EL COLEGIO DE MÉXICO
CENTRO DE ESTUDIOS ECONÓMICOS

LICENCIATURA EN ECONOMÍA

TRABAJO DE INVESTIGACIÓN PARA OBTENER EL GRADO DE LICENCIADO EN ECONOMÍA

Impact of cannabis legalization on the black market of cannabis

Iñaki Zardain Benítez

Promoción 2018-2022

Asesor:

Jaime Sempere Campello

Index

Abstract:

After several states of the United States of America (USA) legalized the production and consumption of cannabis since 2012, in 2016 California implemented its own policy to liberalize the cannabis market statewide. This thesis analyses the effects of the former policy on the illegal market of marijuana in California using an econometrical method in datasets from the United States Drug Enforcement Administration (DEA) and the Substance Abuse and Mental Health Services Administration (SAMHASA). The results demonstrate that California's cannabis liberalization policy produced different outcomes in the black market of cannabis.

Keywords: legalization, liberalization, demand, supply, cannabis, marijuana, efficiency.

I Introduction

In 2016, California which is the state with the biggest eradicated domestic cannabis (total cultivated plants) in the United States of America from 2002 to 2018 legalized the production and consumption of cannabis (Carroll, 2020). Normally this type of policies aims to reduce or damage illegal markets and to get a new income source from tax revenues, but there is not a specific analysis that measures or corroborates negative effects to the illicit market and that is due to the lack of specific information about it, especially from the producer's side. This thesis has as an objective to analyze what are the outcomes of the liberalization of cannabis in the illegal market of marijuana in California by examining important variables related to the consumers and illegal producers before and after the legalization. The hypothesis is that there were not negative outcomes in the illegal market, and the reason behind may be the high product prices in legal stores, consequence of high taxes. This analysis is important because it gives feedback about a very important liberalization policy so that any other government can either follow the same steps or develop something different and be more effective damaging the black market.

To see the product of this policy in the market of cannabis the Difference-in-Differences method was used in target variables for the consumption and production side, such as Asset

Seized Value, Total Cultivated Plants Outdoor and Indoor, and Marijuana Use in the Past Year. Results manifest mixed effects in the illegal market of marijuana of California seeing an increase in the use of marijuana and the value seized by drug enforcement authorities, but a decrease in the quantity of confiscated plants.

The rest of the paper is organized as follows. Section II introduces the market of cannabis. The methodology, explanation of the database, approach to the Difference-in-Differences regression model, and results are explained in Section III. Section IV has the conclusions of the thesis. Section V includes the Appendix (Robustness Tests). Section VI has all references. Finally, the figures index and tables index are in Section VII and Section VIII, respectively.

