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Light cannabis and organized crime: Evidence from (unintended) liberalization in Italy

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ABSTRACT

This paper explores the unintended liberalization of light cannabis that occurred in Italy in December 2016 by means of a legislative gap in order to assess its effect on the illegal supply of marijuana. Although liberalization interested the entire Italian territory, in the short run, the level of intensity varied according to the pre-liberalization market configuration of grow shops, i.e., retailers that sold industrial cannabis-related products. We exploit this variation using a differences-in-differences (DID) design with a unique dataset on monthly confiscations of drugs at the province level during 2016–2018, which is matched with data on the geographical location of shops and socio-demographic variables. We find that the liberalization of light cannabis led to a reduction of up to 14% in marijuana confiscations per each pre-existing grow shop and a significant decrease in both other cannabis-derived drugs and in the number of people arrested for drug-related offences. Back-of-the-envelope calculations suggest that forgone revenue for criminal organizations amount to at least 90–170 million euros per year. These results support the argument that the supply of illegal drugs is displaced by the entry of official and legal retailers.

1. Introduction

According to the most recent European Drug Report (EMCDDA, 2016), "*cannabis accounts for the largest share in value of Europe's illicit drug market,*" and it is the most consumed drug worldwide (UNODC, 2016). The illicit drug market is a long-standing problem in several countries. On the one hand, it constitutes an enormous source of revenue for organized crime; on the other hand, it represents a cost for public authorities, e.g., for law enforcement and public health reasons. To tackle this problem, some countries have recently begun implementing a more liberal approach to cannabis consumption by legalizing and/or decriminalizing its use and commercialization. In the US, recreational marijuana is liberalized in several states (e.g., Colorado and California), and Canada legalized it in October 2018. Other countries have, instead, legalized only its medical use, which requires a doctor's prescription. However, the discussion about legalization has always been accompanied by divisive arguments. On the one hand, promoters of legalization usually argue that doing so would crowd

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out the illicit market, disrupt organized crime, and reallocate police efforts toward other crimes.[1] On the other hand, opponents of legalization contend that eliminating the social stigma associated with marijuana consumption would induce more consumption (Jacobi and Sovinski, 2016) and thus lend itself to negative impacts on social welfare.

Several studies have looked at the effects of legalization by studying its impact on crime (Adda et al., 2014; Shephard and Blackely, 2016; Brinkman and Mok-Lamme, 2017; Chang and Jacobson, 2017; Gavrilova et al., 2019; Hansen et al., 2017; Chu and Townsend, 2018; Dragone et al., 2019), health-related issues (DiNardo and Lemieux 2001; Wen et al., 2015; Sabia et al., 2017), consumption (Jacobi and Sovinsky, 2016), and the presence of spillover effects, such as school attendance and academic achievement (Plunk et al., 2016; Marie and Zolitz, 2017), housing prices (Cheng et al., 2018), traffic fatalities (Anderson et al., 2013; Hansen et al., 2018), and in-migration (Zambiasi and Stillman, 2018).

The study of the impact of legalization on violent and non-violent crimes in the US has attracted most of the attention of economics literature. From a theoretical standpoint, the introduction of legal marijuana retailers can have several effects on the market. Besides a potential market expansion of marijuana users, it makes the market more competitive and more transparent and solves the problem of moral hazard associated with the purity of drugs (see, e.g., Galenianos and Gavazza, 2017). Legal retailers can offer a controlled substitute product, potentially displacing the demand and hence the equilibrium supply in the illegal market, whereas organized crime often operates in the regime of a monopoly. This prediction seems to be indirectly supported by empirical evidence. For instance, Hansen et al. (2017) used a regression discontinuity design (RDD) to study how the legalization of marijuana impacts "drug tourism." They explored two different instances of legalization, in Washington and in Oregon, which showed that when Oregon legalized recreational marijuana, the quantity of marijuana sold in Washington fell by 41%. Hence, many of Oregon's consumers were travelling to Washington to purchase legal marijuana, and interstate spillovers partly displaced the equilibrium supply in Oregon's illegal market. Using similar data, Dragone et al. (2019) found that the legalization of recreational marijuana in Washington resulted in a reduction in thefts and rapes relative to Oregon and the pre-legalization period. More controversial results have been found concerning the legalization of medical marijuana. Chu and Townsend (2018) showed that violent and property crimes significantly decreased only in California but not at the national level. Also in California, a similar pattern was supported by Chang and Jacobson (2017), who showed that closing marijuana dispensaries generated an increase in crime in the proximity. More generally, Gavrilova et al. (2019) studied the impact of medical marijuana laws on drug trafficking organizations in the US. They found that the supply shock offered by the introduction of medical marijuana in the US resulted in a reduction in profits and thus the incentive to settle disputes using violence.

Although these studies advance our knowledge of the impact of liberalization on crime, the interplay between the illegal and legal markets has not yet undergone a throughout examination. In particular, due to the scarcity of relevant data, the displacement effect of liberalization on the supply of illegal drugs remains substantially unexplored. This paper aims to fill this gap by examining the effect of liberalization on the confiscations of drugs sold in the illegal market and other crime-related outcomes through a quasi-experiment that focuses on Italy. In December 2016, a legislative gap created the opportunity to legally sell cannabis with low levels of tetrahydrocannabinol (THC), a psychoactive chemical. As a result, some start-ups (e.g., *Easyjoint, Marymoonlight*) entered the market and began selling *light cannabis* (C-light). Traditional and online media gave wide coverage of the phenomenon and the rapid growth of the market. This (unintended) marijuana liberalization represents an exceptional opportunity to test changes in the (equilibrium) supply of street marijuana in a market where illegal and legal retailers coexist. Italy is an interesting case study to test this effect due to the presence of strong criminal organizations that entirely control the market of illegal substances, often in partnership with international criminal organizations. Moreover, the market of cannabis-derived drugs represents roughly 91.4% of the illegal drugs confiscated in Italy (Dipartimento Politiche Antidroga, 2017) and a significant source of revenue for these organizations.

While liberalization occurred simultaneously in the entire territory, in the short run, the level of intensity was not homogeneous. Specifically, from May 2017 onwards, the cannabis flowering process was completed. Some shops already specialized in the retail of industrial cannabis (i.e., grow shops) began selling C-light on a franchising base, exploiting large economies of scope, namely the possibility to sell, by means of liberalization, both cannabis-related products and flowers. These shops are located in the proximity of cannabis cultivations, which are concentrated in areas close to waterways and humid soil (see Section 3.1 and Fig. 1). In the following months, i.e., after 1 year of post-liberalization, para-pharmacy, herbalists, and tobacco shops followed suit, exposing the Italian territory to more homogenous market coverage. However, during the first year after liberalization, the pre-existing stock of grow shops at the local level largely determined the local availability of C-light. In some places, the existence of grow shops resulted in a high supply of C-light, while in other places, their absence (or the presence of very few grow shops) resulted in a low or zero supply of C-light. Consequently, after liberalization, areas with high numbers of grow shops were more affected by the policy change than areas with low numbers of grow shops.

We exploit this variation in order to identify the effect of liberalization using a differences-in-differences (DID) framework. To accomplish this, we use a unique dataset running from 2016 to February 2018 that was built using several sources of data. Data including the quantity of illicit substances confiscated in the Italian territory, as well as the number of people

[1] In 2016, the National Anti-mafia and Anti-terrorism Directorate (DNA), expressed a positive opinion on the legalization of marijuana. Apart from the possibility of disrupting revenues of organized crime, which is historically rooted in Italy, the DNA claimed that it would reduce the disproportion between the monetary and non-monetary costs of law enforcement and the small results obtained in terms of convicted criminals and drugs confiscated.

