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THE CROSS-BORDER SPILLOVER EFFECTS OF RECREATIONAL MARIJUANA
LEGALIZATION

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ABSTRACT

We examine the spillover effects of recreational marijuana legalization (RML) in Colorado and Washington on neighboring states. We find that RML causes a sharp increase in marijuana possession arrests in border counties of neighboring states relative to non-border counties in these states. RML has no impact on juvenile marijuana possession arrests but is rather fully concentrated among adults. Using separate data on self-reported marijuana use, we show this is accompanied by an increase in use in neighboring states relative to non-neighboring states. We do not find conclusive evidence that marijuana sale/manufacture arrests, DUI arrests, or opium/cocaine possession arrests in border states are affected by RML.

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1. Introduction

Since 2012, eight states and the District of Columbia have legalized personal recreational marijuana use.¹ One often-cited justification for recreational marijuana legalization (RML) in these states concerns its expected positive fiscal impacts.² For example, the state of Washington collected \$186 million in tax revenue from legal sales of recreational marijuana in fiscal year 2016, just its second year with legal sales.³ Other potential impacts include savings to law enforcement and the criminal justice system from no longer investigating and prosecuting certain marijuana-related crimes (Miron, 2010).

Though the fiscal impacts of marijuana legalization may be positive in states that pass RML, the effect on surrounding states is more likely to be detrimental. The nature of these laws is that marijuana can be purchased and possessed legally in RML states by those of majority age (21 and older) regardless of state of residency.⁴ This could lead to an increase in marijuana possession and related crimes in areas that neighbor RML states, which would likely contribute to higher burdens on law enforcement and the criminal justice system in those places. In line with this reasoning, in 2014, Nebraska and Oklahoma launched a federal lawsuit against Colorado, arguing that

¹ Legalization of recreational marijuana took effect in Colorado and Washington in December 2012; in Oregon in July 2015; and in Alaska and Washington DC in February 2015. California, Maine, Massachusetts, and Nevada passed recreational marijuana legalization in November 2016.

² See, for example, <https://taxfoundation.org/marijuana-tax-legalization-federal-revenue/>. Most recent date of access: May 9, 2017.

³ The fiscal year in Washington state runs from previous July 1 to current June 30. Source: Weekly Marijuana Report, Washington State Liquor and Cannabis Board (<http://lcb.wa.gov/marj/dashboard>). Most recent date of access: February 20, 2017.

⁴ Article XVIII, Section 16: Personal Use and Regulation of Marijuana, Colorado Constitution (<https://www.colorado.gov/pacific/sites/default/files/Section%2016%20-%20%20Retail.pdf>). Most recent date of access: March 17, 2017. Washington Initiative Measure No. 502, Office of Washington Secretary of State (<https://sos.wa.gov/assets/elections/initiatives/i502.pdf>). Most recent date of access: March 17, 2017.

Colorado's RML has led to an increase in marijuana-related law enforcement costs and other social costs in their states. While the suit was denied by the Supreme Court, the question of how one state's recreational marijuana legalization affects neighboring states' outcomes has not been examined.⁵ This is the focus of our paper.

Intuitively, for customers living in neighboring non-RML states, the legal cost of acquiring marijuana is reduced after RML because although possessing marijuana is still illegal in their home states, one is now free from penalty for the acts of buying and possessing marijuana across the border. In addition to this, RML most likely reduces the pecuniary cost of marijuana. Anderson, Hansen, and Rees (2013) find that medical marijuana legalization (MML) is associated with sharp decreases in the price of marijuana. Similarly, the average retail price of marijuana in Washington has dropped substantially since the beginning of legalized retail in the state (July 2014) as shown in Table 1. Though an individual can certainly consume the marijuana in the RML state, legal restrictions on where this can occur, as well as simple matters of convenience, may increase individuals' propensity to smuggle marijuana back to their home (non-RML) state.⁶ We expect this to occur most especially for individuals living near the border of RML states, since for these individuals the reduction of the legal and pecuniary costs of buying and possessing marijuana is

⁵ Nebraska and Oklahoma v. Colorado, Supreme Court of the United States Blog (<http://www.scotusblog.com/case-files/cases/nebraska-and-oklahoma-v-colorado/>). Most recent date of access: February 21, 2017. For more information on this case, see: Lyle Denniston, U.S. opposes marijuana challenge by Colorado's neighbors, Supreme Court of the United States Blog (Dec. 17, 2015), (<http://www.scotusblog.com/2015/12/u-s-opposes-marijuana-challenge-by-colorados-neighbors/>). Most recent date of access: March 17, 2017. See also Justice Clarence Thomas' dissent in this case (https://www.supremecourt.gov/opinions/15pdf/144orig_6479.pdf). Most recent date of access: March 17, 2017.

⁶ In Washington state, it is illegal to consume "in view of the general public" (Initiative 502), and in Colorado, a person may not consume "openly and publicly or in a manner that endangers others" (Article XVIII, Colorado Constitution).

most likely to be larger than the travel cost associated with crossing the border to purchase marijuana.

In addition to affecting marijuana possession in neighboring areas, RML may indirectly affect other types of crimes in those areas. For example, the manufacture and sale of marijuana in counties that border RML states may become less attractive after RML because customers can purchase it legally—possibly at a lower price—across the border. This is ambiguous, however, since sellers also have the opportunity to cross the border and purchase marijuana legally (and then return to sell it in the non-RML state). Driving under the influence (DUI) could also theoretically increase or decrease. On the one hand, if marijuana and alcohol are substitutes (as some papers, such as Anderson, Hansen, and Rees, 2013, have suggested), RML may decrease the frequency of DUI in bordering areas. On the other, if individuals are more likely to drive under the influence of marijuana or other drugs, DUI may increase, especially if there is more driving across the border following RML. Similar reasoning render the relationship between RML and other drug possession arrests theoretically ambiguous.

We adopt a difference-in-differences (DID) framework to examine whether RML leads to changes in various marijuana-related arrests in border counties of adjacent states relative to non-border counties in the same states. We use the 2009-14 Uniform Crime Reports (UCR), a nationwide arrest record database, to examine marijuana possession arrests, marijuana sale and manufacture arrests, DUI arrests, and opium/cocaine possession arrests. Because of the recentness of recreational marijuana legalization in the U.S., we focus on the first two states that passed RML laws, Colorado and Washington (both in 2012). We first examine how RML in Colorado has affected counties in 6 neighboring (border) states: Wyoming, Utah, New Mexico, Oklahoma, Kansas and Nebraska (these six states are collectively defined as the “Colorado region” in this

paper). Next, we examine how RML in Washington has affected counties in the border states of Idaho and Oregon (collectively defined as the “Washington region”).

We find that RML causes a sharp increase in marijuana possession arrests of border counties relative to non-border counties in both the Colorado and Washington regions. If a county shares a physical border with an RML state, it experiences an average increase in marijuana possession arrests of roughly 30% following RML implementation (relative to non-border counties in the same region). In subgroup analyses, we show that RML has no impact on juvenile marijuana possession arrests, consistent with previous findings that MML does not lead to increased marijuana consumption among teenagers (Anderson, Hansen, and Rees, 2015). We do not find conclusive evidence that marijuana sale/manufacture arrests, DUI arrests, or opium/cocaine possession arrests of border counties are affected on net by RML.

Other studies have found that drug arrests are generally good indicators of drug use (Rosenfeld and Decker, 1999; Moffatt, Wan, and Weatherburn, 2012; Chu, 2015). However, we recognize that any change in arrests may be driven in part by how law enforcement officials respond to RML in a neighboring state. For example, if police increase efforts toward traffic stops near the RML state border after the law takes effect, this may partly explain any increase in arrests. We address this concern in Section 7 in two ways. First, we show that police employment did not significantly increase in border counties relative to non-border counties following RML. Nevertheless, it is still possible that existing resources are re-allocated toward enforcement of marijuana laws. As a result, we also use National Survey on Drug Use and Health (NSDUH) data to show that self-reported marijuana use in states that border RML states increased after RML relative to those that do not share borders with RML states. Though this data is only publicly available at the state (and not county) level, it provides some evidence that increases in marijuana

use and marijuana possession are likely to drive at least part of the increase in arrests. Consistent with our state-level marijuana use results, Hansen et al. (2017) conclude that a substantial amount of marijuana sold in Washington was trafficked out of the state before Oregon legalized recreational marijuana.

The validity of our DID design is examined using an event study framework, where we allow the effect of RML to vary for every year in our data. We find no evidence that marijuana possession arrests were rising in border counties relative to non-border counties prior to the legalization year (2012), and strong increases in arrests took place in 2013 and 2014 (the latter is the year in which legal sales began in both Colorado and Washington). In addition to the event study, we include a robustness check in which we control for proxies for medical marijuana activity in Colorado (which experienced a large increase in registered medical marijuana patients prior to 2012) and find that our estimates of the RML effect are largely undisturbed.

We also address the fact that RML border counties tend to have higher per capita arrests than non-border counties even before RML in our data. Though our DID design relies on an assumption concerning trends rather than levels—that the marijuana possession arrest trend in non-border counties is a good proxy for the trend in RML border counties if RML had not occurred—the difference in levels between the county types creates concern regarding the validity of this assumption. Thus, we adopt a synthetic control design using as potential “donors” non-RML border counties in each region as well as counties from other western states that did not change their marijuana laws over our sample period. We find that this analysis is also supportive of our baseline DID estimates.

Our results raise concerns about the enforcement of marijuana laws in non-RML states that are neighbors to RML states. Either increased possession of marijuana in these states is giving rise

to more arrests, which places a financial burden on these states (especially in border jurisdictions), or law enforcement officers are intentionally targeting marijuana possession crimes post-RML (or some combination of both). Either possibility may mean that attention is diverted away from other tasks of greater social benefit (Kantor et al., 2017). Thus, even ignoring the public health consequences of marijuana liberalization, the question of how RML in some states affects non-RML states deserves more attention, especially given that many U.S. states are likely to legalize recreational marijuana in the near future while in others there is strong opposition to doing so.

2. Previous Literature

Since recreational marijuana legalization is new in the U.S., evidence on the effects of relaxing marijuana restrictions comes mainly from studies on medical marijuana legalization (MML) and marijuana decriminalization, which have been occurring in many states over the past several decades.⁷ Studies generally find that MML increases the illegal use of marijuana as well as marijuana-related arrests and hospital treatments among adults (Model, 1993; Pacula et al., 2010; Chu, 2014; Kelly and Rasul, 2014; Wen, Hockenberry, and Cummings, 2015). In the context of MML, allowing marijuana possession for some individuals (those who qualify to use it medicinally) appears to lead to an increase in illegal use as well.

Regarding adolescents, previous works suggest that MML does not increase marijuana use among youths and may even discourage it (Harper, Strumpf, and Kaufman, 2012; Lynne-Landsman, Livingston, and Wagenaar, 2013; Choo et al., 2014; Anderson, Hansen, and Rees,

⁷ One recent exception is Dragone et al. (2017), which looks at the effects of RML in Washington on violent crimes. They find that rapes and thefts dropped in Washington relative to Oregon after RML took effect.

2015). This may be because the relative risk of selling marijuana to youth (compared to adults) increases after MML is passed (Anderson and Rees, 2014).⁸

A common theme among many of these studies is that they assume that a change in marijuana policy in one state or location has no effect on outcomes in other locations, including neighboring ones. One contribution of our study is to test whether this assumption holds in practice. To the extent that relaxed marijuana laws in one state affect outcomes in neighboring states, it implies that results in previous studies could be biased depending on how their control group(s) are constructed.

Though there is a dearth of evidence regarding spillover effects of marijuana law specifically, previous papers have considered spillover effects of region-specific policies on surrounding areas in other contexts. Dube, Dube, and García-Ponce (2013) and Knight (2013) examine potential externalities associated with U.S. gun laws, with both finding that weaker gun law restrictions lead to an outflow of firearms. Figlio (1995) studies differential drinking ages between Wisconsin (which had a low drinking age in his data range) and border states and shows that counties on the border had more alcohol-related crashes than other counties. Lovenheim and Slemrod (2010) similarly find that an increase in a state's minimum legal drinking age actually leads to an increase in fatal accidents for 18-19 year-olds in that state living within 25 miles of a jurisdiction with a lower drinking age. Lovenheim (2008) provides evidence that consumers travel to purchase

⁸ The question of how relaxing legal restrictions on the sale and use of marijuana affects public health is complicated due to its potential impacts on the use of other substances. On this point, the literature is mixed. Model (1993) shows that marijuana decriminalization was accompanied by less emergency room episodes involving drugs other than marijuana. Similarly, Bachhuber et al. (2010) and Chu (2015) find that MML lowers state opioid overdose mortality rates as well as heroin treatments and cocaine/heroin arrests. Anderson, Hansen, and Rees (2013) find that MML leads to a reduction in drunk driving fatalities. In contrast, Wen, Hockenberry, and Cummings (2015) provide evidence that MML increases the frequency of binge drinking among adults and has no impact on the use of hard drugs.

cigarettes in lower-price jurisdictions. Finally, Jacks, Pendakur, and Shigeoka (2017) find that the repealing of prohibition in some counties in the 1930's contributed not only to an increase in infant mortality in those counties but in neighboring (dry) counties as well.