II Market of Cannabis

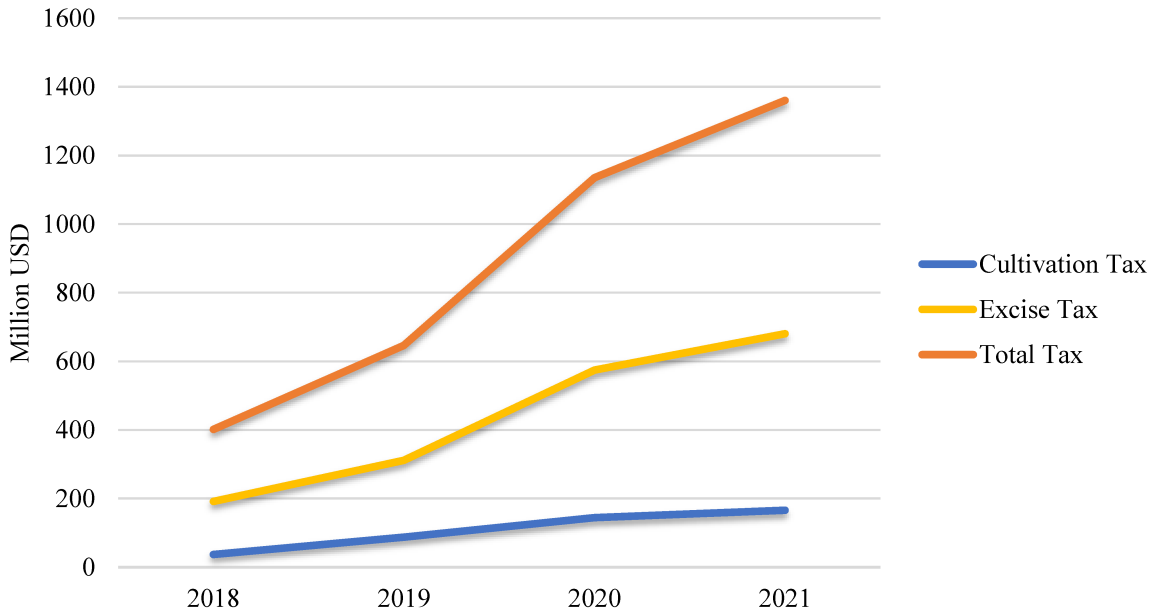
Even though constitutionally cannabis was legalized by 2016, most of the rules for the links of the production chain, cost of license and taxes for the industry started until 2018, the year when retail stores opened officially (California Department of Tax and fee Administration, s.f.). Two of the most important taxes were a cannabis cultivation tax (January 1, 2018-June 30, 2022) imposed on cultivators for all harvested cannabis, except immature plants and seeds, that enters the commercial market based on the weight and category of the cannabis (flowers around $10 USD per ounce, leaves around $3 USD per ounce and plants around $1.4 USD per ounce) and an excise tax (January 1, 2018-currently) of 15% applied to gross receipts of cannabis or cannabis products in a retail sale (California Department of Tax and Fee Administration, s.f.). The cannabis cultivation tax was removed in 2022 possibly due to the lack of ability of the legal market to compete against the illegal market that has less expensive products (Lange, 2022).

Unlike other plant-based drugs, for which cultivation and production are concentrated in only a few countries, cannabis is produced in almost all countries worldwide and North America is the region between the Americas where past-year users of cannabis increased from 40 million to 59 million between 2010 and 2019 (The United Nations Office on Drugs and Crime, 2021). Nowadays marijuana remains illegal under federal law since it is considered a Schedule I substance under the Controlled Substances Act, meaning that it has a high potential for abuse, no currently accepted medical use in treatment in the USA, and a lack of accepted safety for use under medical supervision (Drug Enforcement Administration, 2020). From 2012 and on, many states had started to liberalize this product in mainly two types of markets, state-approved

medical marijuana markets and state-approved personal use/recreational markets (2020 Drug Enforcement Administration National Drug Threat Assessment, 2020). Cannabis has two substances, THC (Tetrahydrocannabinol) is the primary psychoactive cannabinoid, and CBD (Cannabidiol) which is a non-psychoactive cannabinoid, is hypothesized to moderate the effects of THC and is often associated with therapeutical effects (Mahamad, Wadsworth, Rynard, Goodman, & Hammond, 2020). There is a wide option of products related to cannabis, these include plants, flowers, leaves, concentrates, edibles, extracts, and many more.

Analyzing the government, there is a study that suggests that marijuana tax revenues from states that legalize recreational marijuana are modest (Cheng, De Franco, & Lin, 2022), but the tax revenue coming from this new market in California has been increasing, which means that the government is better off as it is shown in the following table (Cannabis Tax Revenues, 2022).

Figure 1 Cannabis Tax Revenue



Notes 1. The figure shows California's increase in tax revenues between 2018 – 2021. Adapted data from California Department of Tax and Fee Administration. (n.d.). Retrieved November 15, 2022, from Tax Guide for Cannabis Businesses / Cultivators: https://www.cdtfa.ca.gov/industry/cannabis.htm#Cultivators.

Theoretically a full legalization (without any tax) of this product would yield a reduction of its price, would make rational past agents increase their consumption and would increase the probability of people that have not tried it to consume it (Becker, Grossman, & Murphy, 1991),

even though before the liberalization of cannabis there was not enough data to estimate changes in consumption and users after a legalization in California, there is one investigation that says it was likely that the consumption would not be unchanged and that the number of users and average quantity consumed among existing users (regular or heavy users) would go up in response to this policy (Liccardo Pacula, 2010). These all may hurt the illegal market of cannabis, but if this liberalization has been going along with taxes that have made the competitive prices of the legal market of cannabis higher than the illegal ones, then the damage to the illegal market may not be that harmful.