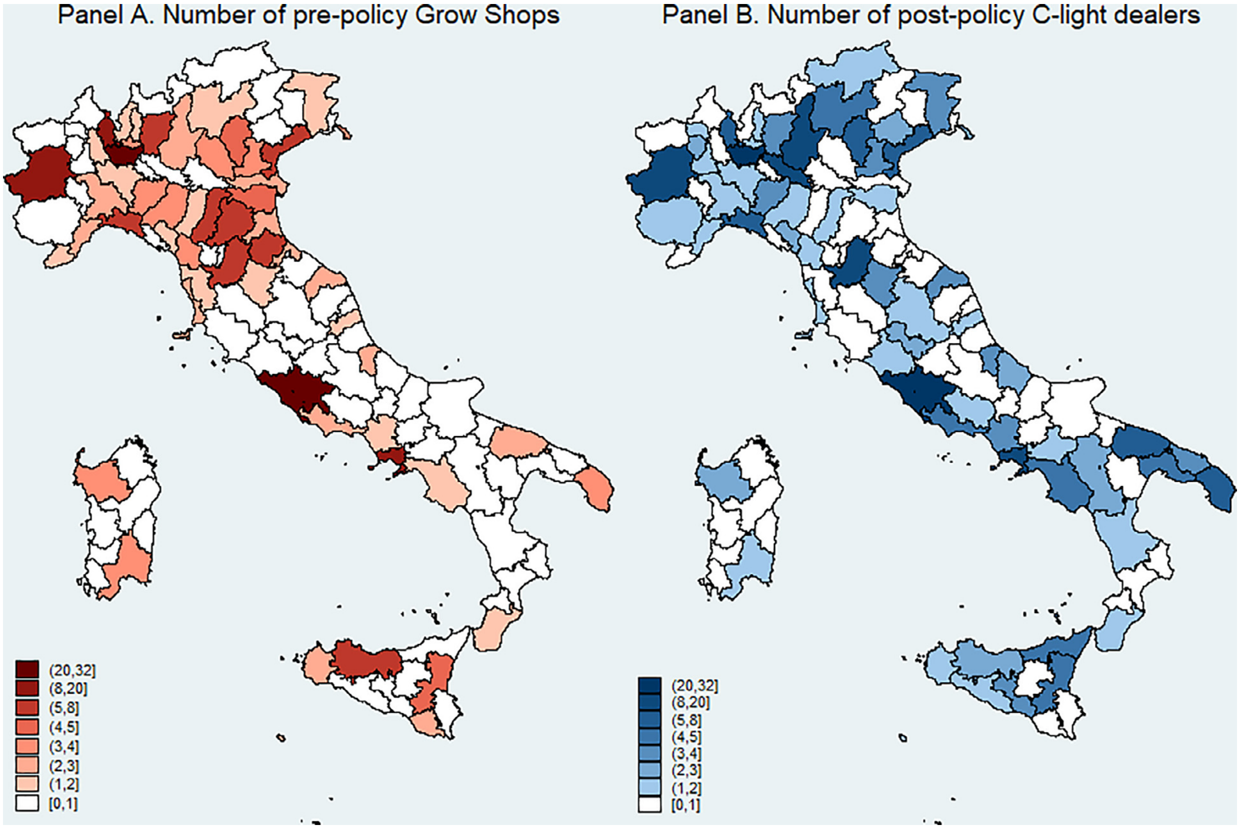

Fig. 1. Distribution of pre-policy grow shops and post-policy C-light dealers.
Panel (A) shows the number of grow shops selling cannabis-related products before the introduction of the policy. The number of grow shops refer to October 2016 and the data have been retrieved using the Internet Archive Wayback Machine on the website http://www.growshopmaps.com/. Panel (B) shows the number of post-policy dealers in February 2018. Data have been collected using the Internet Archive Wayback Machine on the websites of the four major retailers.

arrested for drug-related offences, are made available by the National Police at the province level (NUTS-3), i.e., the administrative division of the intermediate level between a municipality and a region. These data were then matched with provincial data on the number of grow shops that were active in Italy in 2016, which were collected from official retailers' websites. Finally, we linked these data to provincial demographic variables provided by the National Institute of Statistics (ISTAT). An appealing and rare feature of this unique dataset is the availability of monthly data on confiscations and drug-related offences. This feature, coupled with the unexpected nature of liberalization, allows us to estimate the effect of interest within a very short window of time around the policy, when law enforcement and police effort adjustments were extremely unlikely. In order to rule out any endogenous adjustment, however, we also control for the provincial monthly number of police operations and find no effect of the policy on police law enforcement in one of the model specifications. This allows us to interpret any change in the number of drugs confiscated as changes in the equilibrium supply of illegal marijuana.

Under the hypothesis of a common trend in confiscations across provinces with a different number of grow shops that existed pre-liberalization—which is largely supported in our case (see Section 6)—our DID strategy allows us to retrieve the causal effect of liberalization on the quantity of illegal drugs confiscated and other crime-related outcomes. This effect is likely to represent a *lower bound* of the displaced supply of illegal drugs because confiscated drugs obviously represent only a share of the total illegal market.

We find that the liberalization of C-light led to a reduction in the confiscation of illegal marijuana. Our estimates indicate a decrease of up to 14% in monthly confiscations per each pre-existing grow shop as a consequence of the unintended policy change. This corresponds to a decrease in elasticity of 3% in confiscations in response to a 10% increase in the number of grow shops per province. Interestingly, we find that liberalization also impacted the illegal supply of other cannabis-derived drugs. It led to an 8% reduction in the supply of hashish and a 32% decrease in the number of plants confiscated monthly per each grow shop. Moreover, while we do not detect any law enforcement adjustment from police authorities, we find a negative impact of the unintended liberalization on the total number of people (i.e., −3%), foreigners (−3%), and minors (−15%) arrested for drug-related crimes. This result is remarkable as these categories are often used by criminal organizations as street drug dealers, and it provides strong support for our findings: even a mild form of liberalization, such as the one that occurred in Italy and used an imperfect substitute product of street marijuana, can harm organized crime. These results are robust in a number of robustness checks, placebo regressions, and alternative approaches to statistical inference. Back-of-the-envelope calculations on the 106 provinces considered suggest that forgone revenues for criminal organizations amount to around 90–170 million euros per year.

The rest of this paper is structured as follows: in Section 2, we discuss the (unintended) policy change. In Section 3, a description of the dataset and main variables is provided. Identification strategy is presented in Section 4. In Section 5, we present the main results. Section 6 provides some sensitivity analyses and robustness checks, while Section 7 summarizes and concludes the paper.

2. Institutional setting

In December 2016, the Italian government approved a law devoted to regulating and incentivizing the production and commercialization of industrial cannabis (also called hemp). Hemp has a variety of commercial uses, ranging from food (e.g., cannabis flour for pizza) to clothing, from therapy to construction, as well as biofuel. Italy has a long tradition of the cultivation of hemp. In early 1900 and prior to World War II, it was the second largest producer in the world, just behind Russia. This is essentially explained by the presence of several waterways, which were essential for both the production of vapor energy and yarn processing. Most of the production served the navy, army, railway, hospital, and tobacco industries. Today, this heritage is reflected by the higher presence of cannabis cultivations and cannabis-related shops in areas of the country closest to waterways and with humid soils (see Section 3.1 and Fig. 1 for more details).