The paper most similar to ours in terms of topic is Ellison and Spohn (2015), in which the authors examine the impact of the expansion of the medical marijuana program in Colorado on drug arrests and jail occupancy in counties of Nebraska. They find that Nebraska border counties experienced significant growth in marijuana-related arrests and jail admissions after Colorado's policy change. However, their identification strategy does not make use of a control group. They also use data from 2000-2004 and 2009-2013 but not data from 2005-2008, which further underscores the concern that their results may be partially due to other factors that have changed over time. Our contribution is to use a formal DID framework in which we examine the effects of RML (previously unstudied in terms of spillover effects) on all border counties of neighboring states using non-border counties in those states as a control group.⁹

3. Data

⁹ While preparing this manuscript, we became aware of a working paper, Lu (2017), which also examines the effects of RML on marijuana possession in neighboring states. That paper focuses on Colorado and uses arrest and offense data at the police-agency rather than county level. Because of missing data issues at the agency level, Lu (2017) focuses only on city jurisdictions with at least 10,000 residents. This excludes many areas that are physically close to Colorado but are sparsely populated. Our paper includes these areas because the missing data issues Lu (2017) faces are ameliorated at the county level, as described in Section 3. Thus, Lu (2017) ends up with a very different set of "border" jurisdictions than in our paper (with the ones in Lu's paper being more densely populated and farther from the physical border, on average). Our paper examines both the Colorado and Washington regions, while Lu's only examines the Colorado region. The preliminary conclusions in Lu (2017) are largely consistent with ours (that marijuana possession arrests rise following RML).

Our main dataset is compiled from Uniform Crime Reporting (UCR) Program Data: County-Level Detailed Arrest and Offense Data from 2009 to 2014.¹⁰ These datasets report county-level arrests for different offenses including marijuana possession, marijuana sale and manufacture, driving under the influence of drugs/alcohol (DUI), and other drug possession like opium/cocaine possession.¹¹ UCR also reports adult and juvenile sub-group arrests data, allowing us to examine the potential heterogeneous effects of RML along this dimension.¹²

The UCR data are submitted voluntarily by local law enforcement agencies on a monthly basis. This data is then aggregated to the county level. In cases of incomplete reporting, arrest numbers for such agencies are imputed using 1) arrests reported in other months by that agency and 2) arrests in comparable jurisdictions in the month(s) of missing data. The UCR then provides a coverage indicator variable to allow users to set their own threshold for acceptable imputation. The indicator ranges from 100, indicating that all agencies in the county reported for 12 months in the year, to 0, indicating that all data in the county are based on estimates rather than reported data.¹³ We use all counties in our main regressions and check the robustness of our results using more restrictive cutoffs for the coverage indicator later in the paper.

¹⁰ Source: United States Department of Justice. Federal Bureau of Investigation. Uniform Crime Reporting Program Data: County-Level Detailed Arrest and Offense Data, 2009-2014. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor].

¹¹ Apart from marijuana possession arrests, UCR provides 3 categories on drug possession arrests: 1) opium/cocaine possession, 2) synthetic narcotics possession, and 3) other drug possession. Opium/cocaine possession includes possession of opium or cocaine and their derivatives (morphine, heroin, codeine). The UCR database does not distinguish cocaine possession from opium possession or other derivatives possession.

¹² The UCR Program considers a juvenile to be an individual under 18 years of age.

¹³ The detailed imputation method and the coverage indicator formula are presented in the Uniform Crime Reporting Program Resource Guide, National Archive of Criminal Justice Data (NACJD). (<https://www.icpsr.umich.edu/icpsrweb/content/NACJD/guides/ucr.html>). Most recent date of access: May 31, 2017.

We use the County Distance Database from the National Bureau of Economic Research to construct distances between counties in non-RML states to RML state borders. The County Distance Database provides great-circle distances using the Haversine formula based on internal points in the geographic area.¹⁴

As stated in the introduction, we define the Colorado region as all counties in Wyoming, Utah, New Mexico, Oklahoma, Kansas and Nebraska. There are 360 counties in this region and 29 of them share a physical border with Colorado.¹⁵ Similarly, the Washington region is defined as all counties in Oregon and Idaho. There are substantially fewer counties (80) in the Washington region, with 16 physically bordering Washington state.

Among these two cases, we place more emphasis on Colorado and its adjacent states for the following reasons. First, Colorado has substantially more bordering states/counties than Washington does, giving us more observations for the analysis. Second, no states adjacent to Colorado had major changes in terms of their marijuana laws over our study period. In contrast, RML was passed in 2014 in Oregon (Ballot Measure 91). Although Oregon's RML only took effect in 2015, the anticipation of legalization might have affected the behaviors of individual

The quality of UCR county-level data is high, especially considering that many counties in our sample are very rural. Restricting the sample to counties with a coverage indicator of at least 50 results in about a 13% loss of observations in the Colorado region, while restricting the sample to counties with a coverage indicator of at least 90 results in a 26% loss. For the Washington region, the respective losses are even smaller (about 3% and 11%, respectively).

¹⁴ Source: County Distance Database, the National Bureau of Economic Research (<http://www.nber.org/data/county-distance-database.html>). Most recent date of access: February 22, 2017.

¹⁵ Arizona technically borders Colorado at a single point but is excluded from the analysis because of a marijuana policy change in California. In 2010, California decriminalized possession of small amounts of marijuana. In Figures A1 to A3, we can see that it is very likely that marijuana decriminalization strikingly lowered California marijuana possession arrests from 2010 to 2014. Since Arizona shares a border with California, we exclude Arizona in our main regressions due to possible contamination resulting from California's policy change. However, the results with Arizona included in the region are similar to our main results and are available upon request.

Oregonians and Oregon law enforcement officials in 2014. Finally, Colorado opened its first recreational marijuana retail store in January 2014, while Washington opened its first in July 2014. Since the UCR data is currently only available through 2014, the Colorado region results might give us more insight into the impact of a fully operational RML policy on neighboring states.¹⁶

For each of the Colorado and Washington regions, Table 2a shows the descriptive statistics for the full sample, counties that physically border the RML state, and non-border counties in the region. Tables 2b and Table 2c repeat the analysis for the adult and juvenile subgroups separately.

From Panel 1 of Table 2a, the average number of marijuana possession arrests per 10,000 people is 18.4 for the whole period (2009-2014) in the Colorado region, with an average of 18.9 before RML (2009-2012) and 17.6 after RML (2013-2014). Comparing border counties with non-border counties, marijuana possession arrests are higher in border counties even before RML (28.3 arrests per 10,000 people in border counties compared with 18.1 arrests in non-border counties). After the implementation of RML, we see a big rise in marijuana possession arrests in border counties but a drop in non-border counties. Marijuana sale/manufacture arrests are also generally a bit higher in border counties, but both border and non-border counties experience a small increase in these arrests after RML. DUI arrests decrease markedly for both border counties and non-border counties after RML. Opium/cocaine possession arrests increase after RML for border counties but fall slightly for non-border counties.

¹⁶ Colorado also has an arguably more permissible RML law than Washington, allowing for growing one's own recreational marijuana at home, which Washington prohibits. See footnote 3 for details. See also: Philip Wallach and John Hudak, 2013, Comparing Legal Marijuana Systems in Colorado and Washington, Brookings Institution (<https://www.brookings.edu/wp-content/uploads/2016/06/Comparing-Legal-Marijuana-Table.pdf>). Most recent date of access: March 17, 2017.

Panel 2 of Table 2a reports the descriptive statistics for the Washington region. This region has a significantly higher marijuana possession arrest rate than the Colorado region. After RML in Washington, average marijuana possession arrests went from 68.3 to 93.2 in border counties. There was only a slight increase in marijuana possession arrests in non-border counties over the same time period. We also see slight decreases in marijuana sale/manufacture arrests and increases in opium/cocaine possession arrests in both border and non-border counties in the Washington region following RML (in the case of opium/cocaine possession arrests, the increase in border counties is large). Finally, border counties saw slightly higher DUI arrests after RML while non-border counties had lower DUI arrests after RML.

In Tables 2b and 2c, we can see that adult arrests generally follow the same pattern as the total sample. However, marijuana possession arrests of juvenile groups in both the Colorado and Washington regions fell slightly after RML for both county types. Other arrest type averages for juveniles are quite small in magnitude and generally either fall or stay roughly constant over time.

In the analysis below, in addition to defining a “border” county based on sharing a physical border with the RML state in question, we use an alternative (looser) definition based on whether a county is within 100 miles from the RML state border. Lastly, we are interested in whether border counties that are near an interstate highway are especially affected by RML, since the travel cost of crossing the border and purchasing marijuana is especially low in these counties. There are 3 major interstate highways with 5 border crossings in Colorado and 3 major interstate highways with 3 border crossings (to other U.S. states) in Washington.¹⁷ Thus, we employ a third treatment,

¹⁷ The interstate highways, counties with interstate border crossings, and corresponding FIPS county codes in the Colorado region are: 1. interstate 25 north border crossing, Larimer County, 8069; 2. interstate 25 south border crossing, Las Animas County, 8071; 3. interstate 70 east border crossing, Kit Carson County, 8063; 4. interstate 70 west border crossing, Mesa County, 8077; and interstate 76 border crossing, Sedgwick County, 8115. Similarly, the 3

which takes a value of one if a (non-RML) county is within 100 miles of the RML border county containing an interstate highway (and zero otherwise).

Figures 1a and 1b display the trends in marijuana possession arrests of counties in the Colorado and Washington regions under the three treatment definitions discussed above. In each panel of these figures, treatment (border) counties are compared to control (non-border) counties as well as the entire region and the national average. In the upper-left panel of each figure, the border definition is based on sharing the physical border; in the upper-right panel, it is based on being within 100 miles of the border; and in the lower-left panel, it is based on being within 100 miles of an interstate highway border crossing. For the Colorado region, there are 29 counties that physically border Colorado, 57 counties that are within 100 miles of the Colorado border, and 34 counties that are within 100 miles of an interstate border crossing. The corresponding numbers for the Washington region are 16, 33, and 25, respectively.

Two immediate observations from Figures 1a and 1b are that marijuana possession arrests are decreasing nationally for these years and that marijuana possession arrests are always higher in border counties than non-border counties, even before RML. Looking at the Colorado region (Figure 1a), non-border counties generally follow the same trend as the national average. However, in border counties, there is a sharp jump in marijuana possession arrests starting in 2012, with arrests reaching a peak in 2014 (this pattern is most pronounced for counties on the physical border, but it is similar based on the other two treatment definitions).

major interstate highways in Washington state are: Interstate 90, which exits Washington from Spokane County (FIPS 53063); Interstate 82, which exits Washington from Benton County (FIPS 53005); and Interstate 5, which exits Washington from Clark County (FIPS 53011). Interstate 205, which is a small branch deviating from Interstate 5, also exits from Clark County. Readers can refer to national highway system maps provided by U.S. Department of Transportation (https://www.fhwa.dot.gov/planning/national_highway_system/nhs_maps/). Most recent data of access: October 8, 2017.

An important question stemming from Figure 1a is why marijuana possession arrests in border counties rose in 2012 (since recreational legalization in Colorado only took place at the end of 2012). A possibility is the relaxation of medical marijuana restrictions between 2009 and 2011, when the number of medical marijuana enrollees in Colorado soared.¹⁸ This perhaps made it easier to cross the border and obtain marijuana in Colorado during this time period as well. Because our focus in this paper is on the spillover effects of RML, in the econometric analyses described below, we classify 2012 as a “control” year (or, as a robustness check, leave it out of the data altogether) so only increases occurring after 2012 contribute to a positive RML effect. In another robustness check, we control for the interaction between “border county” and the total number of registered medical marijuana enrollees in Colorado in each year and find that our results change very little. Finally, in the synthetic control analysis, we construct a synthetic control county that best matches the pre-RML trend in marijuana possession arrests in border counties.

Moving to the Washington region in Figure 1b, we also notice that border counties see a jump in marijuana possession arrests, but in this case it is in 2013. Arrest numbers also increase after 2012 for non-border counties, although not nearly to the same degree as in border counties.

Overall, the differential marijuana possession arrest trends between border and non-border counties after 2012 hint that RML in Colorado and Washington has affected arrests in nearby counties of non-RML states. In the next section, we examine this hypothesis more rigorously using a regression-based DID framework.

4. Empirical Methodology

We specify our main set of difference-in-difference (DID) models as

¹⁸ Events taking place starting in 2007 that led to an enormous increase in medical marijuana patients in Colorado from 2009 to 2010 are detailed in: <http://www.westword.com/news/the-history-of-cannabis-in-colorado-how-the-state-went-to-pot-5118475> (most recent date of access: May 9, 2017).

$$y_{ist} = \alpha * \text{Physical Border}_i * RML_t + X_{ist}\beta + \theta_i + \tau_t + \epsilon_{ist}, \quad (1)$$

$$y_{ist} = \alpha * \text{Border 100 Miles}_i * RML_t + X_{ist}\beta + \theta_i + \tau_t + \epsilon_{ist}, \quad (2)$$

$$\text{and } y_{ist} = \alpha * \text{Interstate 100 Miles}_i * RML_t + X_{ist}\beta + \theta_i + \tau_t + \epsilon_{ist}. \quad (3)$$

y_{ist} represents the dependent variable of interest in county i of state s in year t including: marijuana possession arrests per 10,000 people, marijuana sale/manufacture arrests per 10,000 people, DUI arrests per 10,000 people, and opium/cocaine possession arrests per 10,000 people.

