UNIVERSITY of York

HEDG

HEALTH, ECONOMETRICS AND DATA GROUP

WP 19/07

Do-It-Yourself medicine? The impact of light cannabis liberalization on prescription drugs

Vincenzo Carrieri; Leonardo Madio and
Francesco Principe

April 2019

http://www.york.ac.uk/economics/postgrad/herc/hedg/wps/

Do-It-Yourself medicine?
The impact of light cannabis liberalization on prescription drugs

Vincenzo Carrieri¶
Leonardo Madio†
Francesco Principe♠

Abstract

This paper provides the first analysis of "Do-it-Yourself Medicine" concerning marijuana consumption by studying the effects of the unintended liberalization of light cannabis that took place in Italy in 2016 on prescription drugs sales. Using a unique and high-frequency dataset on monthly sales of drugs and the location of light cannabis retailers and adopting a staggered DiD research design, we find that the local market accessibility of light cannabis led to a reduction in dispensed packets of opioids, anxiolytics, sedatives, anti-migraines, anti-epileptics, anti-depressives and anti-psychotics. This calls for an effective regulation of the market and a proper evaluation of the use of light cannabis for medical purposes.

JEL Codes: H51, H75, I18, K32, K42.

Keywords: Light cannabis, self-medication, marijuana, differences-in-differences, prescriptions.

¶Department of Law, Economics and Sociology, "Magna Graecia" University, Catanzaro, Italy; RWI-Research Network, Essen, Germany; HEDG, University of York, United Kingdom. E-mail: vincenzo.carrieri@unicz.it

†CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium; CESifo Research Network, Munich, Germany; HEDG, University of York, United Kingdom. E-mail: leonardo.madio@uclouvain.be

♠Erasmus School of Economics, Rotterdam, The Netherlands; HEDG, University of York, United Kingdom. E-mail: principe@ese.eur.nl

We thank Andrea Agnello (Federfarma) for assistance over the use of data.

1 Introduction

In recent years, the cannabis market has gained momentum worldwide. In the US, recreational marijuana is now liberalized in several states (e.g., California, Massachusetts, Michigan, Oregon, amongst others) and Canada legalized its recreational use in October 2018. Many other states and countries, however, have instead restricted their use to medical purposes. For instance, in January 2019, the District of Columbia joined 33 other US states, whereas in 2017 Germany was the last European country to legalize it following more than ten countries. On the other hand, waves of liberalization in Europe also regarded light marijuana use (i.e., The Netherlands, Switzerland, Italy and Belgium), characterized by a relatively low level of tetrahidrocanabinol (THC), which is responsible for euphoric effects, and higher level of cannabidiol (CBD), which is, instead, responsible for relaxant effects.

A growing stream in the economics literature has documented the effect of such forms of liberalization on a variety of outcomes. General beneficial effects are found on crime (Carrieri *et al.* 2019, Shephard and Blackely 2016, Brinkman and Mok-Lamme 2017, Chang and Jacobson 2017, Gavrilova *et al.* 2017, Chu and Townsend 2018, and Dragone *et al.* 2018), and also on the labor supply of older adults (Nicholas and Maclean 2019). More controversial effects or no effects are found on some health-related outcomes such as traffic fatalities (Anderson *et al.* 2013; Hansen et al. 2018), teenager use (Lynne-Landsman *et al.* 2013), body weight and obesity (Sabia *et al.* 2017).

However, insofar as marijuana is responsible for significant effects on the human body, i.e. euphoric and/or relaxant effects, important spillover effects of its liberalization may arise on the pharmaceutical market and in particular on drug consumption. Despite the great relevance of this issue, only a few recent papers have analyzed it so far. Bradford and Bradford (2016; 2017; 2018) documented how the availability of medical marijuana impacted on Medicare and Medicaid drug prescriptions in the US, with a significant reduction in the number of prescriptions for pain relief, anxiety, nausea, depression, psychosis and sleep disorders. Similar patterns were already largely documented for the opioids, for which the introduction of medical marijuana may have contained the epidemic. In this respect, Shy (2017) found a decline in the number of opioid dependence hospitalizations after the medical marijuana law came into effect, and a reduction in the number of opioid prescriptions was reported by Liang *et al.* (2018). More controversial findings were discussed by Bachhubber *et al.* (2014) who found an association between medical marijuana law and a lower opioid analgesic overdose mortality, but these were highly sensitive to the regulation of local dispensaries (Powell *et al.* 2018); greater substitution between opioids and medical marijuana occur when the latter is more accessible to qualified patients.