Industrial cannabis contains a low level of THC, the main psychoactive constituent of marijuana. While incentivizing the cultivation of cannabis, the 2016 law did not regulate the production of flowers. As a result of this legislative gap, after a few months, in May 2017, some start-ups saw a profitable opportunity and began selling cannabis flowers with a low level of THC and a naturally high level of cannabidiol (CBD). In theory, the flowers could not be consumed or smoked. According to the labels applied to the pot, C-light could only be used for technical purposes, e.g. as collectors' items. Moreover, the way they are commercialized, e.g., in sealed packages that should not be opened in the streets, differs visibly from the illegal street cannabis. Paradoxically, given its "technical use," minors of 18 years old could buy C-light but not tobacco.

As a matter of fact, (unintended) liberalization of C-light took place in May 2017, when the fluorescence process was completed, and the flowers were actually commercialized. Indeed, shops selling cannabis-related products for industrial use (i.e., grow shops) began putting the flowers on the market. This relies on the possibility of exploiting large economies of scope, namely the possibility of selling both cannabis-related products and its flowers.[2] As a consequence, in May 2017, the local availability of C-light was essentially determined by the presence of these shops. As explained above, the geographical concentration of grow shops is largely historically rooted in relation to the existence of cannabis cultivations, which tend to be concentrated in areas with humid soil and close to large waterways. The pre-liberalization market configuration of grow shops, indeed, represents a useful source of exogenous variation in the local availability of C-light.

Our strategy allows us to retrieve the causal effect of the policy in the short run (i.e., up to 1 year after liberalization). Indeed, in the long run, the selling of C-light was not only circumscribed to grow shops. C-light became so popular that herbalist and tobacco shops, along with para-pharmacists, also began selling it, covering most of the Italian provinces with different intensities and timelines. In February 2018, 87 out of 106 provinces covered in our study were served by at least one in-store retailer.

Italy is an interesting case study for the analysis of the displacement effect of C-light liberalization on the illegal drug market. Indeed, Italy has historically been pervaded by the presence of organized crime, with four main criminal organizations born in the southern regions (Camorra in Campania, Sacra Corona Unita in Apulia, 'Ndrangheta in Calabria, and Stidda and Mafia in Sicily) but operating in the entire Italian territory. Drug trafficking is the most significant activity pursued by these organizations and is often jointly run with other international criminal organizations. Illegal revenue from the consumption of drugs accounts for 14.2 billion euros in Italy alone. The market of cannabis-derived drugs represents roughly 91.4% of the entire market of illegal drugs and it is estimated in around 3.5 billions of euro.

3. Data

Our empirical analysis is based on a unique dataset recording longitudinal information on all 106 Italian provinces. We built the dataset by merging information from several sources. Monthly data on the drugs seized in each province by police forces were made available by the *Direzione Centrale per i Servizi Antidroga* (Central Direction for Anti-drugs Services), which plays a role in coordination of the Italian police forces with respect to anti-drug operations. Our dataset contains information about kilograms of marijuana, hashish, and the number of cannabis plants seized monthly in each Italian province. For all provinces, we collected information about the monthly number of anti-drug operations conducted by police forces and the number of people arrested for drugs-related crimes, including most sensitive sub-categories, such as foreigners and minors.

[2] As most of the early producers were already in the grow shops network, a local grow shop was chosen as the first point for the commercialization of C-light.

Table 1
Descriptive statistics.

Variable	Description	Mean	Std. dev.
Marijuana	Monthly amount of marijuana confiscated per province (in kilos)	32.89	244.00
Hashish	Monthly amount of hashish confiscated per province (in kilos)	12.71	65.17
Plants	Monthly number of plants of cannabis confiscated per province	102.64	864.49
Grow Shops	Number of grow shops pre-policy per province (October 2016)	2.76	4.24
C-light Shops	Monthly number of retailers per province selling C-light post-policy	0.71	2.14
Operations	Monthly number of police anti-drug operations per province	16.20	28.26
Arrests	Monthly number of arrested people per province	16.00	31.93
Foreigners	Monthly number of foreigners arrested per province	8.31	17.29
Minors	Monthly number of minors ($<$18 years old) arrested per province	0.86	1.66
Territorial controls			
Density	Population density of the province	272.96	380.71
Population	Number of inhabitants per province	571,929.90	616,651.80
Square km	Land area covered by the province	2849.74	1739.51
Nr. observations	106 provinces $\times$ 26 months	2756	

Moreover, we collected data about the pre-policy (October 2016) territorial diffusion of grow shops. These are retailers of cannabis-related products that are used as treatment intensity variables in our empirical analysis. These data were collected using web scraping techniques, along with data on the official dealers of C-light after liberalization.[3] This information will not be used in our empirical strategy as this might be due to an endogenous entry of these shops on the market. However, we will use these data for a descriptive analysis in Section 3.1. Data were aggregated at a provincial basis. This led to a balanced panel dataset composed of roughly 2700 observations, from January 2016 to February 2018.

Concerning demographic characteristics, we use data from the Italian National Institute of Statistics (ISTAT) on population size, density, the territorial extensions of the provinces, and the presence of freight ports.

3.1. Descriptive statistics

The full list of variables included in our dataset is presented in Table 1, along with mean values and standard deviations. Concerning our outcomes of interest, monthly confiscations by Italian police forces at the province level amounted to an average of 33 kg of marijuana, 12 kg of hashish, and 103 plants of cannabis.

Compared to the entire illegal drug market and traffic, cannabis-derived substances (i.e., both herbal and resin) account for more than 90% of the total amount of confiscated drugs, according to our data.

However, large heterogeneity exists among provinces with respect to monthly confiscations. This ranges from no confiscations, to confiscations of a few grams, to maxi-confiscations (tons). The mean values mask a number of important features of our data regarding drug confiscations. First, as shown in the non-parametric distribution reported in Table 2, the distribution is highly right skewed. Second, we observe several zeros in the confiscation variables that must be taken into account in the empirical strategy.

Concerning grow shops, we observe an average of 2.7 shops per province in the period before the policy. Additionally, in this case, the mean value masks a high spatial heterogeneity. Fig. 1 shows the spatial distribution of both grow shops (left) in the pre-policy period (October 2016) and C-light shops (right) in February 2018 over the Italian territory. Each province is colored according to number of the shops existing in the territory.

Panel (A) of Fig. 1 shows that grow shops were located mostly in provinces on the seaside, in the Po valley (Pianura Padana), and in Veneto. These locations are all close to waterways and are characterized by the presence of very humid soil, which make the cultivation of cannabis, and thus its commercialization, more favorable. For instance, the same soil characteristics also make favorable the cultivation of rice, which is indeed located mostly in the same parts of the country. As discussed in Section 1, grow shops were the first to put flowers on the market by exploiting large economies of scope provided by the possibility of selling both cannabis and its flowers. As a matter of fact, these shops faced very small marginal costs when adding the new product to their catalogue.

Panel (B) of Fig. 1 shows that spatial heterogeneity reduced substantially in February 2018, i.e., 10 months after liberalization. A comparison between Panels (A) and (B) reveals two interesting features. First, C-light retailers are more concentrated in areas characterized by a higher pre-policy concentration of grow shops. This is not surprising because grow shops were the first C-light retailers after liberalization. Second, it shows that liberalization caused a massive entry in the market, especially in provinces not previously covered by grow shops. This phenomenon essentially interested herbalists and tobacco

[3] Data on the post-liberalization market came from the websites of the main producers (i.e., Easyjoint, Marymoonlight, RealHemp, XXXJoint), and we accessed archived copies of their early pages using the Internet Archive Wayback Machine https://archive.org/web/. This is a website that memorizes, at different points in time, the content of a given webpage. Data were collected on a monthly basis after the policy and using the last accessible page for each month. The data on the pre-policy number of grow shops comes from http://www.growshopmaps.com/, which maps the grow shops available in the Italian territory. The last archived copy of the map before the policy is October 2016. Data were also collected for March 2016 to control for the number of grow shops per province before the (fake) policy used in the placebo analysis.