Our key independent variables are $\text{Physical Border}_i * RML_t$ in Equation (1), $\text{Border 100 Miles}_i * RML_t$ in Equation (2) and $\text{Interstate 100 Miles}_i * RML_t$ in Equation (3), which are interactions between RML_t (equal to zero for the years 2009-2012 and one for the years 2013-2014, since RML took effect in December 2012 in both Colorado and Washington) and different measures of treatment (border) as described in the last section.¹⁹ County level control variables (contained in the vector X_{ist}) include county population, county median household income, and the county unemployment rate.²⁰ Other independent variables include year fixed effects τ_t and county fixed effects θ_i . This model (that is, two-way fixed effects) generalizes a model including a single “border county” dummy as well as a single “post-RML” dummy. We

¹⁹ Ideally, the RML variable would take a value of one for the last month of 2012, but this is not feasible since we only have annual data. Since it is not clear whether 2012 should be a treatment or control year, we have also performed our analyses with the year 2012 excluded. The results are similar to our main results (with 2012 included as a control year) as shown in Table A1.

²⁰ Data on county median household income comes from Small Area Income and Poverty Estimates, U.S. Census Bureau, Small Area Estimates Branch (<https://www.census.gov/did/www/saipe/data/statecounty/data/index.html>). Most recent date of access: March 1, 2017. All median household income data used in this study is deflated using annual CPI from 2009 to 2014 with 1982-1984 CPI =100. CPI data is from Consumer Price Index - All Urban Consumers, Bureau of Labor Statistics (<https://data.bls.gov/pdq/SurveyOutputServlet>). Most recent date of access: March 1, 2017. Data on the county unemployment rate is from Local Area Unemployment Statistics, Bureau of Labor Statistics (<https://www.bls.gov/lau/#tables>). Most recent date of access: March 1, 2017.

also include state specific linear time trends in some models to control for unobserved factors (such as public sentiment regarding marijuana) that may have changed over this time period.

Because the travel cost associated with purchasing marijuana in a nearby RML state is likely not discontinuous at the edge of a border county, we also perform some specifications in which a continuous measure of distance is substituted for the binary “border” treatment variable in Equations (2) and (3) above. In these specifications, $Distance_i$ and $Distance\ to\ Interstate_i$ represent distance to the nearest county of an RML state and distance to the nearest county in an RML state that has an interstate highway border crossing, respectively. Thus, the models are specified as

$$y_{ist} = \alpha * Distance_i * RML_t + X_{ist}\beta + \theta_i + \tau_t + \epsilon_{ist}, \quad (4)$$

$$\text{and } y_{ist} = \alpha * Distance\ to\ Interstate_i * RML_t + X_{ist}\beta + \theta_i + \tau_t + \epsilon_{ist}. \quad (5)$$

All other variables are defined the same way as in Equations (1)-(3). We estimate Equations (1) to (5) using OLS with standard errors clustered at the county level.

5. Main Results

5.1. Marijuana Possession Arrests

The effects of bordering an RML state (or, alternatively, distance to an RML state) following RML implementation (after 2012) on marijuana possession arrests are shown in Table 3. Panel 1 contains results for the Colorado region and Panel 2 shows results for the Washington region.

From Panel 1, column (1), physically bordering Colorado after RML has a statistically significant positive impact on marijuana possession arrests (at the 5% level). On average, counties that physically border Colorado see an increase of 8.1 in marijuana possession arrests (per 10,000 people) relative to non-border counties following RML, or a 29% increase compared with the pre-RML mean. The number decreases to 6.7 if the border definition is relaxed to being within 100

miles to Colorado (column (3)). When we focus specifically on counties that are within 100 miles of a Colorado interstate border crossing (column (5)), the number jump up to 9.9, suggesting that interstate highways may amplify the spillover effect of RML (to be sure, however, these point estimates are not statistically different from each other at conventional levels). Columns (7) and (9) report the effects of distance to Colorado and distance to a Colorado interstate border crossing on marijuana possession arrests of neighboring states. In these specifications, a 100-mile decrease in distance to Colorado and to a Colorado interstate border crossing increase marijuana possession arrests by 3.2 and 3.5, respectively. Even numbered columns show results of models that include state-specific linear time trends on the right-hand side. All effects are somewhat smaller in magnitude, but the results remain significant at the 10% level or better.

Panel 2 of Table 3 shows the results of the same models for the Washington region. The results generally follow the same pattern as those of the Colorado region in terms of estimated signs and relative magnitudes between results with and without state-specific linear time trends. Of the 5 pairs of results using different treatment (border) definitions, a few coefficients fail to achieve statistical significance at the 10% level, though the estimated magnitudes are relatively large. Counties that physically border Washington see an especially striking increase of 22.9 arrests (or a 33% increase) relative to non-border counties after RML. Results in columns (7) and (9) also indicate that the farther a county is located from Washington state, the smaller the increase in arrests following RML.²¹

²¹ Table A1 shows the results of the same models as Table 3 but with the year 2012 excluded from the data. The results in Table A1 are generally consistent with Table 3 in terms of estimated signs but generally show larger absolute magnitudes, especially for the Colorado region. This is consistent with Figure 1a. However, some of the results in this table are less precisely estimated than in Table 3, which is possibly a result of losing one year of observations out of six total (2009-2014).

We report separate regressions for adult and juvenile subgroups in Tables 4a and 4b. The results show that the RML effect on marijuana possession arrests in border counties is entirely concentrated among adults. Point estimates for juveniles are small, not consistently signed, and never statistically different from zero. These findings appear to be consistent with Anderson, Hansen, and Rees (2015), who find that MML does not increase marijuana use among teenagers.²²

5.2. Marijuana Sale/Manufacture Arrests, DUI Arrests, and Opium/Cocaine Possession Arrests

Tables 5 through 7 show DID results using marijuana sale/manufacture arrests, DUI arrests, and opium/cocaine possession arrests as dependent variables, respectively. Looking across the tables at the Colorado region (Panel 1 in each table), there is little evidence that RML has affected these outcomes in border counties relative to non-border ones (columns (1) to (6) in each table). Estimated signs are not consistent, and no result is statistically significant at conventional levels. Looking at the effect of distance to Colorado and distance to a Colorado interstate border crossing, results without state-specific linear time trends (columns (7) and (9)) show some indication that marijuana sale/manufacture, DUI, and opium/cocaine possession arrests might have risen following RML in areas closer to Colorado relative to areas farther away. However, after adding state-specific time trends (columns (8) and (10)), all results are rendered insignificant (typically with a large reduction in magnitude).

In the Washington region (Panel 2 in Tables 5 through 7), there is some indication that DUI arrests and opium/cocaine possession arrests increased in border counties relative to non-border

²² As discussed in Section 3, we also examine how robust our results are to including only those counties with few imputed values for their individual police agencies. We report our baseline results using only those county-year observations with a coverage index value larger than or equal to 90 in Table A2. This restriction reduces the numbers of observations to 1,595 for the Colorado region and 427 for the Washington region (74% and 89% of the total observations, respectively). The results are similar to those contained in Table 3. We also tried using coverage index cutoffs of 50 and 80 and again obtained similar results (available upon request).

counties following RML. These results are also not generally robust to the inclusion of state-specific time trends. Our view of the body of the results on other arrest types is that the evidence on whether RML affected these arrests in neighboring states is inconclusive. Estimates using the continuous distance measure especially leave open the possibility that other arrest types increased following RML, so we believe that with additional (years of) data, this is a worthwhile topic for future research.

6. Robustness Checks

6.1. Event Study

In this section, we conduct event studies for our three binary treatment variables (border definitions) with marijuana possession arrests as the dependent variable. This allows us to further examine the validity of our DID assumption, which is that the trend in arrests for non-border counties is a good proxy for what would have happened to border counties without RML, controlling for relevant observable characteristics. Though we can obviously not test this directly, if border counties were experiencing a different trend in arrests than non-border counties prior to RML, it would cast doubt on whether RML is in fact responsible for our results. To do this analysis, we simply allow the effect of “border county” to vary for every year in our sample (rather than only for pre- and post-RML periods). The results are contained in Tables 8a and 8b (with 2009 serving as the omitted year).

Table 8a shows our results for all three definitions of “border county” in the Colorado region. There is no evidence that trends in marijuana possession arrests between border counties and non-border counties were different before 2012. Starting in 2012, estimates jump in magnitude, but it is only in 2014, with another jump in magnitude in all three cases, that we see a statistically significant difference from the border/non-border county difference in 2009.

Event study results for the Washington region are shown in Table 8b. The results are a little different than the Colorado ones. In this case, the big jump in the border/non-border difference comes in 2013 (consistent with Figure 1b), with the coefficients falling somewhat in 2014. Point estimates for the 2013 and 2014 interactions are not always statistically significant at conventional levels in these specifications. This may be due in part to the limited sample size in this region. Nevertheless, the much larger coefficients after 2012 compared to earlier years are generally supportive of the notion that RML has affected marijuana possession arrests in counties that neighbor Washington.

6.2. Medical Marijuana

As stated in Section 3 concerning Figure 1a, a question concerning the interpretation of our results for the Colorado region is whether they are due to RML or earlier expansion in the availability of medical marijuana in Colorado. In particular, Colorado experienced growth in the number of registered medical marijuana patients prior to RML passage, likely as a result of the relaxation of requirements to dispense and obtain it. Though we expect the mechanisms by which RML and medical marijuana expansions affect non-RML border states to be similar (but not identical), we would like to know if a divergence between border and non-border counties in these states after 2012 is in fact due to RML. While data limitations make this difficult to address, we can add a proxy for medical marijuana availability to our regressions: the total number of patients enrolled in the Colorado Medical Marijuana Registry program (MMRP) interacted with our border dummies or distance from the border.²³ The drawback of this method is that since this number

²³ Source: Medical Marijuana Registry Program Update, 2009-2014 Medical Marijuana Registry Statistics, Colorado Department of Public Health and Environment (<https://www.colorado.gov/pacific/cdphe/medical-marijuana-statistics-and-data>). Most recent date of access: April 27, 2017. Colorado's county level population data is from Population Totals for Colorado Counties, Colorado Department of Local Affairs

generally increased between 2009 and 2014, some of the variation in marijuana possession arrests that could have been due to RML (after 2012) is now soaked up by these interactions.

The results from regressions with these controls are contained in Table 9. Compared to Table 3, most corresponding point estimates are slightly smaller and the continuous distance-RML interactions with state-specific time trends are no longer statistically significant at conventional levels. In summary, even with the loss of variation described above, the results are broadly consistent with the notion that RML itself is responsible for the divergence in marijuana possessions arrest trends between counties that are closer to Colorado and those that are further from Colorado.²⁴

6.3. Synthetic Control Design

Our last robustness check addresses the question of whether non-border counties serve as a suitable control group for RML border counties in our DID design. Figures 1a and 1b (and Tables 2a-2c) indicate that border counties tend to have higher per capita arrest figures than other counties within their states, on average. To address this issue, we adopt a synthetic control design (Abadie and Gardeazabal, 2003; Abadie, Diamond, and Hainmueller, 2010) that constructs control groups as a weighted average of non-RML border counties where weights are chosen to match the pre-treatment trend in marijuana possession arrests for RML border counties (in each region). We use

(<https://demography.dola.colorado.gov/population/data/profile-county/>). Most recent date of access: April 27, 2017. The total numbers of patients in Colorado who currently possess valid registry ID cards by the end of each year from 2009 to 2014 are: 41,039 in 2009, 116,198 in 2010, 82,089 in 2011, 108,526 in 2012, 110,979 in 2013, and 115,467 in 2014.

²⁴ In Table A3, we try adding a different control for medical marijuana availability to the regressions: the number of MMRP patients per capita in the Colorado border county lying closest to the non-RML county in question. The results are very similar to those in Table 3.

the method in Cavallo et al. (2013), which allows for multiple treatment groups (since we have many “treated” counties on the border).²⁵

We focus on our first definition of RML border county (sharing a physical border with the RML state) in this section of the paper. The pool of counties that might receive positive weight in the synthetic control (donor pool) for the Colorado region RML border counties includes non-border counties in that region plus all counties in other western states that did not experience a change in marijuana law over our time period: Nevada, Texas, Montana, and North and South Dakota.²⁶ The donor pool for the Washington region RML border counties is constructed in like manner.

The marijuana possession arrest trends for border (treatment) counties and the synthetic control county are shown in Figures 2a and 2b (for the Colorado and Washington regions, respectively). The trends for RML border counties are exactly the same as the ones shown in Figures 1a and 1b. The synthetic control county generally matches the pre-treatment trend for RML border counties, though the fit is better in the Colorado region than the Washington one.

In both cases, there is a substantial divergence in trends between the treatment and control counties following RML. The hypothesis that arrest rates between treatment and control are the same in 2014 for the Colorado region is rejected at the 5% level, and the same is true in the Washington region for both 2013 and 2014.

²⁵ To implement this, we use the “synth_runner” package in STATA developed by Galiani and Quistorff (2016). Weights (for the synthetic control group) are chosen to best reproduce the marijuana possession arrest per capita trend for RML border counties in the pre-treatment period.

²⁶ We exclude all counties on the Mexican border from the donor pool due to their persistently high arrest rates and potential to be affected by Colorado’s RML policy directly.

