The Legalization of Recreational Marijuana
How Likely is the Worst-Case Scenario?

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INTRODUCTION

Last fall, voters in Colorado and Washington approved measures legalizing the recreational use of marijuana. In the near future, residents of these states who are 21 years of age and older will be able to purchase marijuana at retail stores (Donlan, 2013). Although it can be difficult to predict future behavior, Mark Kleiman, a prominent drug-policy expert, described what might be characterized as the worst-case scenario. According to Kleiman, this scenario would involve three elements: more heavy drinking, "carnage on our highways", and a "massive" increase in the use of marijuana by minors (Livingston, 2013).

Below, we discuss the likely effects of legalizing marijuana for recreational use on alcohol consumption, traffic fatalities, substance use among high school students, and other outcomes of interest to policymakers and the public. Our discussion draws heavily on studies that have examined the legalization of medical marijuana. These studies are relevant because, in states such as California, Colorado, Oregon and Washington, the legalization of marijuana for medicinal purposes approaches de facto legalization of marijuana for recreational purposes.

One of the key unknowns in the debate over legalization concerns the relationship between alcohol and marijuana use. Researchers have attempted to produce causal estimates of this relationship by exploiting cross-sectional policy and price variation (Pacula, 1998; Williams et al., 2004). We note that these estimates could easily be spurious and that more reliable estimates based on clearly-defined natural experiments show that alcohol and marijuana are substitutes. Because the social costs associated with the consumption of alcohol clearly outweigh those associated with the consumption of marijuana, we conclude that legalizing the recreational use of marijuana is likely to improve public health, although plenty of unanswered questions remain.

BACKGROUND

In 1996, California voters approved the Compassionate Use Act, which removed criminal penalties for using, possessing and cultivating medical marijuana. Under this act, doctors are allowed to recommend the use of marijuana "in the treatment of cancer, anorexia, AIDS, chronic pain, spasticity, glaucoma, arthritis, migraine, or any other illness for which marijuana provides relief", and patients are allowed to designate a caregiver, who can obtain or grow marijuana on their behalf.[1]

The Compassionate Use Act affords growers and distributers some protection against prosecution and allows patients to buy marijuana without fear of being arrested or fined. Because it is prohibitively expensive to ensure that all medical marijuana ends up in the hands of patients, a substantial portion of the California medicinal crop is diverted to the recreational market (Nagourney, 2012; Montgomery, 2010). Since 1996, 19 additional states have passed medical marijuana laws (although, in an effort to prevent diversion to the recreational market, a number of these states limit caregivers to one patient, prohibit home cultivation, or prohibit/limit dispensaries). By examining pre- and post-legalization data from these states, we can make predictions about what will happen in Colorado and Washington.

THE EFEECT OF LEGALIZATION ON PRICE

The legalization of medical marijuana can be thought of as increasing both the supply of and the demand for marijuana (Pacula et al., 2010). Although the effect of legalizing medical

[1] The full text of the Compassionate Use Act of 1996 is available at: http://www.cdph.ca.gov/programs/mmp/pages/compassionateuseact.aspx.

marijuana on consumption is unambiguously positive, its effect on price could be either positive or negative.

Anderson, Hansen, & Rees (2013) collected price data from back issues of *High Times* magazine for the period 1990 through 2011 to gauge the impact of legalizing medical marijuana on the marijuana market. They found that legalization was associated with a 10 to 26 percent decrease in the price of high-quality marijuana, suggesting the supply response to legalizing medical marijuana is larger than the demand response. These authors also compared *High Times* prices from 2011-2012 to prices advertised by dispensaries in Arizona, California, Colorado, Michigan, Nevada, Oregon and Washington. The *High Times* prices were similar to the dispensary prices, suggesting that there is substantial overlap between the medicinal and recreational markets in these states.