Changes in the market of cannabis can include legal prices above or below the illegal ones. In one hand, along 2010 it was expected that a full legalization of cannabis in the USA would make the average retail price of an ounce of marijuana sinsemilla, without package and brand to be reduced from $250-$400 USD to $40 USD due to the reduction in the cost related to the risk of producing illegal cannabis, but would increase the demand (Caulkins, Kilmer, MacCoun, Liccardo Pacula, & Reuter, 2011). In the other hand, Canada in 2018 became the second country to legalize cannabis (after Uruguay) producing with legal prices above the illegal ones and even with this, by 2019 among the general consumers 54% were in the legal market and 46% in the illegal market, so they did accomplish moving consumers from the illegal market to the legal one, even with high legal prices (Mahamad, Wadsworth, Rynard, Goodman, & Hammond, 2020). For prices, there is a significant relationship between price per gram and both THC and CBD in the legal market of Washington, with coefficients of 0.012 and 0.011 respectively, and both being statistically significant at a 95% confidence interval (Smart, Caulkins, Kilmer, Davenport, & Midgette, 2017).

The diversity of products in some legal markets, such as Washington has changed from 2014 to 2016. In this state traditional cannabis flower still account for the majority of spending (66.6%), but the market share of extracts for inhalation increased by 145.8%, now comprising 21.2% of sales and the average THC-level of cannabis is more than three times more that for cannabis flowers (68.7% compared to 20.6%) (Smart, Caulkins, Kilmer, Davenport, & Midgette, 2017).

Talking about substitutability, a recent behavioral study found an elasticity of .0019 to the illegal cannabis and .0002 to the legal cannabis. This basically says that consumers consider the legal cannabis as a superior good and because of this, imposing a tax would not affect that much the consumption and preference of consumers who buy from the legal market (Amlung,

et al., 2018). If the same is true for California, then a legalization with taxes may move a big quantity of consumers from the illegal market to the legal one even with high prices.

In terms of costs, after a legalization, the costs of production would decrease depending in the production method allowed since one of the main drivers of prices in the illegal market are compensations related to the risk of being arrested either for the cultivation, production, delivery or consumption of cannabis. It is estimated that by 2010 the production costs of cannabis sinsemilla are $200-$400 USD per pound, plus $20-$35 USD for crop harvesting and other processes, and that same pound is sold for $3,000-$4,500 USD if it is high quality cannabis (Caulkins, 2010).

The demand is expected to grow as a result of legalization because of an increase in the number of users (actual, former, and new) and the length of consumption for the average consumers. This will all depend on the price; how severe the law enforcement is and how the rules are related to this legalization (Caulkins & Reuter, 2010). By a systematic review and meta-analysis, a legalization of cannabis for recreational purposes suggests a small increase in the use of cannabis for adolescents and young adults (Melchior, et al., 2019).

III Methodology

This thesis uses the Difference-in-Differences method to assess if there was any change in the dependent variables of interest after the liberalization policy, the magnitude and if it was statistically significant or not.

Estimating effects by the Difference-in-Differences method can have severe serial correlation problems in the outcomes, which will exacerbate the bias in standard errors, but this can be solved by using different techniques that include aggregating the data into two periods (pre and post-intervention) for large samples (e.g. 50 states) (Bertrand, Duflo, & Mullainathan, 2002). This thesis is based in information of 50 states and follows that technique by having data for production and consumption variables from the pre-intervention (2011-2016, 2012-2016 respectively) and post-intervention (2016-2019) for production and consumption, where all data related to pre intervention is in the Appendix. Thus, there is no bias in the standard errors in the following analysis.

The regression model analyzed has a dependent variable (y), treatment variable (S), time variable (T), a difference-in-differences estimator (S·T), an error term (e) and has the following form.

$$y = B0 + B1(S) + B2(T) + B3(S \cdot T) + e$$

III.A Regression Models

The dependent variables of Asset Seized Value (ASV) and Total Cultivated Plants Outdoor and Indoor (TCPOI) from the DCE/SP were examined to assess outcomes in the illegal production market of cannabis. For the consumption side, the dependent variable chosen was the Marijuana Use in the Past Year of 2019 (c19) from the NSDUH. The treatment variable was the dummy for the state of California (CA), time variable was a dummy for the year 2019 (d19) and the Difference-in-Differences estimators were the joint variables of treatment and time. Robustness tests are included in the Appendix.

