Two plants are better than one? -

The effect of decriminalization on the eradication of cannabis

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Abstract:
Cannabis cultivation is a thriving business, whether it is for profit or personal use. The reasons for engaging into illegal drug growing are mostly unexplored, especially for modest cultivators. This paper tries to shed some light on the impact of cannabis policy on this phenomenon through two econometric models. First, the kilograms of marijuana herbs seized as an outcome variable and second, the number of cannabis plants eradicated. After controlling for favorable outdoor (temperature) and indoor (electricity consumption) growing condition as well as exports, land area and the rural population, a significant policy effect can be found for the number of cannabis plants grown, but not on the amount of marijuana herbs seized. This can be partly explained by the profit-orientation of herb producers and the need to satisfy the market demand. Small-scale plant cultivators instead seem to be deterred by criminalization.

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1. Introduction

The overall number of drug-related arrests has declined in the last two decades (Willis, 2008). Nevertheless, the number of arrests due to cannabis seizures is still the highest in the domain of drugs since it is a profitable business. On the one hand, there are large-scale, commercial cultivators and on the other, small-scale individual growers. The smaller the growing operation, the lower is the risk of detection. Decorte (2010b) has identified the need to research this market of modest cannabis producers since it is a neglected area.

Willis (2008) characterizes the cannabis cultivation market as one with a low detection risk and vast possibilities for profit. Consequently, the number of cultivators is constantly growing. For example, Plecas, Malm & Kinney (2005) estimate that the harvest of marijuana leaves in kilogram tripled between 1997 and 2003. This is due to (1) the market demand and (2) the size of the retail market. 200 million consumers consume cannabis annually (United Nations Office on Drugs and Crime, 2013) and the retail value is estimated at 126 billion Euros per year (United Nations Office on Drugs and Crime, 2005).

There are three viable policy alternatives for cannabis that can be observed world-wide: Criminalization, Decriminalization and Legalization (Pacula et al., 2005). Here, only criminalization and decriminalization are considered since legalization has only occurred in Uruguay so far (Room, 2014). Under decriminalization the punishment for personal use and possession of cannabis is reduced to an administrative offence, as long as the amount of cannabis stays below a certain threshold. This does not affect the regulation for cannabis cultivation. However, it could have a behavioral impact.

When cannabis cultivation is illicit in order to suppress drug use, several problems occur. First of all, the quality of the drug cannot be monitored and the content as well as the quality are often unknown (Burgdorf, Kilmer & Pacula, 2011). Second, cannabis potency can increase and unaware drug users might overdose (Pijlman, Rigter, Hoek, Goldschmidt & Niesink, 2005). A third fallacy is the inability of the government to collect taxes on drug trade (Caulkins et al., 2013; Gettman, 2007).

The research question therefore tries to highlight whether cannabis producers are affected by the prevailing cannabis policy. To answer this question, a random effects regression is employed for two outcome measures separately: (1) The kilograms of marijuana herbs seized and (2) the number of cannabis plants eradicated. The results show that the amount of circulated marijuana herbs does not change, while the number of plants increases under

decriminalization. The first finding supports the theory of profit-oriented producers and the second highlights the deterrence effect for small-scale growers under criminalization.

2. Literature Review

The discussion about sanctions in rational choice theory has been coined by Becker (1968) and Cooter (1984). Both agree that higher sanctions lead to higher levels of deterrence. On the one hand, Becker (1968) highlights that offenders have to take all costs into account, for example the probability of arrest or social stigmatization, and combine this to a metaphorical price of committing a crime. On the other hand, Cooter (1984) states that a sanction is meant to deter illegal acts and it only comes into play when disregarding the law.

This leads to the conclusion that cannabis cultivation should be deterred by the existing legal sanctions. Furthermore, the amount of marijuana herbs and cannabis plants found should not change under decriminalization since there is no difference in punishment for offences related to growing cannabis. The number of marijuana herbs seized and cannabis plants eradicated would then remain stable, regardless of the legal regime (criminalization or decriminalization).