Both Colorado and Washington have legalized the production and commercial distribution of marijuana for recreational purposes, but these activities are still prohibited under federal law. As a consequence, large-scale farming of marijuana with tractors and unskilled workers is not likely to occur (Caulkins et al., 2012, pp. 192-193). Instead, most production will continue to take place under grow lights inside relatively small facilities. Because the production of medical marijuana under these conditions is already widespread in Colorado and Washington, price may not fall much further than it already has. If a non-medical marijuana state such as New York were to legalize the recreational use of marijuana without first taking the intermediate step of legalizing medicinal use, the price of marijuana would, in all likelihood, fall substantially. The results of Anderson, Hansen, & Rees (2013) suggest that, under these circumstances, the price of marijuana could fall by as much as 40 percent after 4 to 5 years.

MARIJUANA USE

The National Survey on Drug Use and Health (NSDUH) is the best source of information on marijuana consumption by adults living in the United States. However, the NSDUH does not typically provide individual-level data with state identifiers to researchers, and did not publish state-level estimates of marijuana use prior to 1999. Because 5 states (including California, Oregon and Washington) legalized medical marijuana during the period 1996 -1999, the NSDUH is of limited value when trying to estimate the effect of legalization on the use of marijuana.

As an alternative to using NSDUH data, we examined the effect of legalizing medical marijuana on the amount of marijuana eradicated under the Domestic Cannabis Eradication/Suppression Program during the period 1990 through 2010. Standard difference-in-differences estimates based on data at the state-year level are reported in Table 1.

Without state-specific linear time trends, legalizing medical marijuana is associated with an almost 200 percent increase in the number of marijuana plants eradicated under the Domestic Cannabis Eradication/Suppression Program ($e^{1.08} - 1 = 1.94$). This estimate, however, becomes much smaller and insignificant when state-specific linear time trends are added to the model. Without state-specific linear time trends, legalization is associated with a 51.4 percent increase in the number of indoor plants eradicated. When state-specific linear time trends are included, this estimate actually becomes larger: legalization is associated with an 83.7 percent increase in the number of indoor plants eradicated.

These results are consistent with the hypothesis that legalizing medical marijuana leads to a substantial increase in the supply of marijuana grown indoors, but could reflect greater effort on the part of the Drug Enforcement Administration (DEA), the agency tasked with running the

Domestic Cannabis Eradication/Suppression Program. Unfortunately, the DEA provides almost no information on the intensity of their eradication efforts. However, we do know that state officials and lawmakers from medical marijuana states have put pressure on the DEA to scale back its efforts (Slevin, 2010; Aiello, 2011; Graves, 2012; Ingold, 2012). In addition, if the post-legalization increase in indoor plants eradicated were due to a ramping up of effort, price should have increased. Instead, the price of high-quality marijuana fell after legalization (Anderson, Hansen, & Rees, 2013), suggesting that any increase in effort did not keep up with supply. If the DEA allows Colorado and Washington growers to expand their operations, a further decrease in price and a corresponding increase in consumption can be expected. By how much might consumption increase? The answer to this question depends, in part, on the price elasticity of demand for marijuana. A number of studies have attempted to estimate this elasticity (Nisbet & Vakil, 1972; Pacula et al., 2001; DeSimone & Farrelly, 2003; Williams et al., 2004), but none exploited a clearly-defined natural experiment. As a consequence, very little is known about how marijuana consumption would respond to further reductions in price.

ALCOHOL USE

Pacula (1998) and Williams et al. (2004) found evidence of a negative relationship between beer taxes and marijuana use, suggesting that beer and marijuana are complements. However, both of these studies relied on cross-sectional variation in state beer taxes, which could reflect difficult-to-observe factors such as attitudes towards substance use. By way of an example: Utah taxes beer at five times the Colorado rate for historical and cultural reasons; these same reasons probably explain why marijuana use in Utah is so low compared to Colorado.[2]

[2] According to the Tax Foundation, Utah taxes beer at 41 cents per gallon, while Colorado taxes beer at 8 cents per gallon. According to data from the 2009 and 2010 NSDUH, approximately 3 percent of Utah residents ages 12 and

Exploiting within-state variation in the price of beer over time, Farrelly et al. (1999) found evidence of complementarity between alcohol and marijuana among teens but not among young adults. Yörük & Yörük (2011) used data from the National Longitudinal Survey of Youth 1997 (NLSY97) and a regression discontinuity design to examine the effect of the minimum legal drinking age (MLDA) on marijuana use. They also found evidence of complementarity but inadvertently conditioned on having used marijuana at least once since the last interview. When Crost & Rees (2013) applied Yörük & Yörük's (2011) research design to the NLSY97 data without conditioning on having used marijuana since the last interview, they found no evidence that alcohol and marijuana were complements.