Though our ability to match the pre-treatment trends of RML border counties up until 2012 is not perfect, we believe the results using the synthetic control design cast substantial doubt on the notion that the reason marijuana possession arrests increased relatively in border counties following RML is related to differences in baseline levels of arrests or a different pre-treatment trajectory in those counties.

7. Discussion on Mechanisms

An open question concerning the interpretation of our results is how much of the increase in arrests in border counties of non-RML states is driven by increased possession (which would be closely tied to higher use) and how much is driven by the police response to RML across the border.²⁷ In particular, police officers might adopt new techniques or use more resources toward cracking down on what they perceive to be more illegal marijuana possession following RML.

Although we cannot address this question directly since we do not have measures of police resource allocation or effort, we can examine how police employment changed in border versus non-border counties following RML. Furthermore, we can use data from the National Survey on Drug Use and Health (NSDUH) from the Substance Abuse and Mental Health Services Administration to examine how self-reported use of marijuana changed in RML border states relative to non-border states following RML.

First, we examine the effect of RML on one proxy for police presence in a county: the number of police officers employed per capita (or, alternatively, the number of police agency employees per capita). This data also comes from the UCR Program database, which reports the number of

²⁷ We note that an increase in arrests in border counties also need not reflect an increase in marijuana possession among individuals living in those counties; rather, it could be that those living in non-border counties who smuggle marijuana across the border are more likely to be apprehended near the border than in non-border areas.

employed police officers as well as total employees at the police agency level.²⁸ We match each agency to its county using county identifiers from the Law Enforcement Agency Identifiers Crosswalk, 2012.²⁹ We then aggregate the number of employees within a county and divide by county population to obtain total police officers per 10,000 county residents and total police agency employees per 10,000 county residents.

Figure 3 shows that counties that physically border the RML state typically employ more police officers (and total employees) than non-border counties in both regions, though the relative trends are different: in the Colorado region, police presence in RML border counties looks to be diverging somewhat from the rest of the state, while in Washington it is the opposite (at least until 2014).³⁰ We use the same model specification as in Section 4 but with police officer employment as the dependent variable. The results are shown in Table 10. We do not report the results on police agency total employees because they are very similar (available upon request). Table 10 shows that after adding controls, the effects of the interactions between “border county” and the post-RML time period on police officer employment are generally positive in the Colorado region, though the coefficients are small and most are not statistically significant at conventional levels.

²⁸ Source: United States Department of Justice. Federal Bureau of Investigation. Uniform Crime Reporting Program Data: Police Employee (LEOKA) Data, 2009-2014. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor].

²⁹ Source: United States Department of Justice. Office of Justice Programs. Bureau of Justice Statistics. Law Enforcement Agency Identifiers Crosswalk, 2012. ICPSR35158-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2015-04-17. <http://doi.org/10.3886/ICPSR35158.v1>

³⁰ We drop Marion County of Oregon (FIPS code: 41047) in this analysis and in subsequent regressions due to an apparent error in the data. While all other counties in the Washington region have no more than 60 employed officers per 10,000 people in any year, Marion County is recorded as having employed more than 500 officers per 10,000 people in 2011 (in other years, the number for this county is always lower than 40).

This is in contrast to the Washington region, where the interactions tend to be negative in sign, though again they are generally statistically insignificant.

Next, we examine a measure of marijuana use directly. Though data on marijuana use rates at the county level is not publicly available, we can use data at the state-level to see if states that neighbor RML states experienced a relative increase in use compared to non-neighbor states. The data on the percentage of individuals 18 or older in each state who report using marijuana in the past year come from NSDUH in 2-year intervals.³¹

We use the intervals of 2009-10 and 2011-12 as control periods and 2013-14 as the treatment period, which is consistent with our county-level analysis described earlier.³² Because we have few observations at the state level, we pool Washington and Colorado regions and treat all border states (ID, OR, WY, UT, NM, OK, KS, NE) as our treatment group and all other western states except for Washington and Colorado (CA, NV, AZ, MT, ND, SD, TX) as our control group. Table

³¹ NSDUH also releases estimates at the sub-state level in 3-year intervals; however, we cannot use this data because sub-state regions are typically large and overlap both border and non-border portions of the state.

³² Sources: 1. 2009-2010 estimates are from "Table 2. Marijuana Use in the Past Year among Persons Aged 18 or Older, by State: Percentages, Annual Averages, and P Values from Tests of Differences between Percentages, 2008-2009 and 2009-2010 NSDUHs" from "National Survey on Drug Use and Health: Comparison of 2008-2009 and 2009-2010 Model-Based Prevalence Estimates for Adults Aged 18 or Older (50 States and the District of Columbia)". SAMHSA, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health.

2. 2011-2012 estimates are from "Table 2 Marijuana Use in the Past Year among Persons Aged 18 or Older, by State: Percentages, Annual Averages Based on 2010, 2011, and 2012 NSDUHs" from "National Survey on Drug Use and Health: Comparison of 2010-2011 and 2011-2012 Model-Based Prevalence Estimates for Adults Aged 18 or Older (50 States and the District of Columbia)". SAMHSA, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health.

3. 2013-2014 estimates are from "Table 2 Marijuana Use in the Past Year, by Age Group and State: Percentages, Annual Averages, and P Values from Tests of Differences between Percentages, 2012-2013 and 2013-2014 NSDUHs" from "National Survey on Drug Use and Health: Comparison of 2012-2013 and 2013-2014 Population Percentages (50 States and the District of Columbia)". SAMHSA, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health.

11 shows the average percentage of adults using marijuana in the past year for “treatment” states that border Colorado or Washington as well as for the control states. The marijuana prevalence rate increased from 10.64 to 12.32 percent in border states following RML, while it increased more modestly from 11.33 to 11.92 percent in non-border states. This suggests a naïve DID estimate of 1.09 percentage points. To examine this further, we perform a DID regression controlling for year and state dummies as well as medical marijuana legalization status and marijuana decriminalization status in each state. The results are shown in Table 12. From column (1), border states experience an average 1.16 percentage point increase in marijuana prevalence following RML compared with non-border states, which is a 10.5% increase compared with the pre-RML percentage. After adding state specific linear time trends, the effect increases from 1.16 percentage points to 3.49 percentage points, though these results may be less credible due to having only three data periods).

Overall, the results in this section suggest that police employment has not responded significantly to RML in border counties relative to non-border counties. Furthermore, self-reported marijuana use does rise in border states relative to non-border states following RML. Although we are not able to rule out the possibility that even with existing resources, police departments are directing increased attention to marijuana possession in areas near RML states, our results suggest that an increase in possession is likely to be factor in the effect of RML on arrests.

8. Conclusion

In this paper, we examine the impact of recreational marijuana legalization (RML) in Colorado and Washington on their neighboring states in terms of marijuana-related arrests. We find that RML causes a sharp increase in marijuana possession arrests in border counties near both

Colorado and Washington relative to non-border counties, suggesting strong spillover effects of marijuana legalization.

In addition, we provide some evidence using state-level NSDUH data that self-reported use rises after RML in states that border RML states. This is consistent with Hansen et al. (2017), which suggests that a substantial amount of marijuana sold in Washington was trafficked out of the state before Oregon legalized recreational marijuana. These findings suggest that an increase in marijuana possession and use is at least partially responsible for our arrest results. Although intentional police targeting could also lead to an increase in arrests, we have noted that it has its own undesirable consequences.

Our paper suggests that law enforcement efforts to penalize marijuana use in non-RML states are complicated by neighbors' choices to adopt RML. Since 2012, eight states (plus the District of Columbia) have passed RML. As additional states consider legalizing recreational marijuana, the costs and benefits of these decisions from a national perspective should include the spillover effects on non-adopting states, which our paper shows is likely to include law enforcement and criminal justice costs in addition to other social harms associated with increases in arrests and/or use of marijuana. A full analysis of the value of these costs, which is beyond the scope of this paper, would lead to a better understanding of the (dis)advantages of letting states decide whether or not to legalize versus a federal policy on marijuana legality.

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Figure 1a: Marijuana possession arrests (per 10,000 people) trends, Colorado region

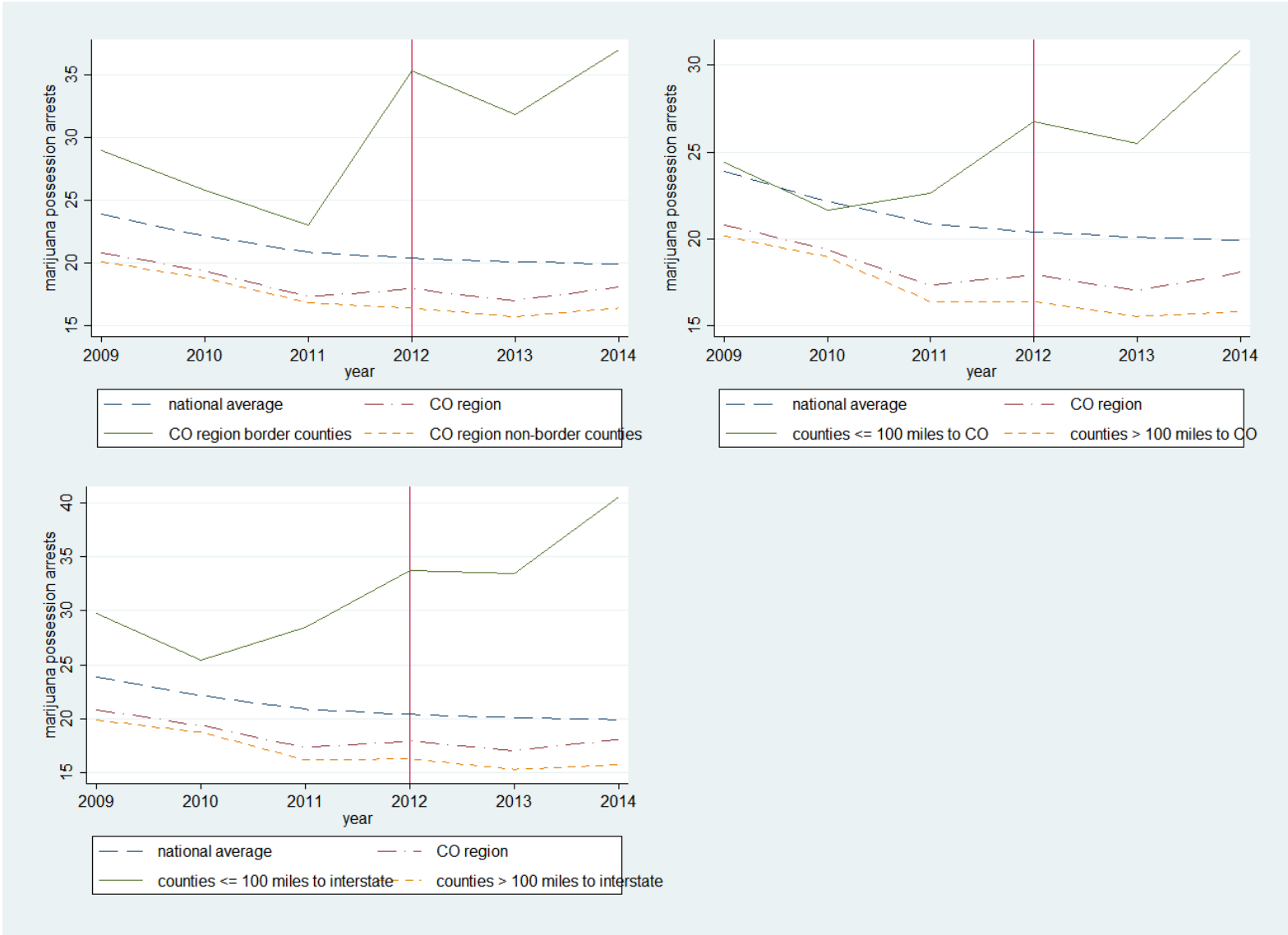


Figure 1b: Marijuana possession arrests (per 10,000 people) trends, Washington region