Even though rational choice theory suggests the deterrence of cannabis cultivation under criminalized schemes, cannabis-related crime still exists. If cannabis cultivation is not deterred by illegality and harsher punishments, one has to look beyond the reasoning of rational choice. It is possible that the number of herbs and plants increases under less strict policies. This is supported through findings by Barrat, Barrat, Chanteloup, Lenton & Marsh (2005): Cannabis cultivation depends on costs, needs and preferences rather than certainty or severity of penalties. Potter (2010) lists potential reasons for growing illicitly, which include (1) profit, (2) ideological or political factors, (3) medical and (4) personal use.

Silverstone & Savage (2010) underscore that profits are the main motivation for cannabis cultivation rather than lifestyle factors. Often it goes along with money laundering to cover the profits made. In Quebec, cannabis growing is one of the most prevalent crimes and is used for diverse reasons ranging from money generation for gangs to personal use in the adolescent population (Bouchard, Alain & Nguyen, 2009). The profitability of the market attracts Mexican cartels to the US (Mallery, 2011).

Small-scale cultivators constitute an important market segment (Decorte, 2010a). They operate independently and out of an ideological motivation (Decorte, 2010b). There is no

deterrence effect for intrinsically motivated growers that gain utility from the growing process and the resulting outcomes (Weisheit, 1991). Those growers generally do not feel as if operating in the illegal sphere (Potter, 2010). Another, more political, reason is unemployment: Hafley & Tewksbury (1995) studied growers in Kentucky and determined cannabis cultivation as an important source of income in the absence of employment.

Many market participants grow cannabis for personal use and possession (Hammersvik, Sandberg & Pedersen, 2012). They do not extend production since this would demand economic, technical and personal resources, such as time and commitment. Nevertheless, they affect natural resources through misusing water resources, the use of chemicals and altering landscapes to fit the need of the cannabis plant. In California, this is frequently done by Mexican cartels (Mallery, 2011). This happens in remote sites in is hard to control for law enforcement officials.

Different lines of reasoning lead to varying predictions of cultivators` behavior. Does the amount of herbs and plants depend purely on market demand or is it affected by political changes and deregulation? This field is mostly unexplored due to the illegality of cannabis production and the unwillingness of producers to admit their actions.

3. Methodology

The research question tries to identify whether cannabis producers are affected by the policy present in a country. To assess this market for cannabis cultivation, Wilkins, Bhatta & Casswell (2002) identified the number of cannabis seizures as the crucial starting point. Nevertheless, they conducted their research with the number of plants eradicated due to the lack of data. For this reason, both measures are employed. In the following the equation for the econometric regression analysis is specified for marijuana herbs. However, the model is the same for the number of eradicated cannabis plants; only the interaction term needs to be changed. Here, macro-level data is analyzed as a panel.

The model for marijuana herbs seized is formally specified as:

$$Y_{ct} = \beta_0 + \beta_1\ Policy\ Dummy + \beta_2\ Temperature + \beta_3\ Electricity + \beta_4\ Exports + \beta_5\ Land + \beta_6\ Rural + \beta_7\ Policy\ Dummy\ x\ Temperature + u_{ct} + \varepsilon_{ct}$$

A random effects model is fitted because fixed effects would only capture time-variant factors and some of the control vectors are time-invariant (Laird & Ware, 1982). The assumption is that variation between countries is uncorrelated to the control variables and random (Greene,

2008). A Breusch and Pagan Lagrangian multiplier test was significant and determined the appropriateness of the random effect model as compared to an OLS regression. Heteroskedasticity was controlled for through robust standard errors. ε_{ct} is the year-specific and within-country error denotation, while u_{ct} symbolized the between-country error term. β_0 is the model intercept.

The outcome measure (Y_{ct}) is the marijuana herbs seized in the first model and the cannabis plants eradicated in the second. This data is not available for all countries world-wide[2]. Nevertheless, a substantial number still has data readily available in the online resources of the United Nations Office on Drugs and Crime (UNODC, 2014). This lead to an analysis of 102 countries, regarding marijuana herbs, and 77 countries in connection to cannabis plants. Seizure data was reported in kilogram found by the police for marijuana herbs and in number of cannabis plants eradicated. To assure comparability between countries these figures were divided by the population in millions. Population data can be retrieved from the World Bank´s World Development Indicators (World Bank, 2014). Furthermore, the variables were log-transformed to improve linearity and attach more weight to changes at lower seizure levels.