Studies based on clearly-defined natural experiments generally support the hypothesis that marijuana and alcohol are substitutes. For instance, DiNardo & Lemieux (2001) found that increasing the MLDA from 18 to 21 encourages marijuana use. Using data from the NSDUH and a regression discontinuity design, Crost & Guerrero (2012) found a sharp decrease in marijuana use at 21 years of age, suggesting that young adults treat alcohol and marijuana as substitutes. Finally, Anderson, Hansen, & Rees (2013) examined the relationship between legalizing medical marijuana and drinking using data from the Behavioral Risk Factor Surveillance System. These authors found that legalization was associated with reductions in heavy drinking especially among 18- through 29-year-olds. In addition, they found that legalization was associated with an almost 5 percent decrease in beer sales, the alcoholic beverage of choice among young adults (Jones, 2008).

The results of DiNardo & Lemieux (2001), Crost & Guerrero (2012) and Anderson, Hansen, & Rees (2013) suggest that, as marijuana becomes more available, young adults in

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over used marijuana in the past month. In comparison, approximately 11 percent of Colorado residents used marijuana in the past month (National Survey on Drug Use and Health, 2012).

Colorado and Washington will respond by drinking less, not more. If non-medical marijuana states legalize the use of recreational marijuana, they should also experience reductions in drinking with the accompanying public health benefits.

TRAFFFIC FATALITES

Reducing traffic injuries and fatalities is potentially one of the most important public health benefits from legalizing the use of recreational marijuana. Tetrahydrocannabinol (THC), the principal psychoactive component of marijuana, impairs driving-related functions (Kelly, Darke, & Ross, 2004), but there is evidence that drivers under the influence of THC compensate for these impairments. For instance, they tend to drive slower and take fewer risks (Robbe & O'Hanlon, 1993; Sewell, Poling, & Sofuoglu, 2009). In contrast, drivers under the influence of alcohol trend to drive faster and take more risks (Burian, Liguori, & Robinson, 2002; Marczinski, Harrison, & Fillmore, 2008; Ronen et al., 2008). While driving under the influence of marijuana is associated with a two-fold increase in the risk of being involved in a collision (Asbridge, Hayden, & Cartwright, 2012), driving with a blood alcohol concentration (BAC) of 0.08 or greater is associated with a 4- to 27-fold increase in this same risk (Peck et al., 2008).

Driving under the combined influence of alcohol and marijuana is especially dangerous (Sewell, Poling, & Sofuoglu, 2009). Therefore, if young adults viewed alcohol and marijuana as complements, legalizing the recreational use of marijuana could seriously jeopardize roadway safety. Fortunately, as noted above, studies based on clearly-defined natural experiments suggest that young adults, a group responsible for a disproportionate share of traffic accidents and fatalities (Eustace & Wei, 2010), typically substitute marijuana in place of alcohol.

Using data from the Fatality Analysis Reporting System (FARS) for the period 1990-2010, Anderson, Hansen, & Rees (2013) examined the effect of legalizing medical marijuana on traffic fatalities. They found that legalizing medical marijuana was associated with a 13 percent decrease in fatalities involving alcohol. It is important to note, however, that their results do not necessarily imply that driving under the influence of marijuana is safer than driving under the influence of alcohol. Because marijuana is not typically consumed in public venues such as restaurants and bars, their results may reflect fewer impaired drivers on the road.[3]