Table 2
Distribution of marijuana confiscations: summary statistics and percentiles.

Mean	32.89
Standard deviation	244.00
Skewness	18.37
Kurtosis	500.31
Minimum	0
P10	0
P25	.02
P50	.35
P75	3.23
P90	25.65
P95	70.00
P99	878.78
Maximum	8193.02

Summary statistics and relevant percentiles of the monthly confiscation of marijuana. All values expressed in kg.

shops. The geographical distribution of the grow shops and of C-light retailers reinforces the idea that although the policy was national, its treatment effect was rather heterogeneous in the short run as the pre-policy market coverage of grow shops was not spread uniformly over the Italian territory. However, it became more homogenous in the long run, i.e., in February 2018. This pattern is one of the main rationales for our decision to focus on the short-run effect of liberalization (see Section 4 for more details).

Finally, Table 1 offers some additional insights regarding other crime measures included in our dataset. It is important to highlight the fact that the monthly average of provincial anti-drug operations is approximately 16. This represents a massive effort in terms of both human resources and budget for Italian law enforcement agencies. On average, 16 people per province were arrested on a monthly basis, with foreigners accounting for almost more than 50% of total arrests. Interestingly, we observe a monthly average of one minor arrested per province.

4. Identification strategy

To identify the effect of unintended liberalization of C-light on the illegal drug supply, we exploit the local availability of the product in order to set up a DID study design. Although the legislative gap was national, the treatment effect was rather heterogeneous over the Italian territories in the short run due to the differentiated extent of the physical availability of the product.

Following the early approach by Card (1992), we employ a DID with continuous treatment, which uses the number of grow shops already in existence in each province before liberalization as the intensity treatment variable. As explained in Section 2, these shops were the first to sell C-light as a result of the opportunity of exploiting large economies of scope given by the possibility of selling both cannabis-related products and its flowers. The distribution of these shops across provinces is driven by province-specific geographical and morphological factors, which make the cultivation and commercialization of cannabis for industrial use more favorable in some areas, as discussed in Section 3. Importantly, this is likely to be essentially unrelated to local demand for illegal drugs, which might, instead, determine an endogenous entry of shops to sell C-light.

The possibility of endogenous entry is essentially ruled out in our study for two main reasons. First, due to the particular nature of the liberalization process, liberalization was unintended, being a consequence of a legislative gap, and was thus unannounced. This ruled out any possibility of an anticipation effect. Second, our monthly data allow us to compare variations in very small windows after the time during which the policy took place (less than a year).

Focusing on a short time period after liberalization is also useful in ruling out long-term trends in cannabis confiscation, which (if negative) might lead to upward biased estimates. This may be caused both by contractions in demand and changes in the efficiency of law enforcement agencies toward the drug war. The latter is often a sensitive point in the empirical analysis on drug confiscations. However, this is unlikely to represent a threat to our identification strategy for a number of reasons. First, due to the unexpected nature of liberalization, making adjustments in police efforts was very unlikely, especially in the very short time windows that we consider (i.e., 10 months after the policy). Second, in the period to which our analysis refers, we did not find evidence of any new public hiring of police and/or measure to displace police forces in specific geographical areas of the country, e.g., the only public displacement of police forces occurred in August 2017 in Foggia (Apulia) to repress the so-called Mafia Garganica. When excluding this province from our analysis, our results are unaffected. In addition, the last round of police hiring was launched in May 2017, and the ranking of admitted people was released only in May 2018. Presumably, these (new) policemen will be hired through 2018. More importantly, any change in law enforcement should be systematically different across provinces experiencing different intensities of liberalization to

Table 3
Differences-in-differences regression.

	(1) marijuana	(2)	(3) Δ marijuana	(4) marijuana	(5) Δ marijuana
DID	−0.115***	−0.116***	−0.140***	−0.327***	−0.106*
	0.033	*0.029*	*0.042*	*0.123*	*0.059*
Post	0.217	0.218	0.243	0.104	−0.472
	0.238	*0.236*	*0.248*	*0.240*	*0.482*
Police operations	0.069***	0.069***		0.064***	
	0.019	*0.019*		*0.018*	
Δ police operations			0.099***		0.109***
			0.022		*0.027*
Other controls	Yes	No	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	No	Yes	No
Province × time	No	No	No	No	Yes
N	2756	2756	1484	2756	1484

Log transformation for all outcomes. (1) with (2) without controls. (3) Seasonally differenced data (4) Log-Log specification (grow shops in log). (5) Seasonally differenced data and province-specific trend included. S.E. clustered at province-level *in italics*. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

represent a threat to our strategy. This appears even more unlikely in our context for the reasons discussed above (the unexpected nature of liberalization and the short time window) but also because law enforcement is administered at national level in Italy, i.e., local police have little responsibility for the concerns of anti-drug operations. In any case, to rule out any residual concern on this point, we also include the monthly number of anti-drug operations conducted in each province as a measure of police effort in our estimates, and we further narrow the time windows and control for province-specific trends in the DID model. Finally, we test whether the policy change had any effect on police efforts, showing that no law enforcement adjustment occurred. These checks are reported in detail in Section 5 of the paper.

Importantly, while the basic DID compares two groups (treatment and control) over pre- and post-policy periods, in our framework, the treatment variable is continuous, and every observational unit is identified by the intensity of the exposure to the policy. A similar strategy has been used by other empirical papers, i.e., Gaynor et al. (2013), to test the impact of hospital competition on healthcare quality. In this framework, the impact of the policy change is identified by the interaction between the pre-existing number of grow shops and the dummy that identifies the post-policy period.

Thus, our model takes the following form:

$$Y_{it} = \beta_1 Post + \beta_2 Post \times Shops_{i,2016} + \beta_3 X_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

where Y_{it} is the quantity of drug (i.e., marijuana, hashish, plants of cannabis) confiscated at the time t (month–year period) in the province i, *Post* is the indicator of the post-liberalization period and takes the value of 1 from May 2017 onwards and 0 otherwise, while Shops is our treatment intensity variable, namely the number of grow shops pre-policy (October 2016). X_{it} is a vector of time-variant covariates that includes the number of anti-drug police operations and time-variant province-specific characteristics (i.e., total population and population density), μ_i is unobserved province fixed effects (which includes the pre-policy configuration of grow shops), and ε is the error term. To deal with the high presence of zeros in the outcome variable, as shown in Section 3.1, we use a log transformation of the dependent variable.[4] This allows us to have a more straightforward interpretation of the impact of liberalization, i.e., on the share of illegal marijuana displaced.

The main coefficient of interest in Eq. (1) is β_2, which measures the change in the illegal market supply post-liberalization per each pre-policy grow shop. As known, this identification strategy relies on the common trend assumption, which requires that in the absence of (unintended) liberalization, provinces would have experience parallel trends in confiscation independently from the presence of grow shops. In Section 6, we test this key assumption in different ways encompassing both graphical regression techniques and alternative approaches to statistical inference. All of these checks provide strong support for the common trend assumption in our setting.

5. Results

Table 3 reports our results from the DID regression, as in Eq. (1), according to several specifications. For all specifications, we report estimates that include standard errors clustered at the province level that are robust to correlated province-level shocks in drug confiscations. The number of clusters (106 provinces) should rule out concerns about the validity of inference

[4] We use zero-skewness log transformation in the spirit of the Box and Cox (1964) transformation. This actually adds a value k to the zeros before operating the log transformation so that the skewness of the dependent variable is reduced to zero.