A policy dummy is the independent variable of interest (β_1 Policy Dummy). It takes the value 0 for criminalized countries and the value 1 for decriminalized countries. Through this value, criminalized and decriminalized countries can be compared regarding the outcome variables and the effect of cannabis legislation on the seizures of marijuana herbs and cannabis plants. The data was extracted from two sources: The European Monitoring Center for Drugs and Drug Addiction (2013) and the National Centre of Expertise on Drugs and Drugs Law (2014).

Multiple control variables were employed to check whether conditions were more favorable for growing cannabis or whether there was more proneness to cultivate it in some countries as

[2] Excluded are: Afghanistan, Albania, Anguilla, Antigua and Barbuda, Aruba, Australia, Bhutan, Bosnia and Herzegovina, British Virgin Islands, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cayman Islands, Central African Republic, Chad, Comoros, Congo, Cook Islands, Democratic Republic Congo, Equatorial Guinea, Eritrea, Falkland Islands, Fiji, French Guyana, French Polynesia, Gabon, Gibraltar, Guadeloupe, Guinea, Haiti, Hong Kong, India, Iran, Iraq, Kenya, Kuwait, Lesotho, Liberia, Libya, Macao, Malawi, Maldives, Mali, Marshall Islands, Martinique, Montserrat, Mozambique, Myanmar, Nepal, Netherlands Antilles, New Caledonia, Niger, Nigeria, Palestine, Qatar, Rwanda, San Marino, Sao Tome and Principe, Seychelles, St. Helena, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Swaziland, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Tonga, Trinidad and Tobago, Togo, Turkmenistan, Turks and Caicos Islands, Uganda, US Virgin Islands, USA, Vanuatu, Zambia and Zimbabwe.

compared to the rest of the sample. These include average yearly temperature (β_2 Temperature), electricity consumption (β_3 Electricity), exports (β_4 Exports), land area (β_5 Land), rural population (β_6 Rural) and neonatal mortality. Correlations between the independent variables were tested and consequently, neonatal mortality was excluded. The correlation coefficient between mortality rate and percentage of rural population was 0.70, which means that the variables would capture a similar effect.

The average yearly temperature indicates whether it is easier to produce cannabis in outdoor conditions. The data was retrieved from an online weather resource (Weatherbase, 2014). The general rule is that a higher average yearly temperature means better preconditions for outdoor cannabis cultivation (Rosenthal, 2014). Different authors publish varying optimal degrees Celsius, but an acceptable range is from 24 to 30 degrees Celsius (Green, 2009; Cervantes, 2006).

Electricity consumption is measured in kilowatt-hours per capita and the data can be accessed through the World Bank´s Development Indicators (World Bank, 2014). This is used as a proxy for indoor cultivation (Cervantes, 2006). Higher electricity consumption facilitates indoor growing through two different mechanisms (Green, 2009): (1) More consumption is connected to better and constant availability throughout a country and (2) more consumption increases the chances to mask the high amount of electricity needed for growing cannabis indoors.

Further control vectors are exports of goods and services as a percentage of the GDP, land area in square kilometers and rural population as a percentage of the whole population and exports of goods and services as a percentage of the GDP. The data is available at the World Bank website and part of the World Development Indicators (World Bank, 2014). The coefficients for all but the rural area are expected to be positive. Although not extensively researched, Russo (2014) finds that more drugs enter a country, if the level of trade is higher. This is connected to a lower risk of smuggling detection and exports are used as a proxy for this effect. According to case studies by Chouvy & Laniel (2007) many African and South American countries are major cannabis producers in their vast areas of deserted and climatically well-suited land. It might also be easier to hide patches of cannabis plants (Anastasijevic, 2008). Consequently, the land area is controlled for. Cannabis cultivation is difficult without the right knowledge and tools (Green, 2009). It is expected that the percentage of rural population negatively affects the number of people that have the right equipment for this task.