Finally, the Washington law that legalized recreational marijuana also established a THC limit for drivers of 5 nanograms per milliliter of blood.[4] A strict THC limit above which drivers are automatically considered impaired may, in the future, be viewed by the public and policymakers as a necessary complement to legalizing recreational marijuana. However, there is little evidence that, as currently implemented, such limits actually improve roadway safety (Anderson & Rees 2012). Given this lack of evidence, policymakers might consider lowering the BAC limit. This could deter drunk driving (Dee, 2001; Eisenberg, 2003) and come with the added benefit of discouraging driving under the combined influence of alcohol and marijuana. Alternatively, a substantial increase in alcohol excise taxes could help to discourage driving under the combined influence of alcohol and marijuana. The current excise tax on liquor sold in Colorado is 60.26 cents per liter, which represents roughly 3 percent of the retail price of Jim Beam Whisky purchased by the bottle.[5] In comparison, Colorado is set to impose a 15 percent

[3] A small number of quasi-private bars and clubs catering to marijuana users have begun operating in Colorado and Washington since the legalization of recreational marijuana (Johnson, 2013). If these establishments become popular, this could lead to more traffic fatalities involving drivers under the influence of marijuana.

[4] The Colorado legislature voted to establish a similar threshold in May of 2013 (Ingold, 2013a).

[5] The retail price of Jim Beam Whisky was obtained from Argonauts Liquor in Denver (http://www.argonautliquor.com), Davidson Liquors in Highlands Ranch (http://davidsonsliquors.com), and Cheers

excise tax and a 10 percent special sales tax on marijuana sales (Ingold, 2013b). Washington is considering taxing producers, sellers and buyers at a total rate of 75 percent (Donlan, 2013).

MARIJUNA USE BY TEENAGERS

Policymakers and the public are especially concerned that legalization of recreational marijuana will encourage substance use among teenagers. This concern is bolstered by the fact that Denver teenagers receiving treatment for substance abuse have reported obtaining marijuana from medical marijuana patients (Thurstone, Lieberman, & Schmiege, 2011; Salomonsen-Sautel et al., 2012). The interesting question, however, is not whether diversion to teenagers will occur with the legalization of recreational marijuana (it will). The more interesting (and policy-relevant) question is whether marijuana use by teenagers will increase when "pot shops" open throughout Colorado and Washington.

Using data from national and state Youth Risk Behavior Surveys (YRBS) for the period 1993 through 2011, Anderson, Hansen, & Rees (2012) found little evidence of a relationship between legalizing medical marijuana and the use of marijuana among high school students.[6] Critics of Anderson, Hansen, & Rees (2012) have argued that youth access to medical marijuana did not appreciably increase until medical marijuana dispensaries became widespread (Ferner, 2013). In an effort to explore the role of dispensaries, we turned to local YRBS data for the period 2001-2011.[7] Specifically, we compared marijuana use among Los Angeles high school students to marijuana use among Chicago, Dallas, Boston, and Miami-Dade County high school

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Liquor Mart in Colorado Springs (http://www.cheersliquormart.com). Jim Beam is the best-selling brand of whisky in the Unites States.

[6] See also Harper, Strumpf, & Kaufman (2012) and Lynne-Landsman, Livingston, & Wagenaar (2013).

[7] These data are available at: http://apps.nccd.cdc.gov/youthonline/App/Default.aspx?SID=HS.

students (Figure 1). The first dispensaries began operating in Los Angeles prior to the passage of the Compassionate Use Act (Curtius & Yates, 1996), but the dispensary boom did not occur until after 2004 (Jacobson et al., 2011). From 2005 to 2010, the number of dispensaries operating in Los Angeles surged from only a handful to more than 600 (Jacobson et al., 2011).[8] There were no legal medical marijuana dispensaries operating in Chicago, Dallas, Boston, or Miami-Dade County during the period 2001-2011.

Figure 1 provides little evidence that marijuana use among Los Angeles high school students increased in the mid-2000s, perhaps because dispensaries could sell to adults with some assurance of not being shut down, while selling marijuana to a minor was still a risky proposition even after the passage of the Compassionate Use Act.[9] Marijuana use among Los Angeles high school students actually declined from 2007 to 2009 and then increased from 2009 to 2011. However, there were comparably-sized increases in marijuana use among Chicago, Dallas and Boston high school students from 2009 to 2011.