To analyze the outcome of legalizing in California the cannabis in 2016, the dummy variables prior to this year were excluded, so that the base time would be 2016.

III.B Database

The Domestic Cannabis Suppression / Eradication Program (DCE/SP) from the DEA includes variables such as Total Eradicated Outdoor Grow Sites (TEOGS), Total Cultivated Plants Outdoor (TCPO), Total Eradicated Indoor Grow Sites (TEIGS), Total Cultivated Plants Indoor (TCPI), Total Cultivated Plants Outdoor and Indoor (TCPOI), Bulk Processed Marijuana (BPM), Number of Arrests (NOA), Asset Seized Value (ASV), Weapon Seizure (WS) for 2011-2019 and in addition variables for the difference from one year to the previous for each previous variable were added. This program is the only nationwide law enforcement program that exclusively targets Drug Trafficking Organizations (DTO) involved in cannabis cultivation (Domestic Cannabis Suppression / Eradication Program, 2018).

The National Survey on Drug Use and Health (NSDUH) from SAMHSA provides database estimates of substance use and mental illness at the national, state and substate levels (National Survey on Drug Use and Health, n.d.). For this thesis only Marijuana Use in the Past Year from 2012-2019 was taken from this dataset. This variable derives from responses to questions about lifetime and recency of use of any type of marijuana product and excludes questions about use

of marijuana in the past 12 months that was recommended by a doctor or other health care professional since 2013 (Substance Abuse and Mental Health Services Administration, 2020).

In addition to the previously defined variables, dummies for California (CA), legalized states by year (Ln), indicators for each year (dn) and states (State) were added to this study. All these variables and datasets explained in this section were joined into a cross-sectional database.

The statistics and description of the only variables used for the Difference-in-Differences estimation in this thesis are presented in "Table1" and "Table 2".

Table 1 Descriptive Statistics of Variables (2016-2019)

	Asset Seized Value (ASV)	**Total Cultivated Plants Outdoor and Indoor (TCPOI)**	**Marijuana Use in the Past Year for Year 2019 (c19)**	**Dummy for California (CA)**	**Dummy for Year 2019 (d19)**
Count	350	350	347	350	350
Mean	974,175.1	92,447.92	130.43	0.02	0.142
Standard Deviation	3,610,922	494,973.8	520.86	0.14	0.35
Min	0	0	0	0	0
Max	38,994,310	4,765,737	6,641	1	1

Notes 1. The data used for this analysis was obtained from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

Table 2 Description of Variables Used (2016-2019)

	Source	**Units**	**Periodicity**
Dependent Variables			
Asset Seized Value (ASV)	NSDUH	$ USD	Yearly

Total Cultivated Plants Outdoor and Indoor (TCPOI)	NSDUH	Number of Plants	Yearly
Marijuana Use in the Past Year for Year 2019 (c19)	SAMHSA	(1,000) Number of Times	Yearly
Independent Variables			
Dummy for California (CA)	Created	Dummy	-
Dummy for Year 2019 (d19)	Created	Dummy	-
Difference-in-Differences Estimator (CA*d19)	Created	Dummy	-

Notes 2. The data used for this analysis was obtained from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

III.C Asset Seized Value (ASV)

To analyze whether the liberalization produced changes in the revenues of illegal producers or not, the following regression model was estimated. Here the Asset Seized Value was the dependent variable, which is the dollar value of all cannabis related products taken from black market producers among all states by the DEA. This includes the value in dollars from cultivated plants indoor and outdoor, bulk processed cannabis, and other products.

$$ASV = B0 + B1(CA) + B2(d19) + B3(d19 \cdot CA) + e$$

Table 3 Asset Seized Value Difference-in-Differences Estimation (2016-2019)

	Intercept	CA	D19	D19*CA
Coefficient	726,500	5,191,000	(445,000)	10,190,000
Standard Error	213,000	1,510,000	426,000	3,010,000
P-Value	0.001	0.001	0.297	0.001

Model	Ordinary Least Squares	**R-squared**	0.193
Observations	200	**Adj R-squared**	0.181
F-Statistic	15.63	**Covariance Type**	Nonrobust

Notes 3. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

The previous regression shows that the average Asset Seized Value of a state that is not California in 2016 is $726,500 USD (statistically significant), the difference in Asset Seized Value between California and all the other states before 2019 is $5,191,000 USD (statistically significant), the difference of Asset Seized Value in all states (except California) from 2016 to 2019 is –$445,800 USD (not statistically significant) and being California is associated with an increase in Asset Seized Value of $10,190,000 USD from 2016 to 2019 (statistically significant).