These findings have relevant implications for health care and public policy. Indeed, as the mere availability of medical marijuana can prompt doctors to prescribe fewer *traditional* drugs, this can generate relevant savings for health systems. But do people substitute marijuana directly with other drugs even when prescriptions are not required? And if so, which drugs are then considered as direct substitutes by patients? These questions have been largely unexplored so far. Yet, they ring multiple alarm bells regarding potentially risky behaviors assumed by individuals when not following medical advice. Forms of self-medication with marijuana are not new in the currently scant literature (Bolton *et al.* 2006; Bolton et *al.* 2008; Sarvet *et al.* 2018). However, these papers fell short of providing causal effects of non-medical marijuana availability on traditional drug consumptions. If appropriately supported, understanding patients' autonomous behavior and their substitution choices has relevant implications for the regulation of new markets such as the emerging cannabis one, whose costs and benefits require careful evaluation. The primary aim of this paper is to fill this gap.

We study the *unintended* liberalization of light cannabis that occurred in Italy in December 2016 when the government passed a law that made possible the commercialization of the cannabis flower with as much as 0.2% of THC. This reform represents a unique opportunity to estimate the substitutional effects between traditional prescribed drugs and a specific compound of marijuana, the CBD, of which light cannabis is uncommonly rich. A unique feature of this liberalization is that it was unannounced as resulting from a legislative void. Hence, it was not meant to legalize (light) cannabis consumption and this provides a plausibly exogenous variation in the policy setting not subsequently followed by changes in the institutional setting. Differently from medical marijuana, which requires a doctor's prescription and is often difficult to access even by qualified patients; light cannabis does not have any therapeutical indication and it is of easy access. For instance, it can even be bought from vending machines and herbalist shops without any age verification or identity check.

To identify the causal impact of this unintended liberalization on prescribed drug sales, we exploit the entry of local cannabis shops in 106 NUTS-3 Italian provinces in a staggered differences-in-differences (DiD) framework and we use high-frequency data. As discussed elsewhere (e.g., Carrieri *et al.* 2019), the territorial localization of light cannabis shops was essentially driven by morphological and geographical conditions of the territory that made the cultivation of cannabis crops more suitable. Subsequently, the commercialization of light cannabis flourished at a different pace across provinces. As the market availability of the product was not linked to demand of illegal or medical marijuana as well as of pharmaceuticals, the market entry of these retailers can be regarded as exogenous in our setting. Hence, we exploit this heterogeneity to estimate the causal effect of the staggered local market availability of light cannabis on the sales of several types of drugs for which cannabis can be regarded as an effective substitute, that is opioids, anxiolytics, sedatives, anti-migraines, anti-epileptics, anti-psychotics and anti-depressives (see e.g. Blessing *et al.* 2015).

Our study provides a number of relevant contributions. First, we study whether, in the eyes of patients, easy access to marijuana retailers can prompt its substitution for traditional drugs even in the absence of medical prescriptions and clinical support. The previous literature focused on a rather different product, i.e., medical marijuana. We focus instead on self-medication, that is, the possibility of seeking relief with non-prescribed, unofficial or alternative treatments resulting from the local availability of the product. Figure 1 provides support for the use of light cannabis as a form of self-medication using Google Trends statistics. It shows that both the general interest in the product and its use to treat anxiety disorders peaked in the month of the introduction of the product on the Italian market (May 2017) and remained at a higher level in the subsequent period. This is also consistent with recent evidence from the US which shows how self-medication is more likely to happen in those states governed by a medical marijuana law (Sarvet *et al.* 2018).