CRIME AND OTHER PUBLIC HEALTH OUTCOMES

There is evidence of a link between alcohol abuse and violent crime, including domestic violence (Markowitz & Grossman, 1998; Markowitz, 2000, 2005; Carpenter & Dobkin, 2010). Therefore, if the legalization of recreational marijuana leads to reduced alcohol consumption, we expect violent crime to fall. It is also possible that non-violent crime will fall as policing resources are freed up and reallocated (Miron & Zwiebel, 1995). Adda, McConnell, & Rasul

[8] In June of 2010, the city of Los Angeles ordered 439 (or approximately 70 percent) of its medical marijuana dispensaries to close (Jacobson et al., 2011, p. 8).

[9] Federal authorities in Los Angeles have focused their attention on medical marijuana dispensaries that violate state law by, for instance, selling to minors (Meyers & Glover, 2009). Medical marijuana patients under the age of 18 must be accompanied by a parent or legal caregiver when visiting a dispensary (Ellison, 2009).

(2011) found that non-drug crime went down after Lambeth, a borough of London, temporarily suspended arrests for marijuana possession.

Other potential public health benefits from legalizing recreational marijuana could include a reduction in suicides (Anderson, Rees, & Sabia, 2012), increased product quality and fewer emergency room episodes resulting from the use of marijuana laced with chemicals such as phencyclidine (PCP) and embalming fluid. Quality oversight by the government is absent for illegal drugs, and repeated interactions between buyers and sellers in a prohibited market is, in all likelihood, only a partial solution (Miron & Zwiebel, 1995).

Finally, it is possible that the legalization of recreational marijuana will impact the demand for hard drugs such as cocaine and heroin. Previous studies have documented a positive association between the use of marijuana and hard drugs (DeSimone, 1998; van Ours, 2003; Fergusson, Boden, & Horwood, 2006; Bretteville-Jensen, Melbergy, & Jonesz, 2008; Melberg, Jones, & Bretteville-Jensen, 2010), but these studies were not based on clearly-defined natural experiments. Two exceptions are Kelly & Rasul (2012) and Model (1993). Kelly & Rasul (2012) found that hospital admissions for hard drugs increased after the borough of Lambeth suspended arrests for marijuana possession. In contrast, Model (1993), who used U.S. data, found that marijuana decriminalization led to fewer emergency room episodes involving drugs other than marijuana.

CONCLUSION

Kleiman's worst-case scenario is possible, but not likely. Based on existing empirical evidence, we expect that the legalization of recreational marijuana in Colorado and Washington will lead to increased marijuana consumption coupled with decreased alcohol consumption. As a

consequence, these states will experience a reduction in the social harms resulting from alcohol use. While it is more than likely that marijuana produced by state-sanctioned growers will end up in the hands of minors, we predict that overall youth consumption will remain stable. On net, we predict the public health benefits of legalization to be positive.

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Figure 1. Local YRBS 2001-2011