A major limitation of this paper is the omitted variable bias. Models with random effects need to be specified with all influential individual characteristics included and some of them might not be salient or data availability is scarce (Greene, 2008). Nevertheless, the advantage of this modelling type is that generalization of outcomes beyond this specific dataset is possible.

4. Empirical analysis

In table 1 the summary statistics are displayed. The outcome variables are marijuana herbs and cannabis plants per 1.000.000 citizens. More observations are available for seized marijuana herbs, namely 2862, than for the number of plants, 1233. The log-transformed means for eradicated herbs and plants were 4.23 (ranging from -8.42 to 14.44) and 7.06 (ranging from -4.48 to 18.66), respectively.

The explanatory variables include a decriminalization dummy with values of 0 for criminalized and 1 for decriminalized countries; about 37 % of the observations are from the period of decriminalization. Furthermore, average temperature was 17.4 degrees Celsius and between countries it varies from -0.6 to 28.5 while electricity consumption in kilowatt-hours per capita has a mean value of 3,965 and a range from 18 to 52,374.

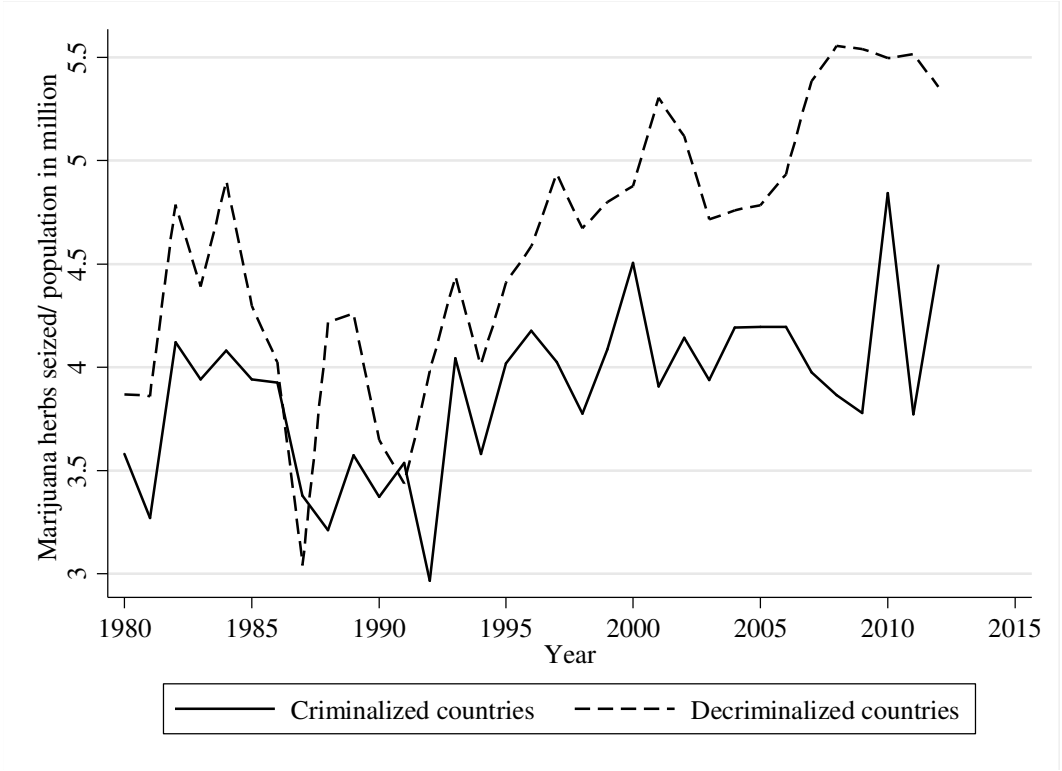
Three more vectors are deemed to be important explanatory factors: (1) The export of goods and services as percentage of the GDP, (2) land in square kilometers and (3) the rural population as percentage of the whole population. Their mean values are 40.3 % (range 3.2 to 230.3), 651,963 square kilometers (range 0 to 16,400,000) and 38.5 % (range 0 to 92.2), respectively.