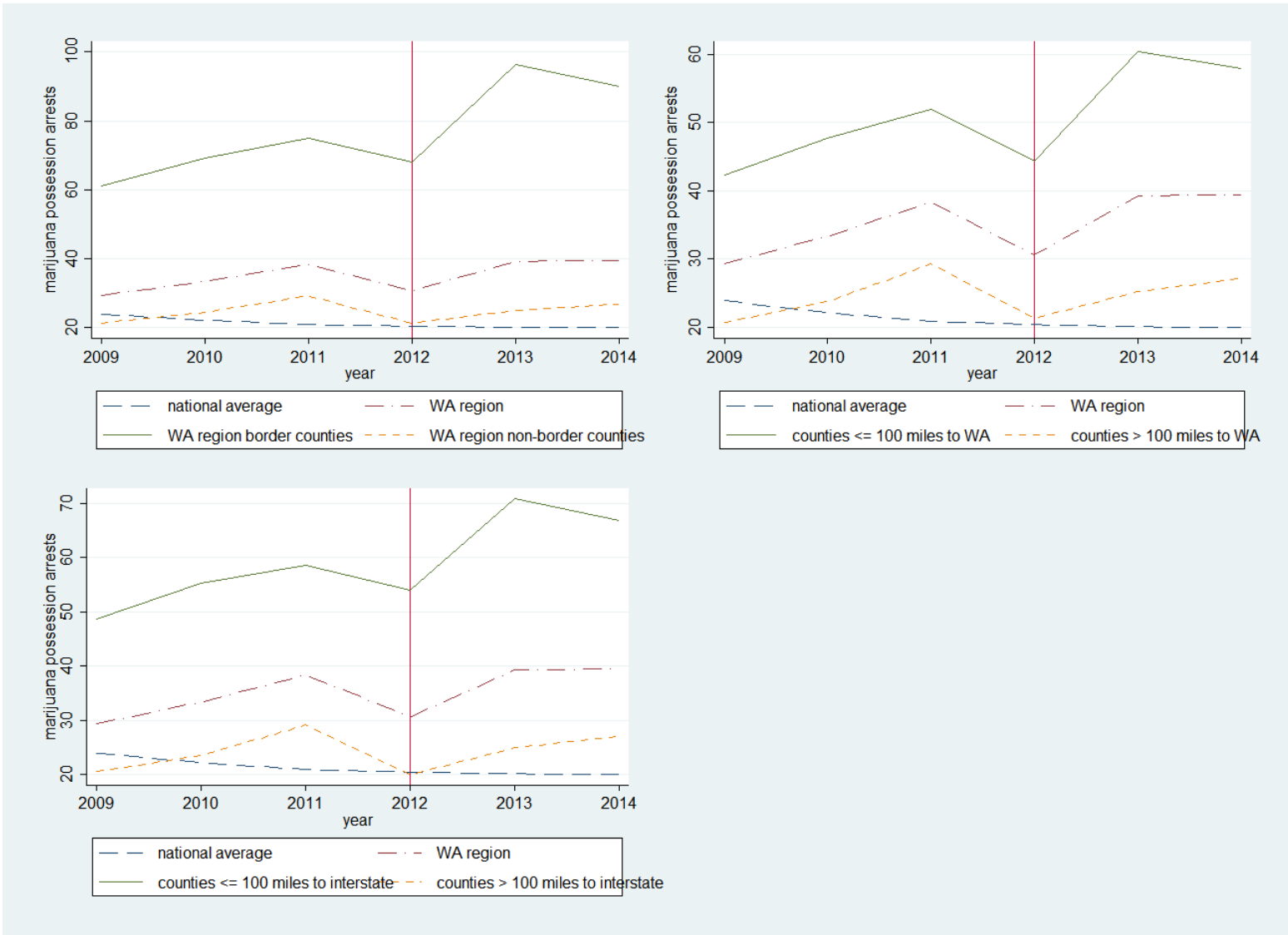


Figure 2a: Colorado region marijuana possession arrests trends vs. synthetic control

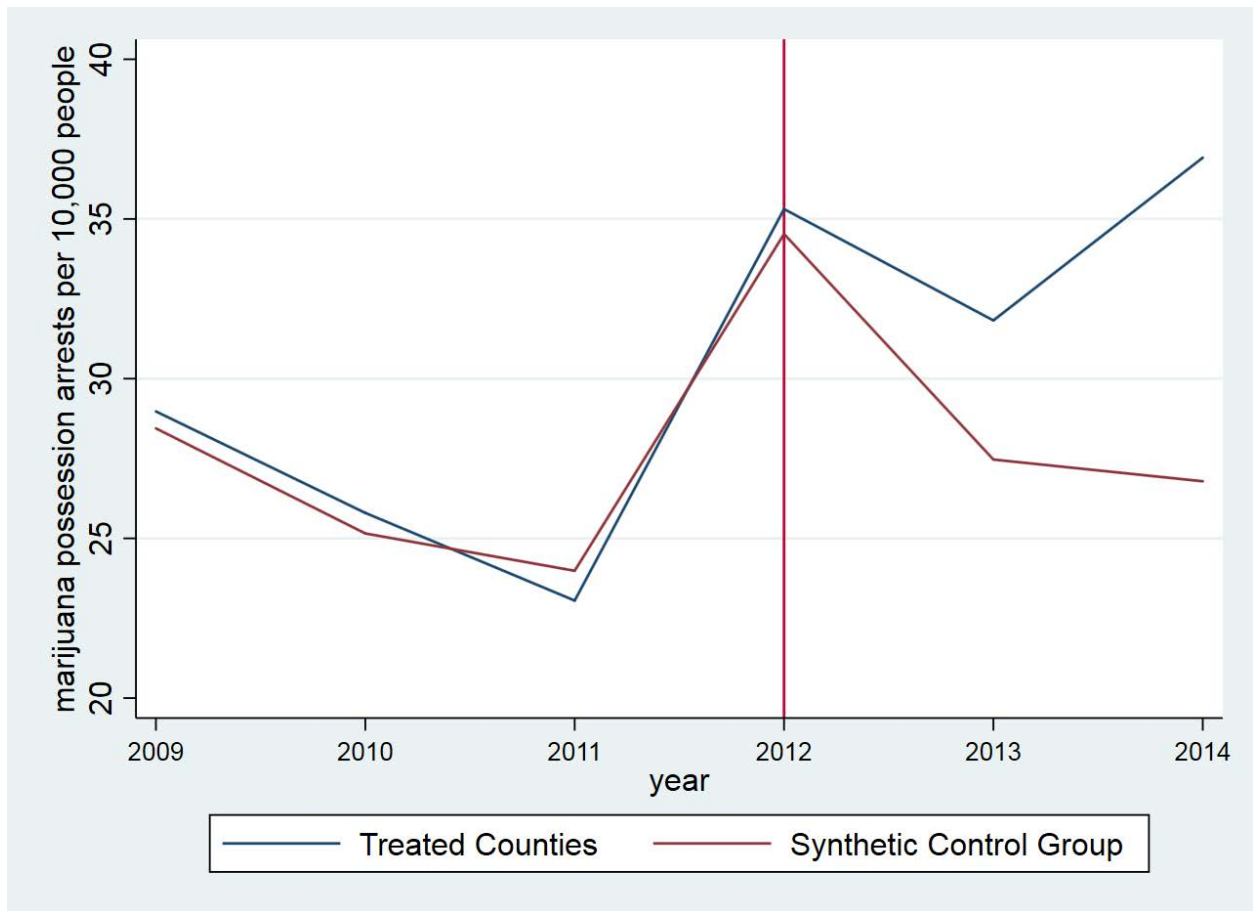


Figure 2b: Washington region marijuana possession arrests trends vs. synthetic control