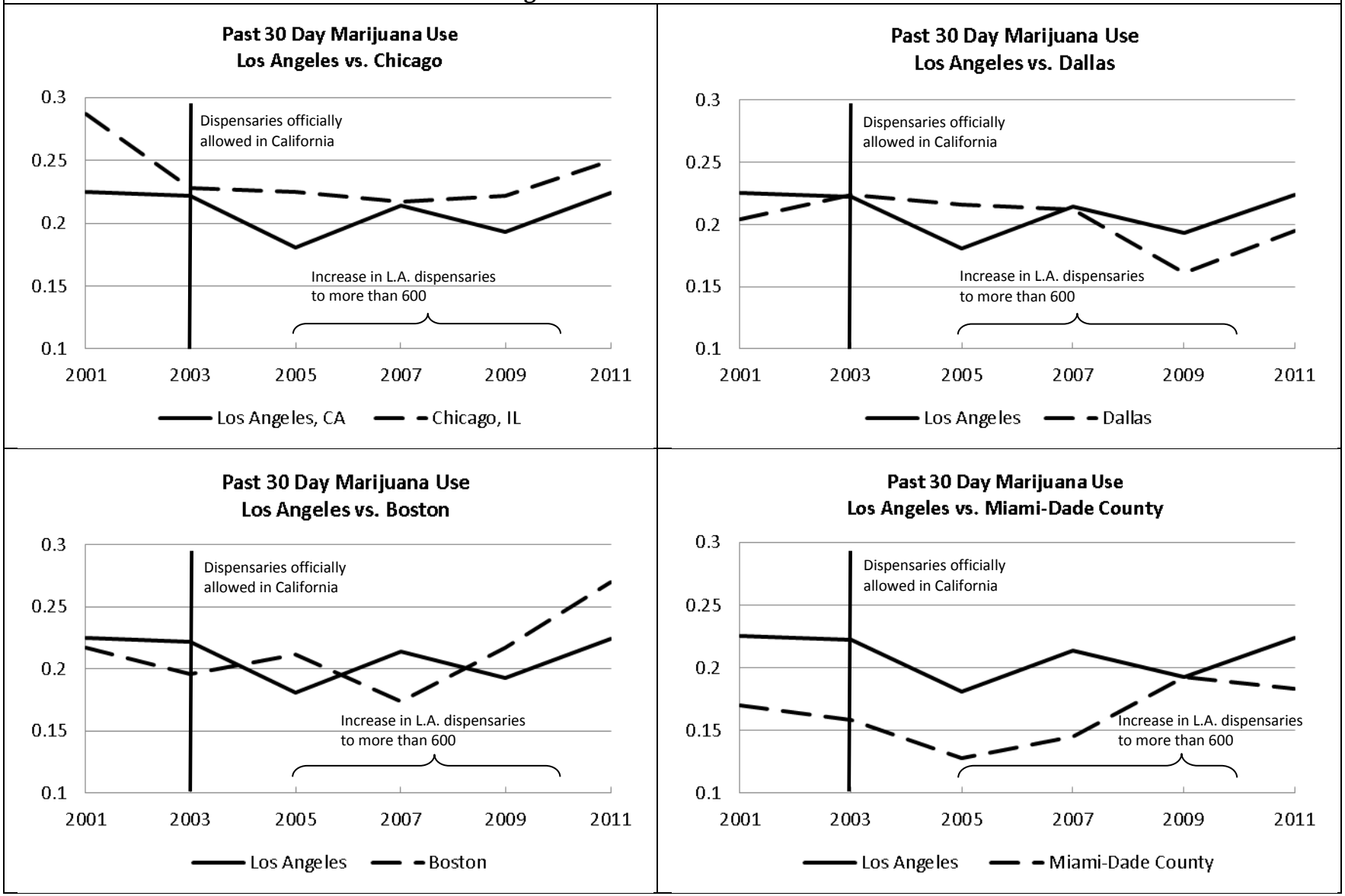

Table 1. The Legalization of Medical Marijuana and DEA Eradication Efforts

	ln(Total Plants Eradicated)		*ln(Outdoor Plants Eradicated)*		*Ln(Indoor Plants Eradicated)*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Legalization of	1.08***	0.113	1.289**	-0.045	0.415*	0 .608*
Medical Marijuana	(0.240)	(0.212)	(0.389)	(0.220)	(0.240)	(0.311)
N	1040	1040	963	963	972	972
R^2	0.859	0.899	0.838	0.896	0.823	0.850
State and Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trends	No	Yes	No	Yes	No	Yes

*Statistically significant at 10% level; **at 5% level; ***at 1% level.

Notes: Based on state-level data produced by the Domestic Cannabis Eradication/Suppression Program for the period 1990-2010 available at http://www.drugscience.org/Archive/DCESP/ and http://www.albany.edu/sourcebook/ind/DRUG_ENFORCEMENT_ADMINISTRATION.Seizures_and_removals.1.html. Each odd-numbered column represents the results from a separate OLS regression of the form:

$$\ln(\textit{Plants Eradicated}) = \beta 0 + \beta 1 \textit{Legalization}_{st} + \boldsymbol{X_{st}\beta 2} + vs + wt + \varepsilon st,$$

where s indexes state and *t*:indexes year. Each even-numbered column represents the results of a separate OLS regression which also includes state-specific linear time trends. The covariates composing the vector X_{st} are: population, mean age, income, and the unemployment rate. Estimates are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Fourteen states enacted implemented a medical marijuana law during the period 1990-2010.