Table 4
Differences in differences regression – other measures of crime.

	(1) Operations	(2) Plants	(3) Hashish	(4) Arrests	(5) Foreigners	(6) Minors
DID	−0.001	−0.320***	−0.077**	−0.030***	−0.026**	−0.148*
	0.005	*0.082*	*0.034*	*0.010*	*0.011*	*0.085*
Post	0.038	2.056***	0.856***	0.057	0.024	−0.306
	0.053	*0.770*	*0.273*	*0.058*	*0.062*	*0.678*
Police operations		0.149***	0.050***	0.029***	0.028***	0.114***
		0.052	*0.019*	*0.009*	*0.008*	*0.043*
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2756	2756	2756	2756	2756	2756

Log transformation for all outcomes. S.E. clustered at the province-level *in italics.* ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

in our estimates. However, in Section 6, we demonstrate that our results are robust also for different approaches to statistical inference (i.e., randomization tests based on simulated liberalizations).[5]

We find a negative and statistically significant DID coefficient in all specifications: this supports the thesis that the liberalization of C-light displaced the market of illegal marijuana. In Columns (1) and (2), we report the results of operating a log-transformation of the dependent variable. According to this specification, we find that the liberalization of C-light resulted in a reduction of 11.5% in confiscations of illegal marijuana for each pre-policy grow shop. In other words, while the policy impacted all Italian provinces, those provinces served by grow shops before the policy experienced a more intense reduction in the amount of seized marijuana. This occurred mainly in provinces where grow shops were located: the greater the number of grow shops in the market, the greater the displacement effect. A startling result is that such a displacement arises also with an imperfect substitute of street marijuana with a low level of THC. Moreover, such a displacement occurs despite a general but not statistically significant increasing trend for the amount of confiscated marijuana, as indicated by the *Post* coefficient. Finally, the number of police operations positively impact the amount of the illicit substance seized: one more operation leads, on average, to an increase of 7% in marijuana confiscated per pre-policy grow shop.

As seasonality is a concern related to crime as well as marijuana consumption, we follow Draca et al. (2011) to seasonally difference the data and then wash out any province-specific seasonality. Results are reported in Column (3) and show that our effect of interest still holds and is also reinforced in its magnitude (−0.14). Moreover, in order to have a more intuitive interpretation of the policy impact, we also present a specification including the log of grow shops. This allows us to estimate the elasticity of the policy effect. According to this specification reported in Column (4), we find that a 10% increase in the number of grow shops led to a 3.3% decrease in monthly marijuana confiscations.

Finally, to account for an eventual dynamic of law enforcement at different territorial levels, we run the DID model that includes province-specific time trends. As shown in Column (5), our results are consistent with the baseline estimates: a negative DID effect of −10.6% is found. This result provides further evidence in support of the parallel trend assumption and allays any concerns regarding province-specific police effort adjustment after the policy.

5.1. Other measures of crime

In Table 4, we report estimates of the DID model on other crime-related outcomes. This helps to shed further light on the effect of the policy change. In Column (1), we report estimates on the total number of anti-drug police operations, which represents a proxy for the police effort. We do not find any significant impact on the number of operations. This result indicates no significant adjustment in police efforts in reply to the liberalization and supports our arguments on the unexpected nature of liberalization. In Columns (2) and (3), we investigate the effect on two other cannabis-derived drugs. In Column (2), we focus on the plants of cannabis. Our results indicate that for any pre-existing grow shop, C-light liberalization caused a reduction of 32% in the cannabis plants confiscated. In Column (3), we focus on hashish. This is the resin of the cannabis plants and is a processed product that is usually stronger and more concentrated than marijuana. Our results suggest that the liberalization of C-light led to a reduction of approximately 8% in hashish confiscated by police forces. All in all, these findings indicate that liberalization generated a spillover on the entire cannabis drug market.

In the last three columns of Table 4, we show the effect of the policy change on arrests for drug-related crimes. Column (4) shows a 3% reduction in the total number of arrests. Among these, we document a significant decline in the number of arrests of foreigners (−3% as reported in Column (5)) and of underage individuals (−15% but significant only at 10% as

[5] We find qualitatively similar results when considering non-linear models, such as the Tobit and Poisson (results are available upon request to the authors). However, their interpretation is problematic in a DID setting (see, e.g., Puhani, 2012; Blundell and Dias, 2009).

Table 5
Differences in differences regression – robustness.

	(1) without ports	(2) with ports	(3) < Mean	(4) > Mean	(5) >May16	(6) +\- 6 months
DiD	−0.093**	−0.096**	−0.096*	−0.065**	−0.115***	−0.094***
	0.038	*0.039*	*0.054*	*0.032*	*0.031*	*0.033*
Post	0.093	0.445	0.150	0.230	1.121***	0.950**
	0.279	*0.423*	*0.266*	*0.683*	*0.170*	*0.373*
Operations	0.106**	0.042***	0.126***	0.032***	0.066***	0.057***
	0.041	*0.012*	*0.016*	*0.009*	*0.018*	*0.016*
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Ports	No	Yes	–	–	–	–
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	2080	676	2288	468	2332	1272

Log transformation for all outcomes. Subsample analyses with provinces: (1) with (2) without ports (3) below (4) above the mean of confiscations in 2016 (i.e., approximately 11 kg). Time windows: (5) May 2016—Feb 2018 (6) Nov 2016–Nov 2017. S.E. clustered at the province-level in italics., bootstrapped S.E. clustered at the province-level for model specifications (3) and (4), 1000 replications. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

reported in Column (6)). Overall, these results suggest that liberalization had a negative and significant effect on organized crime, especially among categories more often used by criminal organizations as drug dealers in the streets.

6. Robustness checks

In this section, we deal with a number of robustness checks. First, we check whether our results are robust in the presence of maxi-confiscation activities. As marijuana mostly arrives via the maritime route (e.g., the Balkan route), the presence of freight ports in some provinces may artificially increase the quantity of drugs confiscated in these provinces. We thus conduct a robustness check that controls for the presence of large freight ports at the province level. Table 5 (Columns (1) and (2)) presents the main results with and without freight ports. We show that the estimates of the DID approach are identical, regardless of the subsample considered. The marginal effect of pre-existing grow shops on marijuana confiscated is approximately 9–10%, thus very close to the one shown in Section 5.

Second, given the skewness of our dependent variable, we perform a subsample analysis of provinces falling below and above the mean of pre-policy confiscations (average annual confiscations in 2016). Results are reported in Table 5 (Columns (3) and (4)) and show a 10% reduction among provinces below the mean and a reduction of approximately 6–7% in confiscations among provinces above the mean. These results are qualitatively similar to the ones obtained by considering provinces with and without ports, and they show a rather homogeneous treatment effect.[6]

Third, we perform additional robustness checks for concerns regarding the time window analyzed in our quasi-experiment. We first reduce the time before the policy to make the pre- and post-policy periods more symmetric. Hence, we consider the period between May 2016 and February 2018. In this case, the estimated DID coefficient is −0.11 and hence is consistent with the main results. Then, we study a symmetric period around the policy (May 2017) by considering six months before and after the unintended implementation of the policy. In this case, the DID coefficient is −0.09 yet is qualitatively similar to the main results. It is important to note here that this result is relevant to further allay concerns about law enforcement adjustments. By further narrowing the time window and focusing on the short run after the policy, the probability of any systematic law enforcement adjustment across periods became even more unlikely.

