yes	$100	Yes			
Nevada	472	Yes	$5,000		Yes*		Yes*
New Mexico	303	Yes	$100			Yes	
New York	397		$100	Yes		Yes	
North Carolina	188	Yes	$200	Yes			
Ohio	434		$100	Yes			
Oklahoma	662	Yes	NA				
Oregon	376	Yes	$1,000	Yes	Yes		Yes
Pennsylvania	94	Yes	$500				
Texas	577	Yes	$2,000			Yes	
Utah	313	Yes	$1,000				
Washington	882	Yes	$250		Yes	Yes	Yes

Notes: * Denotes change during sample period. Arizona and Louisiana have physician prescription laws on the books, they are purely symbolic and do not afford medical users legal protection (MPP 2006). In Arizona, a law was signed in 1997 which required all drugs dispensed as medicine must be approved by the federal FDA (*New York Times*, 1997). This, in essence, repealed the medical marijuana law (Annas, 1997).