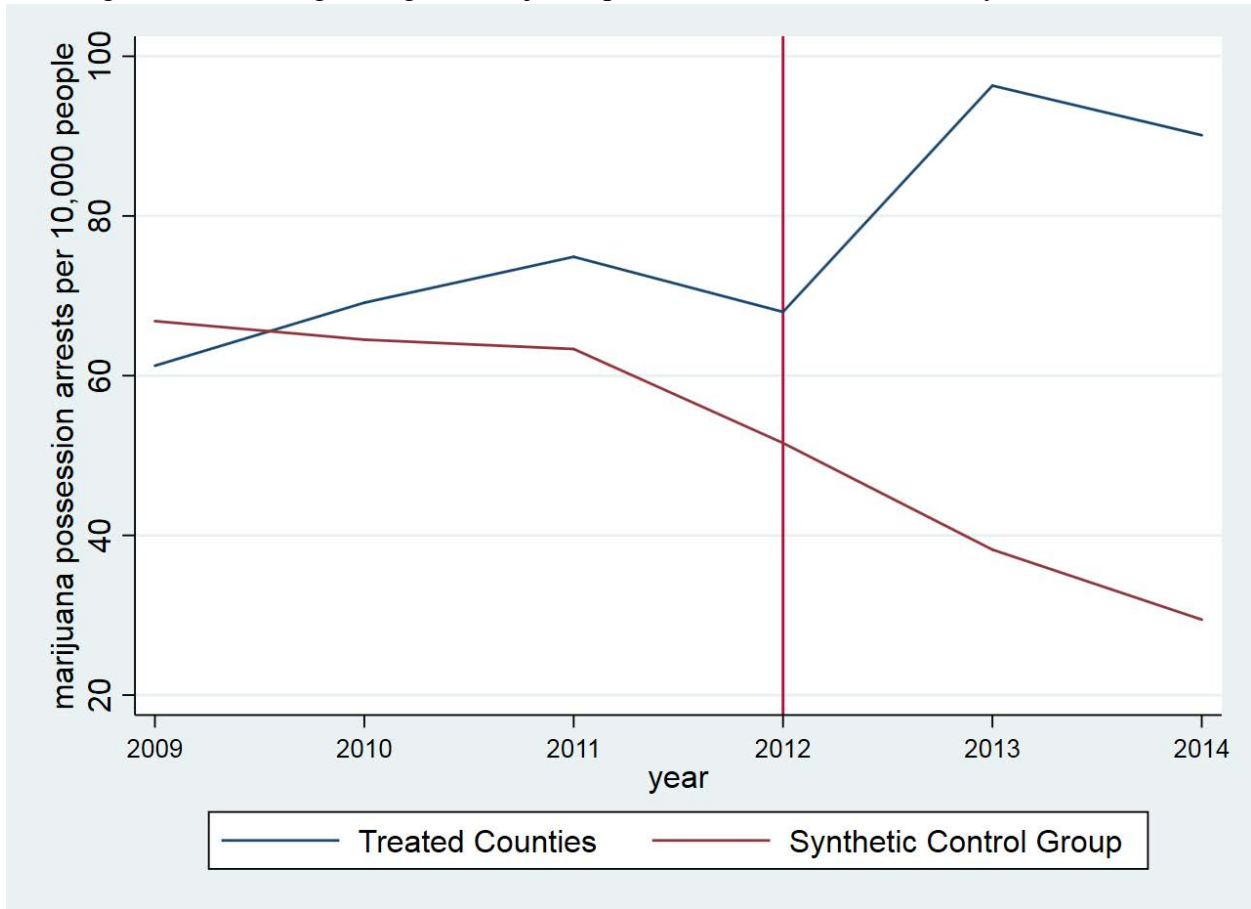


Figure 3: Police employment trends, Colorado and Washington regions

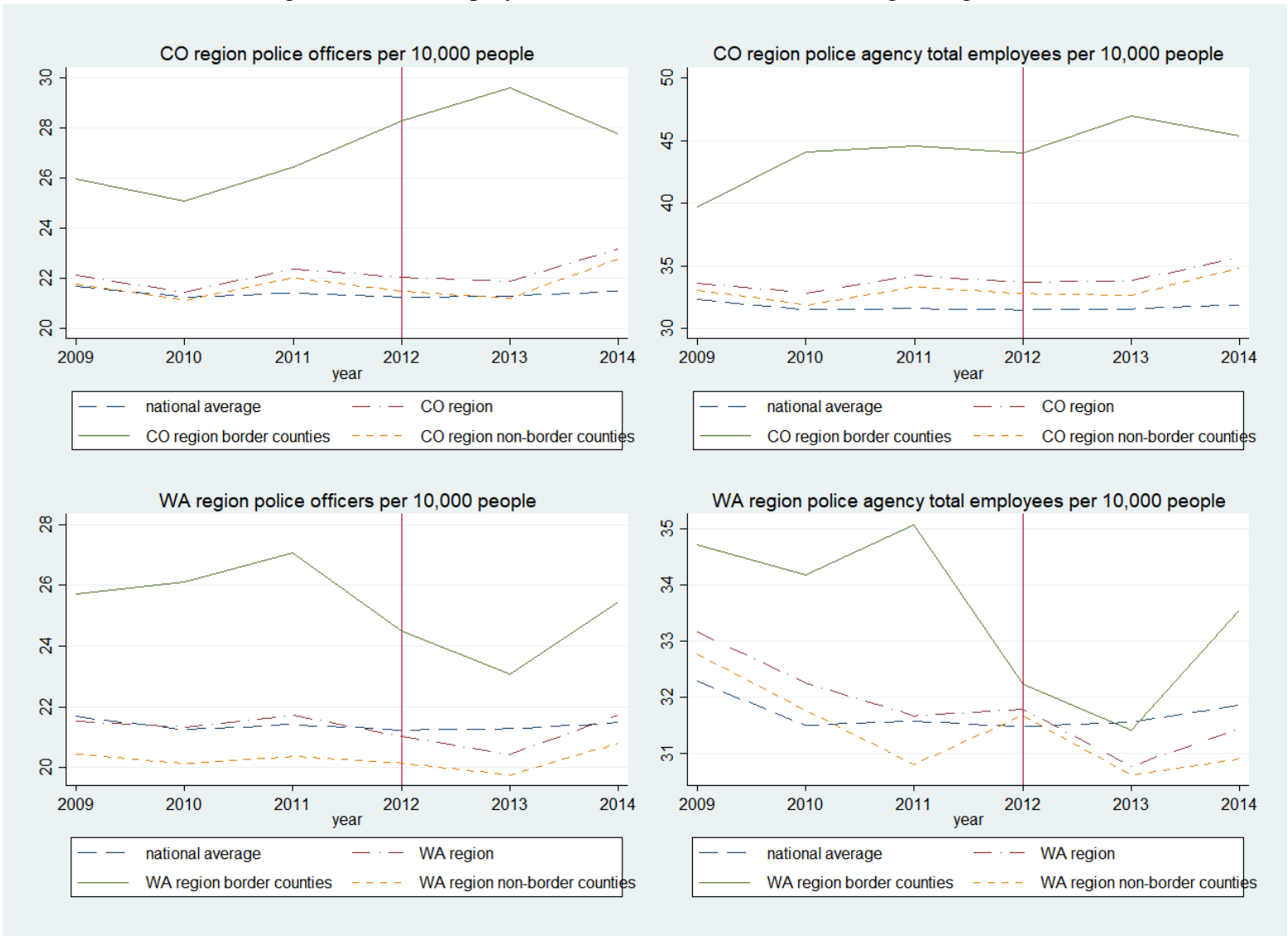


Table 1: Average retail price of marijuana in Washington state

Jul-14	79,160	9,325,000	117.80	117.80
Aug-14	155,626	11,902,000	76.48	76.48
Sep-14	232,740	14,404,000	61.89	61.89
Oct-14	322,402	15,344,000	47.59	47.59
Nov-14	384,838	16,618,000	43.18	43.18
Dec-14	537,021	24,010,000	44.71	44.71
Jan-15	693,564	23,334,000	33.64	33.64
Feb-15	937,586	25,955,000	27.68	27.68
Mar-15	1,241,791	32,730,000	26.36	26.36
Apr-15	1,596,038	36,306,000	22.75	22.75
May-15	1,926,238	42,148,000	21.89	21.89
Jun-15	2,168,402	45,458,000	20.96	20.96
Jul-15	2,756,582	39,640,000	14.38	19.70
Aug-15	3,126,261	43,009,000	13.76	18.85
Sep-15	3,518,838	45,477,000	12.92	17.71
Oct-15	3,613,918	45,272,000	12.53	17.16
Nov-15	3,486,244	42,378,000	12.16	16.65
Dec-15	4,018,693	47,584,000	11.84	16.22
Jan-16	4,111,709	44,934,000	10.93	14.97
Feb-16	4,417,214	47,476,000	10.75	14.72
Mar-16	4,932,556	52,133,000	10.57	14.48
Apr-16	5,373,520	54,863,000	10.21	13.99
May-16	5,566,192	57,683,000	10.36	14.20
Jun-16	5,268,603	59,578,000	11.31	15.49

Notes: Data on marijuana grams sold is from Weekly Marijuana Report, Fiscal Year 2015 and 2016 Data, Washington State Liquor and Cannabis Board (<http://lcb.wa.gov/records/frequently-requested-lists>). Most recent date of access: February 20, 2017. Data on total retail value of marijuana and marijuana products (before tax) is from Marijuana Sales Tax Table, Department of Washington State (http://dor.wa.gov/Content/AboutUs/StatisticsAndReports/stats_MJSalesTaxes.aspx). Most recent date of access: August 17, 2017. Prior to July 2015, all producers, processors, and retailers paid 25% of their marijuana sales revenue as excise tax to the Washington State Liquor Control Board. Effective July 1, 2015, tax reforms defined in HB 2136 change the existing marijuana excise tax structure. A 37 percent marijuana excise tax must now be collected exclusively at the retail level. Source: Washington State Liquor and Cannabis Board (https://lcb.wa.gov/mj2015/faqs_i-502). Most recent date of access: October 5, 2017. The after (state) tax estimated marijuana price is scaled up by 37 percent compare with before tax price.

Table 2a: Summary statistics for full sample, RML border counties, and non-border counties

	Full Sample			Border Counties			Non-Border Counties		
	(1) N	(2) mean	(3) S.D.	(4) N	(5) mean	(6) S.D.	(7) N	(8) mean	(9) S.D.
Panel 1: Colorado Region									
2009-2014									
marijuana possession arrest	2,160	18.44	21.64	174	30.31	46.22	1,986	17.40	17.59
marijuana sale/manufacture arrest	2,160	4.585	6.861	174	5.999	8.494	1,986	4.461	6.687
DUI arrest	2,160	45.17	29.84	174	54.85	36.79	1,986	44.32	29.01
opium/cocaine possession arrest	2,160	1.136	2.406	174	1.637	3.345	1,986	1.092	2.301
2009-2012									
marijuana possession arrest	1,440	18.88	20.99	116	28.28	42.56	1,324	18.05	17.70
marijuana sale/manufacture arrest	1,440	4.505	6.503	116	5.791	8.565	1,324	4.392	6.282
DUI arrest	1,440	49.39	31.25	116	59.03	38.96	1,324	48.54	30.36
opium/cocaine possession arrest	1,440	1.186	2.460	116	1.525	3.404	1,324	1.156	2.358
2013-2014									
marijuana possession arrest	720	17.57	22.86	58	34.37	52.96	662	16.10	17.31
marijuana sale/manufacture arrest	720	4.746	7.526	58	6.416	8.410	662	4.599	7.433
DUI arrest	720	36.72	24.73	58	46.49	30.64	662	35.86	23.98
opium/cocaine possession arrest	720	1.035	2.292	58	1.860	3.241	662	0.963	2.178
distance to Colorado	-	2.324	1.116	-	0.517	0.155	-	2.482	1.020
distance to CO interstate exit county	-	2.604	1.195	-	0.869	0.436	-	2.756	1.118
Panel 2: Washington Region									
2009-2014									
marijuana possession arrest	480	35.06	70.04	96	76.62	145.9	384	24.67	17.83
marijuana sale/manufacture arrest	480	1.781	2.582	96	1.637	2.693	384	1.817	2.556
DUI arrest	480	50.79	21.83	96	55.79	23.73	384	49.54	21.18
opium/cocaine possession arrest	480	2.852	5.711	96	6.787	10.70	384	1.868	2.747
2009-2012									
marijuana possession arrest	320	32.91	63.83	64	68.32	132.6	256	24.06	18.98
marijuana sale/manufacture arrest	320	1.854	2.736	64	1.737	2.880	256	1.883	2.704
DUI arrest	320	52.51	22.93	64	55.18	24.51	256	51.84	22.51
opium/cocaine possession arrest	320	2.363	4.572	64	5.414	8.572	256	1.600	2.254
2013-2014									
marijuana possession arrest	160	39.36	81.10	32	93.22	170.4	128	25.89	15.28
marijuana sale/manufacture arrest	160	1.634	2.245	32	1.436	2.304	128	1.684	2.236
DUI arrest	160	47.34	19.08	32	57.01	22.43	128	44.92	17.42
opium/cocaine possession arrest	160	3.828	7.407	32	9.533	13.78	128	2.402	3.482
distance to Washington	-	1.635	1.097	-	0.371	0.107	-	1.951	1.001
distance to WA interstate exit county	-	2.036	1.313	-	0.628	0.259	-	2.388	1.233

Notes: 1. Colorado region includes all counties in Wyoming, Utah, New Mexico, Oklahoma, Kansas and Nebraska. Washington region includes all counties in Idaho and Oregon. 2. Marijuana possession arrest, marijuana sale/manufacture arrest, DUI arrest, and opium/cocaine possession arrest are measured per 10,000 people. 3. Distance to RML state and distance to interstate exit county are the nearest great-circle distance measured in hundreds of miles.

Table 2b: Summary statistics for Colorado region counties: adult and juvenile subgroups

	Full Sample			Border Counties			Non-Border Counties		
	(1) N	(2) mean	(3) S.D.	(4) N	(5) mean	(6) S.D.	(7) N	(8) mean	(9) S.D.
Panel 1: Adult									
2009-2014									
marijuana possession arrest	2,160	16.08	20.09	174	26.86	44.41	1,986	15.14	16.00
marijuana sale/manufacture arrest	2,160	4.175	6.453	174	5.557	8.167	1,986	4.054	6.268
DUI arrest	2,160	44.55	29.43	174	54.02	36.38	1,986	43.72	28.60
opium/cocaine possession arrest	2,160	1.097	2.358	174	1.563	3.286	1,986	1.056	2.256
2009-2012									
marijuana possession arrest	1,440	16.38	19.19	116	24.63	39.60	1,324	15.66	16.05
marijuana sale/manufacture arrest	1,440	4.108	6.162	116	5.397	8.328	1,324	3.995	5.925
DUI arrest	1,440	48.65	30.81	116	58.08	38.59	1,324	47.83	29.91
opium/cocaine possession arrest	1,440	1.140	2.415	116	1.454	3.381	1,324	1.112	2.311
2013-2014									
marijuana possession arrest	720	15.49	21.78	58	31.34	52.82	662	14.10	15.86
marijuana sale/manufacture arrest	720	4.309	7.001	58	5.876	7.896	662	4.172	6.907
DUI arrest	720	36.35	24.49	58	45.89	30.19	662	35.52	23.77
opium/cocaine possession arrest	720	1.011	2.240	58	1.780	3.107	662	0.943	2.138
Panel 2: Juvenile									
2009-2014									
marijuana possession arrest	2,160	2.313	3.303	174	3.373	4.602	1,986	2.220	3.149
marijuana sale/manufacture arrest	2,160	0.371	1.068	174	0.415	1.674	1,986	0.367	0.998
DUI arrest	2,160	0.561	1.089	174	0.796	1.752	1,986	0.541	1.009
opium/cocaine possession arrest	2,160	0.0369	0.192	174	0.0589	0.367	1,986	0.0349	0.169
2009-2012									
marijuana possession arrest	1,440	2.448	3.404	116	3.539	4.965	1,324	2.352	3.217
marijuana sale/manufacture arrest	1,440	0.358	0.960	116	0.353	1.092	1,324	0.359	0.948
DUI arrest	1,440	0.676	1.233	116	0.928	1.963	1,324	0.654	1.146
opium/cocaine possession arrest	1,440	0.0434	0.187	116	0.0482	0.204	1,324	0.0430	0.185
2013-2014									
marijuana possession arrest	720	2.043	3.076	58	3.041	3.792	662	1.956	2.993
marijuana sale/manufacture arrest	720	0.396	1.258	58	0.540	2.464	662	0.384	1.093
DUI arrest	720	0.331	0.662	58	0.533	1.196	662	0.313	0.591
opium/cocaine possession arrest	720	0.0237	0.203	58	0.0805	0.569	662	0.0188	0.129

Notes: Same as Table 2a.

Table 2c: Summary statistics for Washington region counties: adult and juvenile subgroups

	Full Sample			Border Counties			Non-Border Counties		
	(1) N	(2) mean	(3) S.D.	(4) N	(5) mean	(6) S.D.	(7) N	(8) mean	(9) S.D.
Panel 1: Adult									
2009-2014									
marijuana possession arrest	480	30.44	67.69	96	69.91	141.7	384	20.58	16.12
marijuana sale/manufacture arrest	480	1.528	2.421	96	1.409	2.567	384	1.558	2.385
DUI arrest	480	50.20	21.47	96	55.35	23.51	384	48.92	20.76
opium/cocaine possession arrest	480	2.780	5.684	96	6.698	10.70	384	1.801	2.684
2009-2012									
marijuana possession arrest	320	28.13	61.37	64	61.38	128.5	256	19.81	16.92
marijuana sale/manufacture arrest	320	1.597	2.584	64	1.454	2.702	256	1.633	2.558
DUI arrest	320	51.82	22.48	64	54.72	24.32	256	51.09	21.99
opium/cocaine possession arrest	320	2.287	4.531	64	5.318	8.560	256	1.529	2.168
2013-2014									
marijuana possession arrest	160	35.08	78.83	32	86.98	166.0	128	22.11	14.31
marijuana sale/manufacture arrest	160	1.391	2.055	32	1.319	2.312	128	1.409	1.995
DUI arrest	160	46.98	18.93	32	56.61	22.12	128	44.57	17.31
opium/cocaine possession arrest	160	3.767	7.393	32	9.458	13.78	128	2.345	3.442
Panel 2: Juvenile									
2009-2014									
marijuana possession arrest	480	4.572	4.505	96	6.784	6.783	384	4.019	3.526
marijuana sale/manufacture arrest	480	0.253	0.595	96	0.226	0.615	384	0.260	0.591
DUI arrest	480	0.535	0.792	96	0.424	0.660	384	0.563	0.820
opium/cocaine possession arrest	480	0.0635	0.219	96	0.0820	0.216	384	0.0589	0.220
2009-2012									
marijuana possession arrest	320	4.750	4.865	64	7.155	7.458	256	4.149	3.748
marijuana sale/manufacture arrest	320	0.259	0.583	64	0.284	0.730	256	0.253	0.542
DUI arrest	320	0.633	0.864	64	0.453	0.537	256	0.678	0.924
opium/cocaine possession arrest	320	0.0695	0.246	64	0.0854	0.228	256	0.0656	0.250
2013-2014									
marijuana possession arrest	160	4.216	3.670	32	6.042	5.207	128	3.759	3.032
marijuana sale/manufacture arrest	160	0.241	0.621	32	0.111	0.238	128	0.274	0.681
DUI arrest	160	0.338	0.577	32	0.364	0.862	128	0.332	0.486
opium/cocaine possession arrest	160	0.0515	0.154	32	0.0752	0.193	128	0.0455	0.142

Notes: Same as Table 2a.