	# of observations	Mean	Standard Deviation	Minimum	Maximum
	United Nations Office on Drugs and Crime (UNODC, 2014):				
Log Marijuana Herbs (kg)/ population in million	2862	4.228	3.113	-8.423	14.438
Log Plants (#)/ population in million	1233	7.059	3.371	-4.478	18.663
	European Monitoring Center for Drugs and Drug Addiction (2013); National Centre of Expertise on Drugs and Drugs Law (2014):				
Decriminalization Dummy	3345	0.367	0.482	0	1
	Weatherbase (2014):				
Average annual temperature (in degrees Celsius)	3345	17.404	7.880	-0.6	28.5
	World Development Indicators (World Bank, 2014):				
Electricity consumption (in kilowatt-hours per capita	2697	3,964.9	4,878.5	18.4	52,373.9
Exports of goods and services (% of GDP)	3120	40.293	26.425	3.2	230.3
Land (in square kilometers)	3325	651,962.7	1,807,822	2	16,400,000
Rural population (% of total population)	3345	38.472	20.845	0	92.2

Year of observations	3345	1997.12	9.045	1970	2012

Table 1: Descriptive statistics for the variables of analysis.

Figure 1 and 2 display the trends for marijuana herbs and cannabis plants eradicated. The straight line shows criminalized countries and the other one decriminalized countries. Marijuana herbs seized have similar trends for both groups of countries. Both lines show the same in- and decreasing trends throughout the years with slightly more seizures in decriminalized countries. Nevertheless, this does not hold for the number of cannabis plants (figure 2). The two lines show irregular patterns and their trends do not match in a visual inspection. The number of plants eradicated in decriminalized countries seems to rise constantly, while criminalized countries have a rather stable average eradication number.



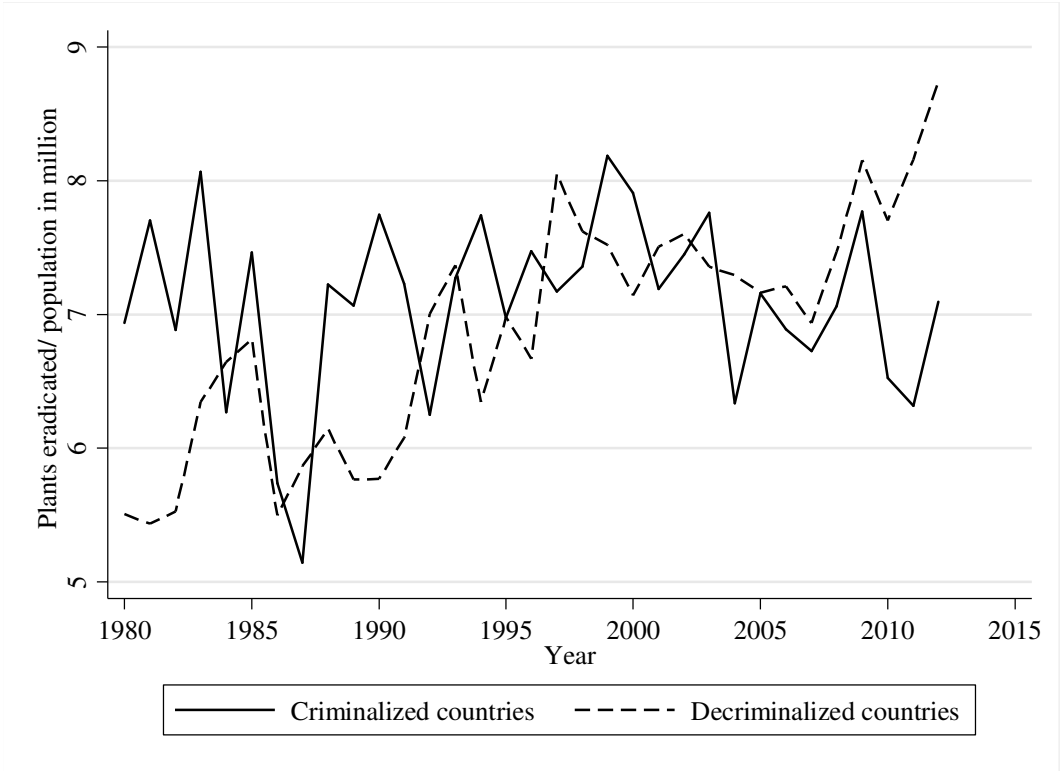


Figure 1 and 2: Trends for marijuana herbs seized and cannabis plants eradicated for criminalized and decriminalized countries.