As an additional set of robustness checks, we deal with the validity of the common trend assumption in our setting. One usual concern when using a DID model specification is that the results can be driven by pre-policy trends and by the presence of confounding factors. While the presence of confounding factors is rather limited in our case because the liberalization of C-light was unintended, and the industry was not regulated in the past, we conduct several tests to ensure that the common trend hypothesis was satisfied. First, we make a graphical inspection of the common trend assumption. The graphical analysis of the common trend assumption in the basic DID framework requires both groups to follow a parallel path. In Fig. 2, we present trends in marijuana confiscations according to terciles of pre-policy grow shops at the province level. This allows us to verify the robustness of the assumption for different levels of the treatment variable. Interestingly, the different lines follow a very parallel pre-policy path that leads us to be confident about the credibility of the common trend hypothesis. A small difference in confiscations across terciles is observed in the months of November and December. This is not surprising as confiscation rates exhibit a reduction in these months due to a reductions of police operations (e.g.,

[6] It is important to notice that when doing subsample analyses, the number of clusters available is reduced (i.e., to around 20 for “above” the mean of confiscation estimates) and approximates to a level that might be problematic for statistical inference (Cameron and Miller, 2015, for instance, suggest a “safe” threshold of 50 clusters in state-year panel data). For this reason, in Table 5, we use bootstrapped clustered standard errors for these estimates and, more generally, we suggest a more cautious interpretation of these results.

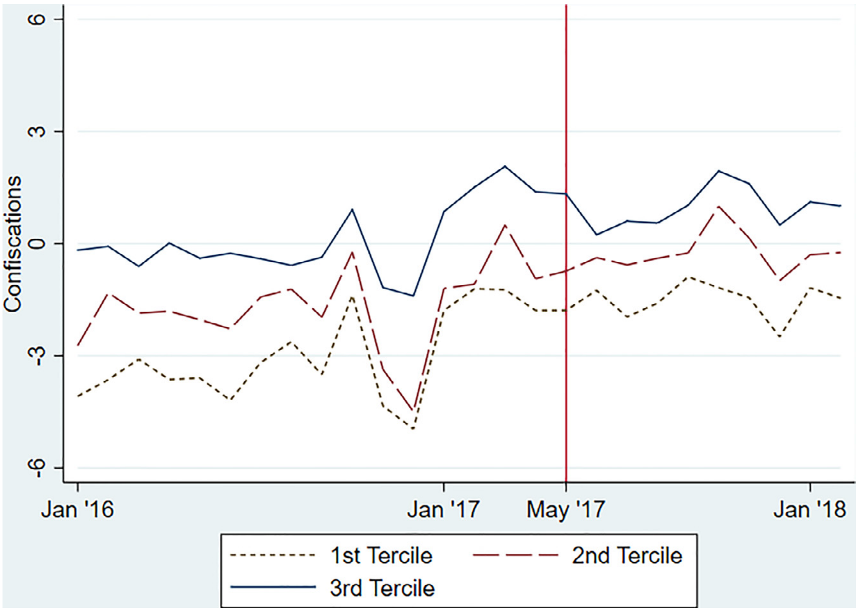

Fig. 2. Common trend – monthly confiscation of marijuana per terciles of pre-policy grow shops
Normalized illegal marijuana confiscation rates within terciles of the treatment intensity variable.

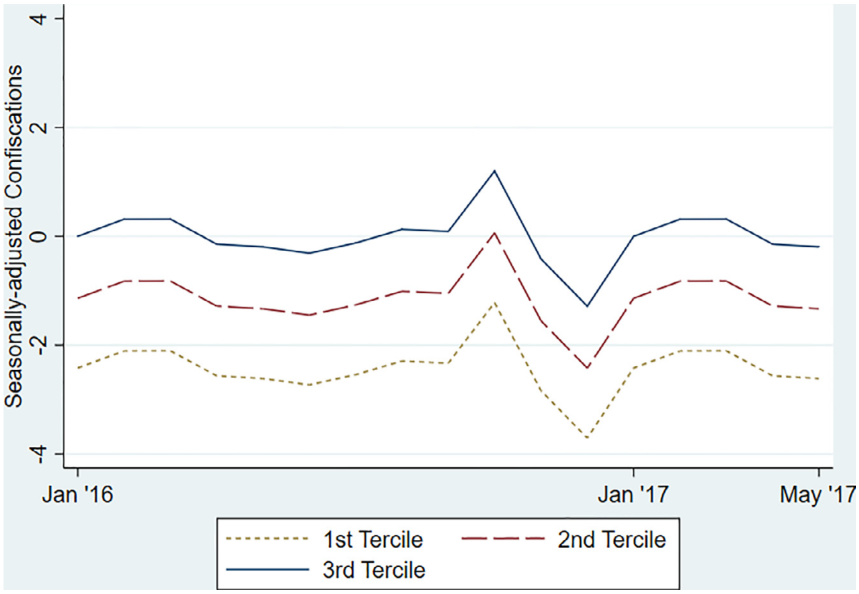

Fig. 3. Common trend – seasonally adjusted pre-liberalization trend.
Seasonally-adjusted pre-liberalization illegal marijuana confiscation rates. Normalized within terciles of the treatment intensity variable.

because of Christmas holidays). Indeed, the average number of police operations per province is around 12 in December vs around 16 in the other months. When accounting for seasonality, the common trend in the pre-policy period becomes even more evident, as shown by Fig. 3.

However, in our framework, the presence of a continuous treatment variable makes the graphical solution less straightforward. Thus, we complement our graphical analysis with a placebo regression. We essentially test the effect of a fake policy for May 2016, and we control for its effect up to the period covered by the real policy. In other words, we shorten our sample period and consider only the period running from January 2016 to April 2017 by anticipating the policy from May 2017 to May 2016. Indeed, due to the sample cut, the total number of observations considered is reduced to 1676. As the number of grow shops used in our main analysis refer to October 2016, we used the Internet Archive Wayback Machine to collect data on grow shops for March 2016—two months before the fake policy.

Table 6
Placebo policy: May (2016).

	(1) marijuana
DID (Mar 2016)	0.039
	0.049
Post May (2016)	1.568***
	0.215
Police operations	0.084***
	0.021
Other controls	No
Province FE	Yes
Year FE	Yes
Month FE	Yes
N	1696

Log transformation of the dependent variable. S.E. clustered at the province-level *in italics*. ***, **, *, indicate statistical significance at 1%, 5% and 10%, respectively.

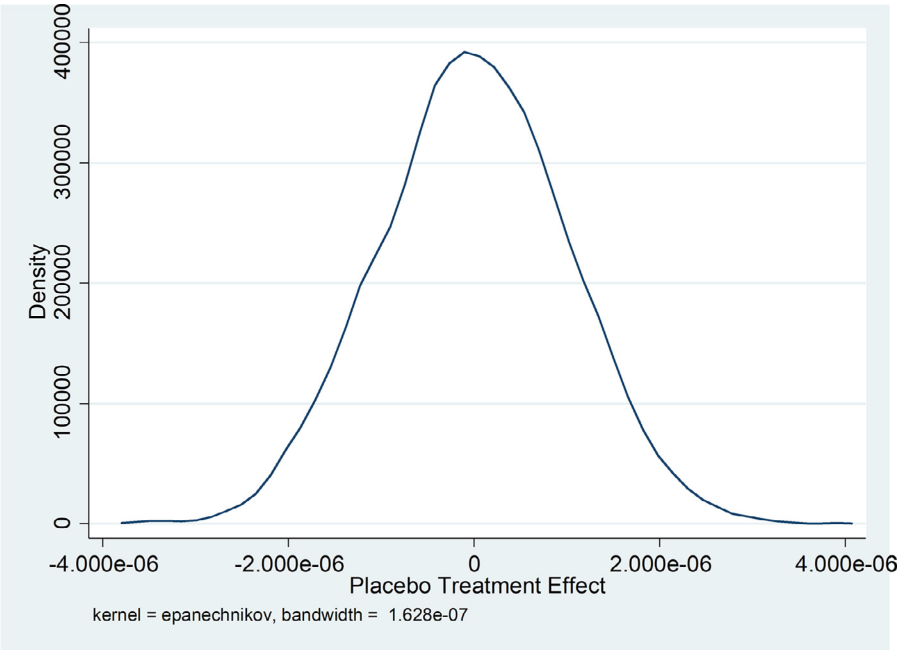

Fig. 4. Kernel density distribution of placebo liberalization.
Kernel density distribution of 5000 placebo estimates of the effects of the liberalization on illegal marijuana confiscations.