Comparing the previous results with the robustness test in "Table 8" we can see that being California after the legalization is associated to a significant increase in the Asset Seized Value, since the same variable is not statistically in the period of 2011-2016, having a p-value of 0.994 and a coefficient of -$12,970 USD. This shows that the legalization may have contributed to an increase in the value of the production of cannabis trafficking gangs in the USA.

III.D Total Cultivated Plants Outdoor and Indoor (TCPOI)

In order to study the effects of the legalization of cannabis in the produced amount of marijuana the following regression model was evaluated. The analysis included Total Cultivated Plants

Outdoor and Indoor as a dependent variable and represents the quantity of plants seized from illicit producers by the DEA per state in the USA, without discrepancy in the type of marijuana.

$$TCPOI = B0 + B1(CA) + B2(d19) + B3(d19 \cdot CA) + e$$

Table 4 Total Cultivated Plants Outdoor and Indoor Difference-in-Differences Estimation (2016-2019)

	Intercept	CA	D19	D19*CA
Coefficient	23,890	2,655,000	(7,223.61)	514,700
Standard Error	10,300	72,500	20,500	145,000
P-Value	0.021	0.000	0.725	0.000

Model	Ordinary Least Squares	**R-squared**	0.910
Observations	200	**Adj R-squared**	0.909
F-Statistic	659.7	**Covariance Type**	Nonrobust

Notes 4. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

This estimation shows that the average Total Cultivated Plants (Outdoor and Indoor) of a state that is not California in 2016 is 23,890 plants (statistically significant), the difference in Total Eradicated Cultivated Plants between California and all the other states after 2016 and before 2019 is 2,655,000 plants (statistically significant), the difference of Total Cultivated Plants in all states (except California) from 2016 to 2019 is –7,223.61 plants (not statistically significant) and being California is associated with an increase in Total Cultivated Plants of 514,700 from 2016 to 2019 (statistically significant).

Analyzing "Table 9", we can see that from 2011 to 2016 California was associated with an increase in Total Cultivated Plants of 923,700 units, thus the legalization may have made the production of plants decrease almost 400,000 units. This could be related to many reasons; one

option was the new possibility of illegal producers increase their prices (not as much as the legal ones) without compromising losing customers since the alternative legal option is more expensive. Another option could be producers moving their whole production from the black market to the legal market allowing overall customers to get that production now in legal stores. Seeing that the real reason why this production has been reduced is unknown and as it was written before, this production may now be sold in legal stores where customers from the illegal market can keep consuming this product means that this decrease in production may not necessarily be associated to negative outcomes for producers in the illegal market and there was no harm to consumers.

From the two variables analyzed from the production side of the illegal cannabis market we can see that the legalization from 2016 seems not to have a negative effect in the revenues of the illegal market but may have reduced the number of produced plants available in this market.

III.E Marijuana Use in the Past Year (c19)

To analyze if there was any outcome in the demand of cannabis after the legalization of marijuana the following regression model was estimated. The dependent variable resembles Marijuana Use in the Past Year (in thousands) for people over 12 years old and as mentioned in Section III.B, it tells the regency and lifetime of use of any marijuana product that was not recommended by a health care professional.

$$c19 = B0 + B1(CA) + B2(d19) + B3(d19 \cdot CA) + e$$

Table 5 Marijuana Use in the Past Year Difference-in-Differences Estimation (2016-2019)

	Intercept	**CA**	**D19**	**D19*CA**
Coefficient	(1.114e-13)	(5.899e-13)	839.54	5,801.46
Standard Error	15.183	107.36	41.28	284.202
P-Value	1.000	1.000	0.000	0.000

Model	Ordinary Least Squares	**R-squared**	0.752

Observations	347	**Adj R-squared**	0.750
F-Statistic	347.4	**Covariance Type**	Nonrobust

Notes 5. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

Regarding the last regression, only two of the examined variables are statistically significant and have a significant coefficient. The difference in the number of Marijuana Use in the Past Year in all states (except California) from 2016 to 2019 is 839,540 times and California is associated with an increase in the number of Marijuana Use in the Past Year of 5,801,456 times from 2016 to 2019.