[Figure 1 around here]

Second, we are able to clearly estimate the effect of the local availability of light marijuana substitution in the absence of any form of institutional adaptation. As we focus on a very short period after the law (10 months), our estimates provide a clear picture of substitutional patterns avoiding any potential confounding factors (e.g., change in national or local health policies). Moreover, this also allows us to exclude any doctor's systematic adjustment across provinces in the prescription choices of medical doctors. Third, we provide the first contribution from Europe, and specifically from Italy, which adopted a rather conservative approach to cannabis. Last but not least, the substitutional patterns we identify arise as a monetary cost for patients. Whereas traditional drugs are either free of charge or require a small co-payment, light cannabis cannot be reimbursed by the NHS and is sold at a price ranging from 8 to 12 euro per gram depending on the quality.

We find that the local availability of light cannabis led to a significant decrease in the number of packets of drugs dispensed by the Italian NHS. Specifically, after the introduction of the policy, we find that the arrival of light cannabis in a given province led to a reduction in the number of dispensed boxes of anxiolytics by approximately 11.5%, reduction of dispensed sedatives by 10% and a reduction of dispensed anti-psychotics by 4.8%. More nuanced negative effects are found for anti-epileptics (-1.5%), depressives (-1.2%), opioids (-1.2%), anti-migraines (-1%). Results from an event-study specification show that the substitution between these pharmaceuticals took place especially from the third month after the introduction of the product in the local market. Moreover, we find that drug prescriptions across provinces did not trend differently for up to six months prior to the light cannabis seller entry in the province. These results are also robust to a number of checks and falsification tests.

This article is structured as follows. In Section 2, we present the policy reform that occurred in Italy. In Section 3, we discuss our data and the identification strategy we follow. In Section 4, we present our main results, followed by some sensitivity analysis and robustness checks of these results in Section 5. In the final section, we present some concluding remarks.

2 Institutional setting

Italy has a long historical tradition of the cultivation of cannabis. One of the earliest large cultivation dates back to the 1st century A.D. (Mercuri *et al.* 2002). In the 1940s, Italy was the second largest producer of industrial cannabis worldwide. Despite this fact, marijuana cultivation, possession and sale remain illegal, except for its industrial and medical use.

However, in 2016, the government passed a law intended to regulate industrial cannabis (also called hemp) and to remove some restrictions. The Law (242/16) incentivizes the cultivation of hemp but did not explicitly intervene on the commercialization of the cannabis flower. As a result, the sale of light cannabis was liberalized by means of a legislative gap. From May 2017 onwards, several startups exploited this grey market and started selling cannabis flowers as a “technical product”, that is as a collector’s item not meant to be smoked or consumed.

However, local availability of light cannabis did not arise simultaneously in all geographical areas of the national territory. Indeed, due to the unannounced liberalization, local availability in the first months after the policy mainly affected those areas previously served by grow shops, that is shops selling seeds and cannabis-related products. As documented elsewhere (e.g., Carrieri *et al.* 2019), these grow shops were mainly concentrated in areas in which industrial cannabis cultivation was more likely due to the geographical and morphological conditions of the territory.

Figure 2 depicts this staggered entry into the market during the time period of this study. In May 2017, 22 out of 106 provinces were served by at least one light cannabis retailer. After a first introductory phase, light cannabis shops blossomed becoming a "social phenomenon". Tobacco and herbalist shops, para-pharmacists and automatic machines began selling this product as well and expanded their local coverage. As shown by Figure 1, by February 2018, the number of provinces reached 87 and the entire country was gradually covered by retailers throughout 2018. In Table A2 in the Appendix, we provide details on the number of provinces covered by light cannabis availability for each month.

[Figure 2 around here]

3 Data and Methods

We use a unique longitudinal dataset recording drug sales with the local market availability of retailers selling light cannabis. Data on these dispensaries were collected using the Archive Internet Archive Wayback Machine on the websites of the four main sellers of light cannabis in 2017. We, therefore, collected data on a monthly basis for all 106 Italian provinces (NUTS 3) over the period from January 2016 to February 2018.[1] These were then matched with data on drug sales obtained by Federfarma, the Italian association of pharmacy owners. Our data tracks the pharmaceutical expenditure of the Italian NHS for each Local Health Authority (ASL) and covers more than 95% of Italian pharmacies. As provinces can be served by one or more ASLs, data were therefore aggregated at the province level.