Table 3: The effect of RML on marijuana possession arrests by RML border status and distance to RML state

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	8.107**	6.343*								
	(3.644)	(3.487)								
CO Border 100 Miles*RML			6.693***	4.339*						
			(2.515)	(2.390)						
CO Interstate 100 Miles*RML					9.927***	7.172**				
					(3.705)	(3.441)				
Distance to CO*RML							-3.206***	-1.253**		
							(0.651)	(0.609)		
Distance to CO Interstate*RML									-3.480***	-1.139*
									(0.625)	(0.598)
R-squared	0.738	0.756	0.739	0.756	0.740	0.757	0.742	0.755	0.744	0.755
Panel 2: Washington Region										
WA Border*RML	22.859**	21.420**								
	(10.365)	(9.616)								
WA Border 100 Miles*RML			10.535*	8.223						
			(6.257)	(5.369)						
WA Interstate 100 Miles*RML					12.659	10.195				
					(7.670)	(6.756)				
Distance to WA*RML							-5.814**	-4.630**		
							(2.785)	(2.322)		
Distance to WA Interstate*RML									-4.400**	-3.176*
									(2.160)	(1.703)
R-squared	0.941	0.941	0.938	0.939	0.938	0.939	0.939	0.939	0.938	0.939
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160 in Panel 1 and 480 in Panel 2. Observations per year are 360 in Panel 1 and 80 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 4a: The effect of Colorado RML on marijuana possession arrests, adult and juvenile sub-groups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Adult										
Border*RML	8.330**	6.553*								
	(3.866)	(3.729)								
Border 100 Miles*RML			6.922***	4.664*						
			(2.618)	(2.496)						
Interstate 100 Miles*RML					10.144***	7.557**				
					(3.914)	(3.647)				
Distance*RML							-3.198***	-1.312**		
							(0.664)	(0.629)		
Distance to Interstate*RML									-3.445***	-1.214*
									(0.638)	(0.619)
R-squared	0.727	0.746	0.728	0.746	0.729	0.747	0.731	0.745	0.734	0.745
Panel 2: Juvenile										
Border*RML	-0.108	-0.104								
	(0.547)	(0.544)								
Border 100 Miles*RML			-0.155	-0.251						
			(0.420)	(0.418)						
Interstate 100 Miles*RML					-0.232	-0.388				
					(0.545)	(0.541)				
Distance*RML							-0.027	0.037		
							(0.109)	(0.112)		
Distance to Interstate*RML									-0.048	0.052
									(0.103)	(0.113)
R-squared	0.599	0.601	0.599	0.601	0.599	0.601	0.599	0.601	0.599	0.601
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160. Observations per year are 360. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 4b: The effect of Washington RML on marijuana possession arrests, adult and juvenile sub-groups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Adult										
Border*RML	23.011**	21.427**								
	(10.633)	(9.850)								
Border 100 Miles*RML			10.733*	8.193						
			(6.353)	(5.425)						
Interstate 100 Miles*RML					12.740	10.003				
					(7.822)	(6.871)				
Distance*RML							-5.933**	-4.599*		
							(2.812)	(2.330)		
Distance to Interstate*RML									-4.589**	-3.224*
									(2.188)	(1.714)
R-squared	0.941	0.942	0.938	0.939	0.938	0.939	0.939	0.939	0.938	0.939
Panel 2: Juvenile										
Border*RML	-0.650	-0.487								
	(0.953)	(0.907)								
Border 100 Miles*RML			-0.498	-0.246						
			(0.635)	(0.611)						
Interstate 100 Miles*RML					-0.434	-0.138				
					(0.711)	(0.676)				
Distance*RML							0.260	0.102		
							(0.302)	(0.294)		
Distance to Interstate*RML									0.300	0.154
									(0.247)	(0.245)
R-squared	0.679	0.682	0.679	0.681	0.679	0.681	0.680	0.681	0.680	0.682
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 480. Observations per year are 80. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 5: The effect of RML on marijuana sale and manufacture arrests by RML border status and distance to RML state

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	0.409 (1.258)	0.292 (1.273)								
CO Border 100 Miles*RML			-0.024 (0.955)	-0.332 (0.968)						
CO Interstate 100 Miles*RML					1.474 (1.180)	1.403 (1.195)				
Distance to CO*RML							-0.508* (0.269)	-0.376 (0.305)		
Distance to CO Interstate*RML									-0.575** (0.240)	-0.438 (0.294)
R-squared	0.596	0.602	0.596	0.602	0.597	0.603	0.598	0.603	0.598	0.603
Panel 2: Washington Region										
WA Border*RML	-0.079 (0.320)	-0.076 (0.340)								
WA Border 100 Miles*RML			-0.124 (0.382)	-0.126 (0.428)						
WA Interstate 100 Miles*RML					-0.250 (0.356)	-0.264 (0.389)				
Distance to WA*RML							0.068 (0.176)	0.074 (0.203)		
Distance to WA Interstate*RML									0.065 (0.148)	0.079 (0.174)
R-squared	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160 in Panel 1 and 480 in Panel 2. Observations per year are 360 in Panel 1 and 80 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 6: The effect of RML on DUI arrests by RML border status and distance to RML state

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	0.307 (5.489)	0.033 (5.350)								
CO Border 100 Miles*RML			-0.945 (3.457)	-2.367 (3.329)						
CO Interstate 100 Miles*RML					3.412 (3.403)	1.556 (3.252)				
Distance to CO*RML							-1.045 (0.974)	0.420 (0.967)		
Distance to CO Interstate*RML									-1.750** (0.862)	0.110 (0.874)
R-squared	0.716	0.734	0.716	0.735	0.716	0.734	0.716	0.734	0.717	0.734
Panel 2: Washington Region										
WA Border*RML	9.060* (4.884)	5.118 (3.951)								
WA Border 100 Miles*RML			8.547** (4.229)	2.429 (3.480)						
WA Interstate 100 Miles*RML					7.936** (3.956)	0.849 (3.788)				
Distance to WA*RML							-4.486** (1.747)	-0.503 (1.539)		
Distance to WA Interstate*RML									-4.729*** (1.427)	-0.625 (1.405)
R-squared	0.682	0.737	0.684	0.736	0.682	0.735	0.687	0.735	0.693	0.735
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160 in Panel 1 and 480 in Panel 2. Observations per year are 360 in Panel 1 and 80 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 7: The effect of RML on opioid/cocaine possession arrests by RML border status and distance to RML state

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	0.514 (0.495)	0.270 (0.489)								
CO Border 100 Miles*RML			0.273 (0.305)	0.110 (0.293)						
CO Interstate 100 Miles*RML					-0.019 (0.304)	-0.081 (0.304)				
Distance to CO*RML							-0.208** (0.087)	-0.050 (0.083)		
Distance to CO Interstate*RML									-0.181** (0.080)	-0.023 (0.083)
R-squared	0.580	0.598	0.580	0.598	0.580	0.598	0.582	0.598	0.581	0.598
Panel 2: Washington Region										
WA Border*RML	3.303* (1.753)	2.851* (1.621)								
WA Border 100 Miles*RML			1.494 (1.035)	0.756 (0.921)						
WA Interstate 100 Miles*RML					2.111* (1.260)	1.320 (1.151)				
Distance to WA*RML							-0.799* (0.447)	-0.338 (0.401)		
Distance to WA Interstate*RML									-0.750** (0.337)	-0.280 (0.296)
R-squared	0.723	0.734	0.715	0.726	0.718	0.727	0.716	0.726	0.718	0.726
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160 in Panel 1 and 480 in Panel 2. Observations per year are 360 in Panel 1 and 80 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 8a: Event study of RML on marijuana possession arrests, Colorado region

	(1)	(2)	(3)	(4)	(5)	(6)
pseudoRML2010*Border	-1.848 (2.884)	-2.472 (2.986)				
pseudoRML2011*Border	-2.624 (3.431)	-3.782 (3.441)				
pseudoRML2012*Border	10.130 (8.622)	8.364 (8.655)				
pseudoRML2013*Border	7.309 (5.991)	5.008 (5.946)				
pseudoRML2014*Border	11.751*** (4.455)	8.887** (4.324)				
pseudoRML2010*Border 100 Miles			-1.526 (2.062)	-2.311 (2.134)		
pseudoRML2011*Border 100 Miles			2.015 (2.640)	0.502 (2.656)		
pseudoRML2012*Border 100 Miles			6.252 (4.947)	3.927 (4.903)		
pseudoRML2013*Border 100 Miles			5.855 (3.821)	2.765 (3.711)		
pseudoRML2014*Border 100 Miles			10.991*** (3.270)	7.151** (3.084)		
pseudoRML2010*Interstate 100 Miles					-3.283 (2.989)	-4.141 (3.093)
pseudoRML2011*Interstate 100 Miles					2.352 (3.913)	0.616 (4.004)
pseudoRML2012*Interstate 100 Miles					7.535 (7.563)	4.879 (7.419)
pseudoRML2013*Interstate 100 Miles					8.329 (5.639)	4.790 (5.410)
pseudoRML2014*Interstate 100 Miles					14.955*** (4.649)	10.529** (4.320)
R-squared	0.741	0.758	0.741	0.757	0.742	0.758
Year Dummies	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. Total number of observations is 2,160 for all specifications.

Table 8b: Event study of RML on marijuana possession arrests, Washington region

	(1)	(2)	(3)	(4)	(5)	(6)
pseudoRML2010*Border	4.655 (7.530)	4.198 (7.457)				
pseudoRML2011*Border	5.505 (11.950)	4.528 (11.666)				
pseudoRML2012*Border	6.422* (3.458)	4.979 (3.309)				
pseudoRML2013*Border	31.124** (14.874)	29.215** (13.902)				
pseudoRML2014*Border	22.979 (14.281)	20.584 (13.243)				
pseudoRML2010*Border 100 Miles			1.912 (4.364)	1.003 (4.237)		
pseudoRML2011*Border 100 Miles			0.916 (6.771)	-0.843 (6.399)		
pseudoRML2012*Border 100 Miles			1.612 (3.372)	-0.905 (3.160)		
pseudoRML2013*Border 100 Miles			13.660 (8.701)	10.331 (7.487)		
pseudoRML2014*Border 100 Miles			9.629 (8.615)	5.532 (7.362)		
pseudoRML2010*Interstate 100 Miles					3.750 (5.263)	2.882 (5.139)
pseudoRML2011*Interstate 100 Miles					1.964 (8.263)	0.259 (7.895)
pseudoRML2012*Interstate 100 Miles					6.515** (3.257)	4.004 (2.990)
pseudoRML2013*Interstate 100 Miles					18.696* (10.774)	15.377 (9.591)
pseudoRML2014*Interstate 100 Miles					12.759 (10.487)	8.638 (9.224)
R-squared	0.941	0.942	0.938	0.939	0.939	0.939
Year Dummies	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. Total number of observations is 480 for all specifications.

Table 9: The effect of RML on marijuana possession arrests in Colorado region controlling for trends in Medical Marijuana Registry Program (MMRP) enrollees

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CO Border*RML	6.687** (3.267)	5.340* (3.101)								
CO Border 100 Miles*RML			5.987** (2.466)	4.160* (2.379)						
CO Interstate 100 Miles*RML					9.392** (3.659)	7.235** (3.481)				
Distance to CO*RML							-2.477*** (0.602)	-0.983 (0.599)		
Distance to CO Interstate*RML									-2.659*** (0.572)	-0.891 (0.591)
R-squared	0.739	0.756	0.739	0.756	0.740	0.757	0.743	0.756	0.746	0.755
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160. Observations per year are 360. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles. Total MMRP enrollees are coded as: 41,039 in 2009, 116,198 in 2010, 82,089 in 2011, 108,526 in 2012, 110,979 in 2013, and 115,467 in 2014.

Table 10: The effect of RML on police officer employment in Colorado and Washington regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
Border*RML	1.813 (1.875)	1.794 (1.727)								
Border 100 Miles*RML			0.994 (1.073)	0.939 (1.041)						
Interstate 100 Miles*RML					-0.479 (0.596)	-0.789 (0.592)				
Distance*RML							-0.324 (0.227)	-0.247 (0.166)		
Distance to Interstate*RML									-0.324** (0.164)	-0.230 (0.141)
R-squared	0.921	0.921	0.921	0.921	0.920	0.921	0.921	0.921	0.921	0.921
Panel 2: Washington Region										
Border*RML	-1.447 (1.405)	-1.578 (1.351)								
Border 100 Miles*RML			-1.488 (1.012)	-1.747* (0.933)						
Interstate 100 Miles*RML					-0.644 (0.898)	-0.868 (1.058)				
Distance*RML							0.550 (0.389)	0.750** (0.350)		
Distance to Interstate*RML									0.309 (0.274)	0.524** (0.262)
R-squared	0.861	0.861	0.862	0.862	0.860	0.860	0.861	0.862	0.860	0.861
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160 in Panel 1 and 474 in Panel 2. Observations per year are 360 in Panel 1 and 79 in Panel 2 (Marion County excluded). Apart from year and county dummies, control variables include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table 11: Average percentage of adults using marijuana in the past year by state and time period

	(1)	(2)	(3)	(4)	(5)	(6)
	Treatment States			Control States		
	N	mean	S.D.	N	mean	S.D.
2009-2012	16	10.64	2.948	14	11.33	2.529
2013-2014	8	12.32	3.414	7	11.92	2.356

Notes: Treatment states are all that border RML states, including ID, OR, WY, UT, NM, OK, KS, and NE. Control States include CA, NV, AZ, MT, ND, SD, and TX.