Taking into consideration "Table 10", the previous result says that after the legalization there was an important increase in Marijuana Use of 25% from 2011-2016 to 2016-2022. If we connect this finding to the ones related to production, we can presuppose that overall consumers and demand in both markets has increased and that may be a reason why the Asset Seized Value was not negatively affected after the legalization.

IV Conclusions

With the use of the Difference-in-Differences method this thesis provides three insights about the effects of the cannabis liberalization policy of California on the black market. First, legalizing marijuana in California increased the asset seized value and so did the revenues of the illegal market since these assets represent potential production earnings. Second, the present policy increased the overall marijuana use in habitants older than 12 years old in California by 25% from 2016 to 2019 supporting Gary Becker's research. Given that consumers can buy from the legal or illegal market, this increase in consumption represents an expansion of the demand in both markets. However, the third result says that after the liberalization the number of plants seized decreased around 40% compared to the levels of 2011-2016. This last finding contradicts the first one since it seems difficult to believe that there was a revenue increase from 2011-2016 to 2016-2019, especially since the products sold were less from the former than the latter. To know the precise effects of the legalization over black market producers' profits further research and information about the illegal market of cannabis is needed, meanwhile this investigation provides a hypothesis explained below.

The profitability of illegal producers in California may have increased after the legalization due to higher legal prices compared to the ones in the illegal market as a result of taxes, regulatory costs and licenses. This might have enabled black market producers increase their price helping them achieve a higher revenue per unit sold, while reducing their level of production. Having a legal price above the illegal price is against what was expected to happen by many investigators (Caulkins, J in 2010 and Becker, G.) who thought that the reduction in risk associated costs would drop legal prices.

If California's objective was to damage or end the black market of cannabis, it was not accomplished since producers' revenues and overall use of marijuana increased after the liberalization policy.

This thesis has some advantages and disadvantages. As an advantage, it uses institutional data that comes from law enforcement authorities and health institutions and can be used as an approximation of illegal consumption and production levels, which are difficult to find. In addition, this is one of the first research documents that uses the Difference-in-Differences estimation model with variables from SAMHSA and DEA to assess the outcomes of a cannabis legalization on the marijuana's black market. Disadvantages includes the fact that the variables and datasets used do not give precise information about consumption and production since the data has not been supplied directly by illegal producers and there are many incentives for consumers not to report their true levels of consumption thinking that they can be punished socially or legally. Hence the data supplied by the DEA and SAMHSA might be an underestimation of real marijuana values.

The most important idea of the present investigation is that in order to have an efficient liberalization policy that wants to tackle the illegal market, new regulations and taxes shall not be high, so that new producers would want to enter the new legal market as a consequence of high profitability and former illegal consumers would be willing to switch their entire consumption to the legal market because of competitive prices imposed by producers that would not need to offset high taxes and regulations. These would all damage the profitability and competitive power of the black market and did not happen with California's marijuana legalization policy.

The implications of the results of this document in Mexico, which is a country that has recently legalized cannabis recreational consumption are the following. Since drug trafficking groups have great presence and power among all states of the Mexican Republic and marijuana

production taxes and regulations have not been fully implemented in the region, a legalization accompanied with taxes and regulations that would make legal prices and products more competitive against the illegal market would reduce narcotraffic revenues. In terms of consumption, it will probably increase since the quantity offered in the overall cannabis market would grow as well as the incentives to consume a product not related to any constitutional punishment and with higher quality. In order to evaluate the effectiveness of the Mexican cannabis legalization, information about legal and illegal production, prices and consumption should be provided either from drug enforcement authorities or any institution.

Finally, to have a better understanding about the outcomes of cannabis liberalization policies further research involving the use of anonymous public queries for marijuana consumers and opened access to detailed data from drug enforcement authorities should be followed. Any investigational tool that allows the researcher to distinguish between legal and illegal producers and consumers would be exhaustive.