The model for marijuana herbs includes 2322 observations for 102 countries. The observations per country range from 1 to 33 and average at 22.8 observations. The variance explained can be shown through the between and overall R square. Model 1, 2 and 3 have a between R square of 9.32, 13.14 and 13.68 % and an overall R square of 6.67, 11.30 and 8.90 %, respectively. As the between country variance explained increases, the fit of the model is deemed to improve.

Model 1 is a basic test of the control variables, while interaction terms were included in model 2. There are three significant interactions were between (1) decriminalization and temperature, (2) decriminalization and exports and (3) temperature and exports. When including all of them in the model (2) only the interaction between decriminalization and temperature remains significant. The final model (3) then merely considers the significant interaction.

The effect of the coefficients has to be interpreted with care since between- and within-group effects are considered. As usual, the coefficient will display the mean change the control

vector has on the outcome variable (marijuana herbs/ cannabis plants). However, this only holds for a 1 unit change between countries and across time (Greene, 2008).

In the model (3) for the number of seized marijuana herbs the decriminalization dummy does not have a significant effect. The control vectors that turn out as significant are the kilowatt hours of electricity used, the land area a state possesses and the interaction term between decriminalization and temperature.

	Model 1	**Model 2**	**Model 3**
Decriminalization Dummy	2.067 (0.000)*	-1.736 (0.150)	-0.217 (0.814)
Temperature	0.115 (0.001)*	0.102 (0.086)	0.052 (0.200)
Electricity	0.000 (0.044)*	0.000 (0.083)	0.000 (0.040)*
Exports	0.009 (0.294)	0.016 (0.551)	0.010 (0.233
Land	0.000 (0.017)*	0.000 (0.001)*	0.000 (0.003)*
Rural	-0.017 (0.296)	-0.018 (0.264)	-0.014 (0.394)
Interaction (Decriminalization and Temperature)		0.163 (0.008)*	0.152 (0.017)*
Interaction (Decriminalization and Exports)		0.032 (0.093)	
Interaction (Temperature and Exports)		-0.001 (0.382)	
Constant	0.875 (0.408)	1.729 (0.150)	1.905 (0.058)

Table 2: Models for the seizure of marijuana herbs.

The model for cannabis plants is based on 1061 observations with 77 countries. The number of observations ranges from 1 to 32 and the mean is at 13.8 observations per country. The R

square between countries explains 0.45, 7.63 and 2.87 % of the variance, while the overall R square can account for 0.88, 4.42 and 3.22 %. Again, the model fit increases with the inclusion of interactions.

Parallel to the models above for marijuana herbs in table 2, the first model tests the control variables and the second includes interaction terms. In table 3 the results are displayed and it is salient that model 2 is specified with five interactions, which are significant if tested one by one. Nevertheless, only two of them remain significant and model 3 only considers these significant interaction terms.

In the model (3) for cannabis plant seizures policy plays a significant role. Furthermore, electricity is, again, a significant explanatory variable. Two interaction terms are fitted: one between temperature and electricity and the other one between land area and the percentage of the rural population.

	Model 1	**Model 2**	**Model 3**
Decriminalization Dummy	1.498 (0.028)*	1.499 (0.029)*	1.522 (0.023)*
Temperature	0.090 (0.124)	0.115 (0.119)	0.086 (0.154)
Electricity	0.000 (0.000)*	0.000 (0.000)*	0.000 (0.000)*
Exports	0.017 (0.298)	0.024 (0.152)	0.019 (0.239)
Land	0.000 (0.585)	0.000 (0.084)	0.000 (0.017)
Rural	-0.023 (0.385)	-0.002 (0.941)	0.016 (0.589)
Interaction (Temperature and Electricity)		-0.000 (0.119)	
Interaction (Electricity and Land)		0.000 (0.030)*	0.000 (0.008)*
Interaction (Electricity and		-0.000 (0.401)	

Rural)			
Interaction (Land and Rural)		0.000 (0.000)*	-0.000 (0.000)*
Interaction (Land and Exports)		0.000 (0.984	
Constant	3.678 (0.012)*	3.466 (0.008)*	2.574 (0.058)

Table 3: Models for the eradication of cannabis plants.