Table 12: The effect of RML on state marijuana use

	(1)	(2)
Border*RML	1.155*	3.492**
	(0.550)	(1.502)
R-squared	0.432	0.814
Year Dummies	YES	YES
County Dummies	YES	YES
State Specific Linear Time Trends	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by states. The number of observations for both specifications is 45. Apart from year and state dummies, control variables also include medical marijuana legalization status and marijuana decriminalization status.

Appendix A

Figure A1: County marijuana possession arrests per 10,000 population, 2010

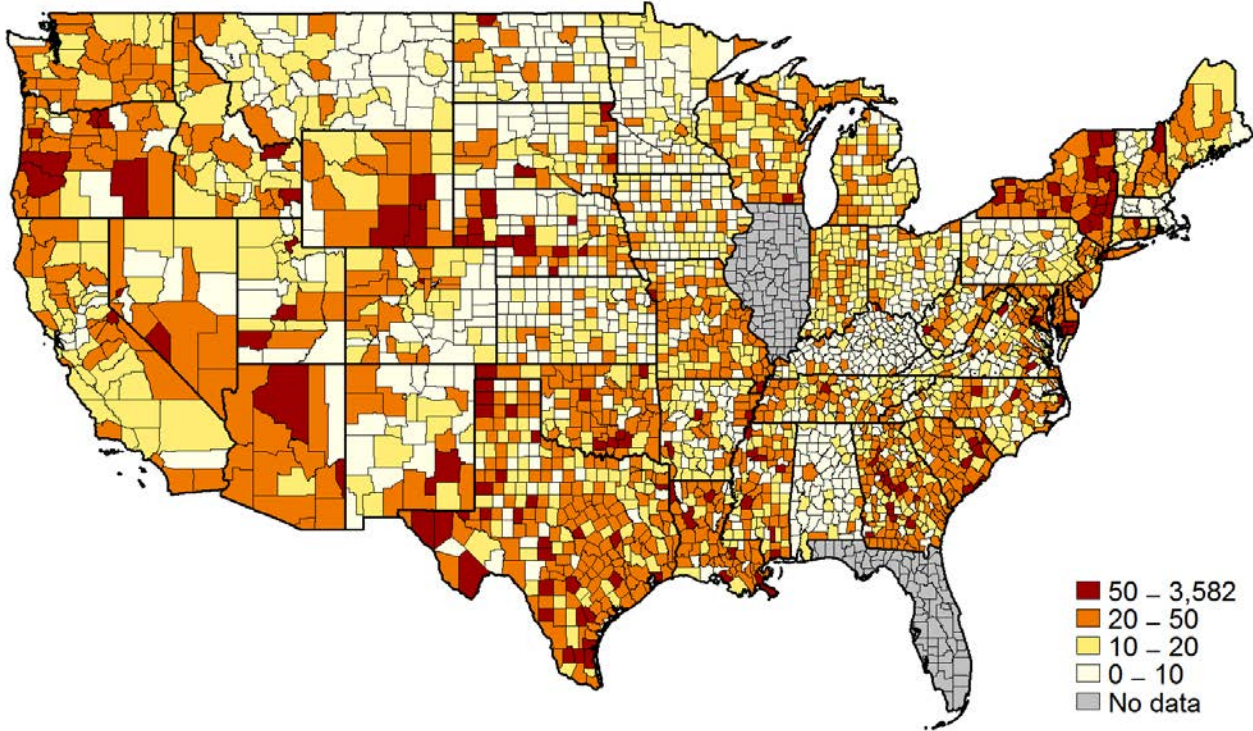


Figure A2: County marijuana possession arrests per 10,000 population, 2012

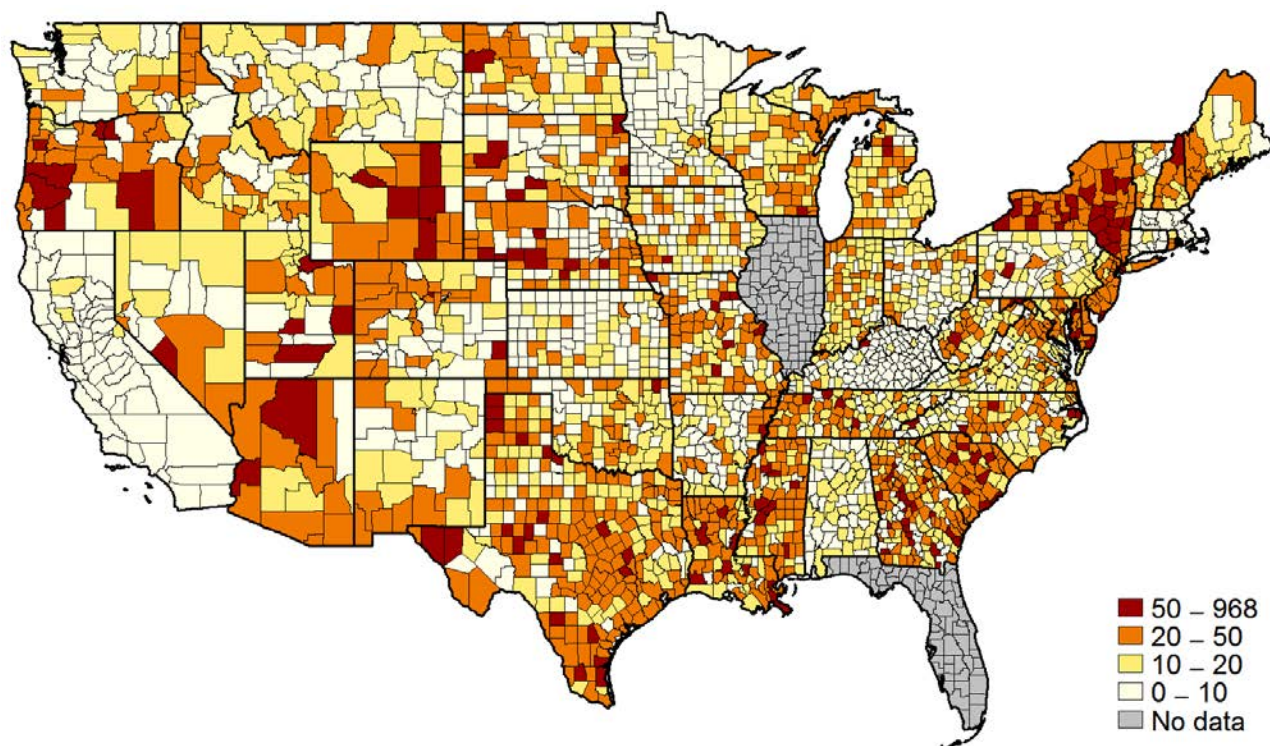


Figure A3: County marijuana possession arrests per 10,000 population, 2014

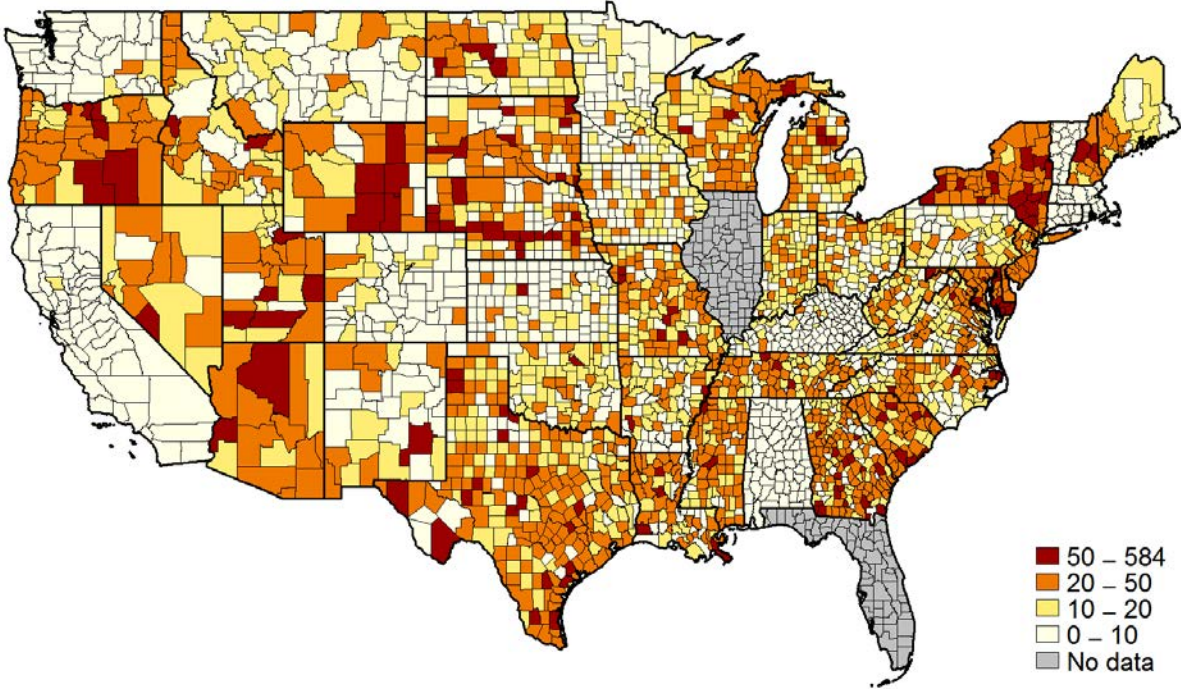


Table A1: The effect of RML on marijuana possession arrests by RML border status and distance to RML state (year 2012 excluded)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	11.049**	9.063								
	(5.609)	(5.533)								
CO Border 100 Miles*RML			8.272**	5.565*						
			(3.407)	(3.319)						
CO Interstate 100 Miles*RML					11.817**	8.688*				
					(5.099)	(4.904)				
Distance to CO*RML							-3.930***	-1.761*		
							(0.908)	(0.943)		
Distance to CO Interstate*RML									-4.245***	-1.698*
									(0.882)	(0.991)
R-squared	0.751	0.773	0.751	0.771	0.753	0.773	0.756	0.771	0.760	0.771
Panel 2: Washington Region										
WA Border*RML	23.253**	21.414**								
	(9.807)	(8.886)								
WA Border 100 Miles*RML			10.698*	7.709						
			(6.248)	(5.208)						
WA Interstate 100 Miles*RML					13.728*	10.626*				
					(7.435)	(6.309)				
Distance to WA*RML							-6.298**	-4.820**		
							(2.889)	(2.389)		
Distance to WA Interstate*RML									-4.856**	-3.337*
									(2.286)	(1.848)
R-squared	0.940	0.940	0.937	0.938	0.937	0.938	0.938	0.938	0.937	0.938
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 1,800 in Panel 1 and 400 in Panel 2. Observations per year are 360 in Panel 1 and 80 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table A2: The effect of RML on marijuana possession arrests by RML border status and distance to RML state, coverage index ≥ 90 .

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel 1: Colorado Region										
CO Border*RML	10.336*	7.939								
	(5.651)	(5.244)								
CO Border 100 Miles*RML			8.145**	4.695						
			(3.172)	(2.856)						
CO Interstate 100 Miles*RML					11.620**	7.644*				
					(4.661)	(4.086)				
Distance to CO*RML							-3.690***	-1.336*		
							(0.819)	(0.734)		
Distance to CO Interstate*RML									-4.030***	-1.231*
									(0.771)	(0.704)
R-squared	0.751	0.771	0.751	0.771	0.752	0.771	0.755	0.770	0.758	0.770
Panel 2: Washington Region										
WA Border*RML	16.690*	16.054*								
	(9.450)	(8.718)								
WA Border 100 Miles*RML			6.048	4.864						
			(5.365)	(4.235)						
WA Interstate 100 Miles*RML					8.478	7.356				
					(6.563)	(5.334)				
Distance to WA*RML							-3.810	-3.380*		
							(2.457)	(1.904)		
Distance to WA Interstate*RML									-2.586	-2.101*
									(1.818)	(1.251)
R-squared	0.952	0.952	0.950	0.950	0.951	0.951	0.951	0.951	0.950	0.951
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 1,595 in Panel 1 and 427 in Panel 2. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles.

Table A3: The effect of RML on marijuana possession arrests in Colorado region controlling for MMRP enrollees in nearest Colorado county

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CO Border*RML	8.175**	6.381*								
	(3.436)	(3.484)								
CO Border 100 Miles*RML			6.394***	4.359*						
			(2.430)	(2.394)						
CO Interstate 100 Miles*RML					9.204**	7.178**				
					(3.599)	(3.441)				
Distance to CO*RML							-2.920***	-1.263**		
							(0.615)	(0.612)		
Distance to CO Interstate*RML									-3.104***	-1.143*
									(0.592)	(0.599)
MMRP enrollees	0.323***	0.031	0.312***	0.027	0.299***	0.023	0.277***	0.029	0.238***	0.024
	(0.072)	(0.084)	(0.072)	(0.084)	(0.070)	(0.083)	(0.070)	(0.084)	(0.068)	(0.084)
R-squared	0.742	0.756	0.742	0.756	0.743	0.757	0.745	0.755	0.746	0.755
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
County Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
State Specific Linear Time Trends	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Estimates are obtained using OLS with standard errors (in parentheses) clustered by county. The number of observations for each specification is 2,160. Observations per year are 360. Apart from year and county dummies, control variables also include county population, county unemployment rate, and county median household income. Distances are measured in the unit of 100 miles. MMRP enrollees are measured as the Colorado Medical Marijuana Registry program enrollees per 1,000 people in the nearest Colorado county.