V Appendix (Robustness Tests)

Table 6 Descriptive Statistics of Variables (2011-2016)

	Asset Seized Value (ASV)	Total Cultivated Plants Outdoor and Indoor (TCPOI)	Marijuana Use in the Past Year for Year 2016 (c16)	Dummy for California (CA)	Dummy for Year 2016 (d16)
Count	400	400	397	400	400
Mean	894,542.6	97,601.93	91.47	0.02	0.125
Standard Deviation	3,195,360	482,808.3	393.67	0.14	0.33
Min	0	0	0	0	0
Max	38,994,310	4,765,737	5,296	1	1

Notes 6. The data used for this analysis was obtained from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

Table 7 Description of Variables Used (2011-2016)

	Source	Units	Periodicity
Dependent Variables			
Asset Seized Value (ASV)	NSDUH	$ USD	Yearly
Total Cultivated Plants Outdoor and Indoor (TCPOI)	NSDUH	Number of Plants	Yearly
Marijuana Use in the Past Year for Year 2016 (c16)	SAMHSA	Thousand Number of Times	Yearly
Independent Variables			
Dummy for California (CA)	Created	Dummy	-
Dummy for Year 2016 (d16)	Created	Dummy	-
Difference-in-Differences Estimator (CA*d16)	Created	Dummy	-

Notes 7. The data used for this analysis was obtained from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

$$ASV = B0 + B1(CA) + B2(d16) + B3(d16 \cdot CA) + e$$

Table 8 Asset Seized Value Difference-in-Differences Estimation (2011-2016)

	Intercept	CA	D16	D16*CA
Coefficient	450,700	9,662,000	395,000	(12,970)
Standard Error	105,000	739,000	256,000	1,810,000

P-Value	0.000	0.000	0.124	0.994

Model	Ordinary Least Squares	**R-squared**	0.412
Observations	300	**Adj R-squared**	0.406
F-Statistic	69.15	**Covariance Type**	Nonrobust

Notes 8. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

$$TCPOI = B0 + B1(CA) + B2(d16) + B3(d16 \cdot CA) + e$$

Table 9 Total Cultivated Plants Outdoor and Indoor Difference-in-Differences Estimation (2011-2016)

	Intercept	**CA**	**D16**	**D16*CA**
Coefficient	38,050	2,822,000	(5,987.42)	923,700
Standard Error	7,620.41	53,900	18,700	132,000
P-Value	0.000	0.000	0.749	0.000

Model	Ordinary Least Squares	**R-squared**	0.926
Observations	300	**Adj R-squared**	0.925
F-Statistic	1,237	**Covariance Type**	Nonrobust

Notes 9. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

$$c16 = B0 + B1(CA) + B2(d16) + B3(d16 \cdot CA) + e$$

Table 10 Marijuana Use in the Past Year Difference-in-Differences Estimation (2011-2016)

	Intercept	CA	D16	D16*CA
Coefficient	(1.342e-13)	(6.904e-12)	674.28	4,621.72
Standard Error	10.80	76.38	31.41	216.165
P-Value	1.000	1.000	0.000	0.000

Model	Ordinary Least Squares	**R-squared**	0.744
Observations	397	**Adj R-squared**	0.742
F-Statistic	380.1	**Covariance Type**	Nonrobust

Notes 10. Standard Errors assume that the covariance matrix of the errors is correctly specified. The regression model used in this study incorporates data from a private database by Iñaki Zardain. The database sources include datasets from The National Survey on Drug Use and Health (NSDUH) by SAMHSA and The Domestic Cannabis Suppression/Eradication Program (DCE/SP) by the DEA.

VI References

2020 Drug Enforcement Administration National Drug Threat Assessment. (2020, March). Retrieved November 10, 2022, from Drug Enforcement Agency: https://www.dea.gov/sites/default/files/2021-02/DIR-008-21%202020%20National%20Drug%20Threat%20Assessment_WEB.pdf

Amlung, M., Reed, D., Morris, V., Aston, E., Metrik, J., & MacKillop, J. (2018). Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. *Addiction, 114*, 112-118.

Becker, G., Grossman, M., & Murphy, K. (1991). Rational Addiction and the Effect of Price on Consumption. *The American Economic Review, 81*(2), 237-241.