Table 6 shows that a fake policy has no significant effect on illegal marijuana confiscated at the province level. All other controls, such as the time trend, the number of operations, and the number of grow shops in March 2016, are instead positive and highly significant.

Lastly, to reduce any residual concern about possible violations of common trend assumptions, we also perform a permutation test based on a Monte Carlo simulation. The permutation test also allows us to explore the robustness of the results to assumptions about the structure of the error distribution. This is a strategy that is increasingly used in many empirical applications (i.e., Wing and Marier, 2014; Carrieri and Principe, 2018). Indeed, although we rely on a sufficient number of clusters (106) in our empirical analysis, inference in the DID setting might be sensitive to the choice of the cluster unit and the approach to the statistical difference (Bertrand et al., 2004; Donald and Lang, 2007).

Formally, we randomly select a set of different time periods and treatment intensities (Month $\times$ Year $\times$ Number of Shops) in order to simulate the effect of a “fake liberalization” and estimate the average treatment effect in our DID framework by using the fake policy in place of the real one. Then, we simulated the model 5000 times and stored the estimated coefficient in order to plot the non-parametric distribution of placebo estimates. The key assumption of this randomization test based on placebo laws is that the fake liberalization should not generate any effect on the marijuana confiscation since the timing of the policy change is randomly assigned. Thus, on average, the estimated effect should be zero.

Fig. 4 presents the non-parametric distribution of placebo estimates of the (unintended) liberalization of C-light on marijuana confiscation. As the mean of the distribution is virtually zero, the estimator is unbiased. Moreover, the average treatment effect we estimate (about −11%) falls in the very extreme left tail of the distribution. As a result, this increases the confidence that the liberalization-driven reduction in illegal marijuana supply was not generated by chance.

7. Conclusions

Marijuana is the most popular drug in Europe. According to the EMCCDA, approximately 7% of the European population smoked cannabis (23.5 million people) in 2016, with a peak of approximately 13.9% among young adults (17.1 million). In Italy, cannabis is even more popular in the young population, with 19% of young adults using it in 2016. However, as marijuana remains illegal, users face no alternative to purchasing it in the streets, which generates revenue for those active in the black market. Proponents of legalization of cannabis identify the possibility of diverting revenue from the illegal and untaxed market to the legal one as their main argument. However, a potential for the legalization of cannabis has always brought about a polarized discussion, and due to the scarcity of relevant data, the displacement effect of liberalization on the supply of illegal drugs remained substantially unexplored. The main purpose of this paper was to fill this gap.

We looked at the effect of liberalization of light pot in Italy through a quasi-experiment that occurred in December 2016 by means of a legislative gap that created the opportunity to legally sell cannabis with a low level of tetrahydrocannabinol (C-light). To identify the effect of interest, we exploited the fact that the intensity of liberalization in the short run varied according to the pre-liberalization market configuration of grow shops, i.e., shops selling industrial cannabis-related products that have been able to put cannabis flowers (light cannabis) on the new market by exploiting large economies of scope (i.e., the opportunity to sell both cannabis-related products and its flowers). Pre-policy localization of these shops essentially depends on the proximity to cannabis cultivations, which are concentrated in areas close to waterways and humid soil.

We employed a unique dataset on monthly confiscations of drugs and other crime-related measures at the province level (NUTS-3) over the period from 2016–2018, which was matched with data on the geographical location of grow shops as well as socio-demographic variables. Several features of our analysis allowed us to make a number of contributions to existing literature on the interplay between the legal and illegal market of drugs. First, the availability of monthly data, coupled with the unexpected nature of liberalization, allowed us to estimate our effect of interest in a very short time window around the policy. This makes changes in law enforcement and police efforts extremely unlikely (however, controlled in several ways) and allowed us to interpret any change in the number of drugs confiscated as changes in the equilibrium supply of illegal marijuana. Second, unlike previous evidence coming quite exclusively from the US, we estimated the displacement effect in a European country and, in particular, a country where criminal organizations are historically rooted and have very strong monopolistic power and entire control over the smuggling of the drug, often jointly with international criminals. Last but not least, the availability of data on confiscations allowed us to quantify the amount of illegal drugs displaced by a mild form of liberalization and then to assess, albeit roughly, the foregone revenues for criminal organizations. This is useful in order to evaluate the main expected beneficial effect from a liberalization process.

According to our differences-in-differences (DID) estimates, for any grow shop serving a local market before the policy, liberalization led to a contraction of up to 14% of the monthly confiscation of illegal marijuana. In terms of elasticity, we documented that a 10% increase in the number of grow shops per policy caused a 3.3% reduction in the confiscation of illegal marijuana. These results are robust to a set of different checks and model specifications. We also found significant spillover effects on other cannabis-related drugs, i.e., a reduction of 33% in the number of cannabis plants illegally cultivated and 8% for hashish. Moreover, we showed that the unintended policy also caused other indirect effects on organized crime, such as a reduction of 3% in the number of people arrested for drug-related crimes. Interestingly, we also found that the number of foreigners arrested for drug-related offences fell by 3% and roughly 15% for the number of minors arrested. Overall, the policy had the beneficial effect of reducing the number of people incarcerated for drug-related offences.

These estimates allow for a back-of-the-envelope calculation of the forgone revenues for the criminal organizations. Considering that the average number of grow shops at the province level is around 2.76 and that the marijuana price is estimated to be 7–11 euros per gram (ECCMDA, 2016), our estimates over the 106 provinces imply that forgone revenue due to C-light liberalization ranges from 90–170 million euros per year, on average.[7] This refers to the only market of marijuana and thus excludes other cannabis-related drugs, such as plants of cannabis and hashish.

The implied forgone revenue, despite being statistically different from zeros, is not very high if evaluated as a share of revenue for the entire market of illegal cannabis-related drugs, estimated to be around 3.5 billion euros in Italy. In particular, our estimates suggest that the liberalization of C-light led to a reduction in revenue from street marijuana of around 3–5% of the entire cannabis-related market. This may suggest underplaying the role of liberalization as a way to fight criminal organizations in the short run. However, it is important to highlight that we are able to estimate only a (very) lower bound of the real displacement effect of liberalization. This is for a number of reasons. First, it is because we used data on confiscations of illegal drugs, which obviously represent only a lower bound of the stock of marijuana available in the illegal market. Second, it is because we dealt with liberalization of a rather imperfect substitute of the marijuana available in the illegal market. Indeed, C-light contains a low level of THC and a naturally high level of CBD, the cannabidiol. Consequently, it has much less of a recreational effect. Last but not least, liberalization was unintended and received very little attention

[7] The estimates were made on the basis of the DID treatment effect of −11.5 % and −14% as shown in Table 3 and using the average confiscation mean of 32.89 kg. By considering a price of 7 euro/gr, forgone revenues range between 92.95 and 113 million euros, according to the DID treatment effect parameter. Similarly, by considering a price of 11 euro/gr, forgone revenues account for 146–177 million euros.

by the media, at least in the short term to which our analysis refers. This implies that product advertisement was very low, at least in the short run.