5. Discussion

The number of marijuana herbs seized was not significantly different under criminalization or decriminalization policy because the dummy for decriminalization is not significant. Since legislation regarding cannabis cultivation remained unchanged, this is an expected outcome. According to rational choice theory, a high punishment will be followed by deterrence. Nevertheless, the number of plants eradicated increased significantly under decriminalization. As explained in section 2, there is a behavioral impact of a change in legislation. Ideological reasons and an increased feeling of safety under decriminalization could have contributed to this outcome.

Significant predictors in the model for marijuana herbs are electricity, land mass and an interaction (decriminalization and temperature). More energy used as well as more land area possession lead to a higher herb production; however, these positive effects are very limited with a coefficient of 0.000 (0 % change). The categorical variable for decriminalization interacts with the continuous predictor for temperature. Therefore, both independent variables are necessary for the model. And this means that the effect of temperature on the herb production is dependent on the prevailing policy. Given that all other variables are held at 0, a higher temperature leads to more herb production (coefficient 0.052), when a country has a criminalized policy (decriminalization dummy = 0). However, if the country decriminalizes cannabis for personal use, this effect is even bigger due to the addition of the coefficients (0.052 + 0.152*1 = 0.204). The other way around, the effect of decriminalization is affected by temperature. The coefficient (-0.217) shows that decriminalization is connected to less herb production, but only if the temperature is 0. At higher temperatures, more herbs are produced. This can be tested by using the equation -0.217 + 0.152*Temperature.

In the model with cannabis plant seizures, the policy dummy, electricity used and two interaction terms are significant. Decriminalization and more use of electricity lead to more cannabis cultivation; however, the coefficient for energy used is 0.000, which shows a marginal positive impact. Moreover, the two interaction terms also have a limited positive (for the interaction between temperature and electricity) or negative (for the interaction between land mass and rural population) effect. An interaction means a difference in slopes; nevertheless, this change in the coefficient of the decriminalization dummy can be disregarded due to the low interaction coefficients.

An important point of discussion is the herb and plant seizure level. Since cannabis is consumed by 200 million consumers world-wide (United Nations Office on Drugs and Crime, 2013), it seems impossible that law enforcement manages to eradicate the entire cannabis production. Rather the seizure rate is estimated at 11 percent by Bouchard (2008) and at 26 to 31 percent by Wilkins, Bhatta & Casswell (2002). However, this only strengthens the findings since the analysis is conducted with a subset of the cultivators´ population.

The R square of the model for marijuana herbs shows that around 10 percent of the variance can be explained by the model. For cannabis plants, the model can account for about 5 percent which shows that the full explanation for cannabis cultivation is not explored yet. This is a field wide-open for future research into the factors behind growing drugs and engaging into illegal activities. Nevertheless, this econometric analysis has provided some insight into the motivation of cannabis cultivators.

6. Conclusion

The research question was whether cannabis cultivators are affected by the prevailing policy. The results show that the amount of herbs eradicated does not change under decriminalization. The producers in the cannabis market are profit-orientated and cultivate cannabis regardless of the legal regime. There is a deterrence effect for a segment of the potential growers, which is visible from the significant change in cannabis plants after decriminalization. Even though legal factors regarding cultivation are not altered under decriminalization, a behavioral or ideological shift away from deterrence is visible from the data at hand. These cultivators are most likely small-scale offenders.

The title, in line with a famous saying, asks whether two plants are better than one. As apparent from this analysis, the deterrence effect for cannabis cultivation declines under

decriminalization. This holds for the number of plants cultivated and shows that there is a behavioral mechanism to become a small-scale cultivator. Nevertheless, the cannabis market in general remains the same since no statistical significance could be found for the amount of marijuana herbs seized. Therefore, the answer to the question is that it depends on the focus: the marijuana herbs or cannabis plants.

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