Bertrand, M., Duflo, E., & Mullainathan, S. (2002, March). *How Much Should We Trust Differences-in-Differences Estimates?* Retrieved from National Bureau of Economic Research: https://www.nber.org/system/files/working_papers/w8841/w8841.pdf

California Department of Tax and fee Administration. (n.d.). Retrieved November 14, 2022, from Tax Guide for Cannabis Businesses / Retailers: https://www.cdtfa.ca.gov/industry/cannabis.htm#Retailers

California Department of Tax and Fee Administration. (n.d.). Retrieved November 15, 2022, from Tax Guide for Cannabis Businesses / Cultivators: https://www.cdtfa.ca.gov/industry/cannabis.htm#Cultivators

Cannabis Tax Revenues. (2022). Retrieved November 16, 2022, from California Department of Tax and Fee Administration: https://www.cdtfa.ca.gov/dataportal/dataset.htm?url=CannabisTaxRevenues

Carroll, J. (2020). *Trump White House.* Retrieved from 2020 National Drug Control Strategy: https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/02/2020-NDCS-Data-Supplement.pdf

Caulkins, J. (2010). *Estimated Cost of Production for Legalized Cannabis.* Retrieved from RAND Corporation: https://www.rand.org/pubs/working_papers/WR764.html.

Caulkins, J., & Reuter, P. (2010). How Drug Enforcement Affects Drug Prices. *Crime and Justice, 39*, 213-271.

Caulkins, J., Kilmer, B., MacCoun, R., Liccardo Pacula, R., & Reuter, P. (2011). Design considerations for legalizing cannabis: lessons inspired by analysis of California's Proposition 19. *Addiction, 107*, 865-871.

Cheng, S., De Franco, G., & Lin, P. (2022, June). *Marijuana liberalization and public finance: A capital market perspective on the passage of medical use laws.* Retrieved from Science Direct: https://www.sciencedirect.com/science/article/pii/S0165410122000398

Domestic Cannabis Suppression / Eradication Program. (2018, July). Retrieved November 17, 2022, from Unites States Drug Enforcement Administration: https://www.dea.gov/operations/eradication-program

Drug Enforcement Administration. (2020, April). Retrieved November 14, 2022, from Drug Fact Sheet: https://www.dea.gov/sites/default/files/2020-06/Marijuana-Cannabis-2020_0.pdf

Lange, T. (2022, July 1). *California Eliminates Cannabis Cultivation Tax, Effective Immediately.* Retrieved November 10, 2022, from Cannabis Business Times: https://www.cannabisbusinesstimes.com/article/california-cannabis-cultivation-tax-eliminiated-removed-excise-budget/

Liccardo Pacula, R. (2010). *Examining the Impact of Marijuana Legalization on Marijuana Consumption.* Retrieved from RAND Corporation: https://www.rand.org/pubs/working_papers/WR770.html.

Mahamad, S., Wadsworth, E., Rynard, V., Goodman, S., & Hammond, D. (2020). Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. *Drug and Alcohol Review, 39*, 337-346.

Melchior, M., Nakamura, A., Nakamura, A., Bolze, C., Hausfater, F., El Khouty, F., . . . Azevedo Da Silva, M. (2019). *Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis.* Retrieved from BMJ Open: https://bmjopen.bmj.com/content/9/7/e025880

National Survey on Drug Use and Health. (n.d.). Retrieved November 16, 2022, from Substance Abuse and Mental Health Services Administration: https://www.samhsa.gov/data/data-we-collect/nsduh-national-survey-drug-use-and-health

Smart, R., Caulkins, J., Kilmer, B., Davenport, S., & Midgette, G. (2017). Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. *Society for the Study of Addiction, 112*, 2167-2177.

Substance Abuse and Mental Health Services Administration. (2020). Retrieved November 15, 2022, from 2020 NSDUH Detailed Table: https://www.samhsa.gov/data/sites/default/files/reports/rpt35323/NSDUHDetailedTabs2020/NSDUHDetailedTabs2020/NSDUHDetTabsAppA2020.pdf

The United Nations Office on Drugs and Crime. (2021, June). Retrieved November 1, 2022, from United Nations: https://www.unodc.org/res/wdr2021/field/WDR21_Booklet_3.pdf

VII Figures Index

VIII Tables Index