Despite this, our estimates indicate that even a mild form of liberalization, such as the one that occurred involuntarily in Italy, can accomplish the purpose of reducing the quantity of marijuana sold in the illegal market and the related revenues for organized crime, and this is likely to also encompass a variety of cannabis-related drugs. This result is ultimately supported by the fact that while police forces did not adjust their effort, anti-drug operations resulted in fewer arrests.

Our results also have a number of other interesting implications. Besides the positive effect on crime, our results show that a substitution effect on the demand side exists between high- and low-THC products. According to the EMCDDA (2016), the potency of the substance has been increasing in recent years, reaching an average percentage of THC in street marijuana of 10.8, with peaks of 22%, relative to 0.2–0.6% of THC permitted by the current Italian regulation. Given the substitution pattern, we may speculate that all potential consequences of the direct liberalization of recreational marijuana (e.g., negative effects on school achievement as shown by Plunk et al., 2016) are not likely to arise with this light substance. Evidence in this direction may inform policymakers about a mixed approach to legalization which, on the one hand, diverts illegal consumption toward legal consumption, disrupting the black market, and on the other hand, it also reduces the negative externalities associated with the abuse or misuse of these substances.

This paper also sets the ground for future research. This may also be devoted to investigating, in the Italian context, the effect of this mild form of liberalization on other violent and non-violent crimes. This might be particularly relevant in the long run, with a more efficient reallocation of police resources toward the repression and prevention of other crimes. Lastly, it might be beneficial for an assessment of potential forgone tax revenue resulting from C-light liberalization. This may represent another argument in favor of liberalization, especially in times of strict public budget constraints.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2019.01.003.

References

Adda, J., McConnell, B., Rasul, I., 2014. Crime and the depenalization of cannabis possession: evidence from a policing experiment. J. Polit. Econ. 122 (5), 1130–1202.
Anderson, M.D., Hansen, B., Rees, D.I., 2013. Medical marijuana laws, traffic fatalities, and alcohol consumption. J. Law Econ. 56 (2), 333–369.
Bertrand, M., Duflo, E., Mullainathan, S., 2004. How much should we trust differences-in-differences estimates? Q. J. Econ. 119 (1), 249–275.
Blundell, R., Dias, M.C., 2009. Alternative approaches to evaluation in empirical microeconomics. J. Hum. Res. 44 (3), 565–640.
Box, G.E., Cox, D.R., 1964. An analysis of transformations. J. R. Stat. Soc. Ser. B Methodol. 211–252.
Brinkman, J., Mok-Lamme, D., 2017. Not in my backyard? Not so fast. The effect of marijuana legalization on neighbourhood crime. FRB of Philadelphia Working Paper No. 17-19. https://ssrn.com/abstract=3005262.
Cameron, C., Miller, D., 2015. A practitioner's guide to cluster-robust inference. J. Hum. Res. 50 (2), 317–373.
Card, D., 1992. Using regional variation in wages to measure the effects of the federal minimum wage. ILR Rev. 46 (1), 22–37.
Carrieri, V., Principe, F., 2018. WHO and for how long? An Empirical Analysis of the Consumers' Response to Red Meat Warning (No. 18/08). HEDG, c/o Department of Economics, University of York.
Chang, T.Y., Jacobson, M., 2017. Going to pot? The impact of dispensary closures on crime. J. Urban Econ. 100, 120–136.
Cheng, C., Mayer, W.J., Mayer, Y., 2018. The effect of legalizing retail marijuana on housing values: evidence from Colorado. Econ. Inquiry 56 (3), 1585–1601.
Chu, Y.W.L., Townsend, W., 2018. Joint culpability: The effects of medical marijuana laws on crime. J. Econ. Behav. Org..
DiNardo, J., Lemieux, T., 2001. Alcohol, marijuana, and American youth: the unintended consequences of government regulation. J. Health Econ. 20 (6), 991–1010.
Dipartimento Politiche Antidroga. 2017. Relazione annuale al Parlamento sullo stato delle tossicodipendenze in Italia. June 2017.
Donald, S.G., Lang, K., 2007. Inference with difference-in-differences and other panel data. Rev. Econ. Stat. 89 (2), 221–233.
Draca, M., Machin, S., Witt, R., 2011. Panic on the streets of London: Police, crime, and the July 2005 terror attacks. Am. Econ. Rev. 101 (5), 2157–2181.
Dragone, D., Prarolo, G., Vanin, P., Zanella, G., 2019. Crime and the legalization of recreational marijuana. J. Econ. Behav. Org. https://doi.org/10.1016/j.jebo.2018.02.005.
EMCDDA. 2016. European drug report 2016: trends and developments.
Galenianos, M., Gavazza, A., 2017. A structural model of the retail market for illicit drugs. Am. Econ. Rev. 107 (3), 858–896.
Gavrilova, E., Kamada, T., Zoutman, F., 2019. Is legal pot crippling Mexican drug trafficking organisations? The effect of medical marijuana laws on US crime. Econ. J. 129 (617), 375–407. doi:10.1111/ecoj.12521.
Gaynor, M., Moreno-Serra, R., Propper, C., 2013. Death by market power: reform, competition, and patient outcomes in the National Health Service. Am. Econ. J. Econ. Policy 5 (4), 134–166.
Hansen, B., Miller, K.S., Weber, C., 2017. How Extensive is Inter-state Diversion of Recreational Marijuana?. National Bureau of Economic Research No. w23762.
Hansen, B., Miller, K.S., Weber, C., 2018. Early Evidence on Recreational Marijuana Legalization and Traffic Fatalities. National Bureau of Economic Research No. w24417.

Jacobi, L., Sovinsky, M., 2016. Marijuana on main street? Estimating demand in markets with limited access. Am. Econ. Rev. 106 (8), 2009–2045.
Marie, O., Zölitz, U., 2017. "High" achievers? Cannabis access and academic performance. Rev. Econ. Stud. 84 (3), 1210–1237.
Plunk, A.D., Agrawal, A., Harrell, P.T., Tate, W.F., Will, K.E., Mellor, J.M., Grucza, R.A., 2016. The impact of adolescent exposure to medical marijuana laws on high school completion, college enrollment and college degree completion. Drug Alcohol Depend. 168, 320–327.
Puhani, P.A., 2012. The treatment effect, the cross difference, and the interaction term in nonlinear "difference-in-differences" models. Econ. Lett. 115 (1), 85–87.
Sabia, J.J., Swigert, J., Young, T., 2017. The effect of medical marijuana laws on body weight. Health Econ. 26 (1), 6–34.
Shepard, E.M., Blackley, P.R., 2016. Medical marijuana and crime: Further evidence from the western states. J. Drug Issues 46 (2), 122–134.
UNODC. 2016. United nations office on drugs and crime. World drug report 2016. https://www.unodc.org/wdr2016/.
Wen, H., Hockenberry, J.M., Cummings, J.R., 2015. The effect of medical marijuana laws on adolescence and adult use of marijuana, alcohol, and other substances. J. Health Econ. 42, 64–80.
Wing, C., Marier, A., 2014. Effects of occupational regulations on the cost of dental services: evidence from dental insurance claims. J. Health Econ. 34, 131–143.
Zambiasi, D., Stillman, S., 2018. The pot rush: is legalized marijuana a positive local amenity? IZA Discussion Paper No. 11392. http://ftp.iza.org/dp11392.pdf.