A key feature of our dataset is tracking all "Class A" drugs dispensed by the Italian NHS which contain active ingredients often used to treat symptoms for which marijuana can also provide relief. This group of drugs refers to the group "N - Nervous System" according to the

[1]These we collected monthly information on the entry in a market in each Italian province by having access to archived copies of their early pages of the four main retailers in 2017 (Easyjoint, Marymoonlight, RealHemp, XXXJoint) using the Internet Archive Wayback Machine https://archive.org/web/. Data were collected on a monthly basis after the policy and using the last accessible page for each month. When data were not available, average data were imputed.

WHO Centre for Drug Statistics Methodology. These drugs require a doctor's prescription and are available either free of charge or with a very small patient co-payment, which depends on the region and individuals' equivalent income.[2] Our dataset tracks all those prescriptions that translated into a final sale in a given province.

We consider the following drugs categories: opioids, anxiolytics, sedatives, anti-migraines, anti-epileptics, anti-psychotics and anti-depressives. These pharmaceuticals have shown patterns of substitutability with medical marijuana (Bradford and Bradford 2016; 2017; 2018). For instance, medical marijuana, rich in THC, is largely used to deal with chronic pain, glaucoma, insomnia and anxiety. Instead, for its clinical effects, CBD is often associated with anti-psychotic, analgesic, anti-inflammatory, anti-arthritic, and anti-neoplastic properties and is used to treat inflammations, migraines, depression and anxiety (Blessing et al. 2015; CIBG 2018). Opioids were also included as, according to recent anecdotal evidence, Canadian veterans started substituting opioids (along with benzodiazepines) with marijuana after their introduction of medical marijuana in Canada to treat anxiety, insomnia and for pain-relief. Similar patterns of substitutability with medical marijuana were documented by several scholars (e.g., Bradford and Bradford 2016,2018, Shi 2017, Bachuuber *et al.* 2014).

[Table 1 around here]

Table 1 provides a description of the main variables we use and shows a large heterogeneity across drug categories in the number of dispensed drug packets. On a monthly average, the Italian NHS provides reimbursement for 28 packets of sedatives and 72 boxes of anxiolytics per province. Much higher numbers are documented for opioids (12,610 packets), anti-epileptics (18,460 packets), anti-depressives (27,198 packets), anti-psychotics (4,802 packets) and anti-migraines (2,504 boxes). By matching this information with those available from light cannabis retailers, we obtained a balanced panel with a total of 2,756 province-month observations.

[2] According to Federfarma (2018), "Classe A" drugs are the most consumed drugs in Italy, accounting for approximately 52% of all market for pharmaceutical products (which it also includes dietary products, herbs, para-pharmaceuticals, and products for health and beauty care). Co-payments range from 1 euro per box to 4 euro per the entire prescription.

3.1 Identification Strategy

In order to identify the causal effect of light cannabis on the prescriptions of drugs, we employ a staggered DiD, which exploits the idiosyncratic entry of cannabis light retailers in a given province. Thus, our identification relies both on the staggered timing of the product availability and the provinces without any retailer as the control group. More formally, we estimate the following equation:

$$Y_{it} = \alpha + \sum_{k} \beta_k \, Entry_{ik} + \delta X_{it} + \gamma_i + \mu_t + \varepsilon_{it}$$

where Y_{it} is the number of packets of dispensed drugs (i.e., opioids, anxiolytics, sedatives, anti-migraines, anti-epileptics, anti-depressives and anti-psychotics) reimbursed by NHS at the time t in the province i, $Entry$ is an indicator that takes value 1 if at least a cannabis retailer has entered in all periods k in province i. γ and μ are province and time (month and year) fixed effects, ε represents the error term. X_{it} is a vector of controls for province population size and density and a dummy for post-May period to take into account eventual changes which occurred at national level after the unintended liberalization. Our coefficient of interest is β, which captures the monthly change in the demand for dispensed drugs due to the local availability of light cannabis.

The credibility of our identification strategy relies on the natural experiment which characterized the policy. As discussed, the policy was unannounced and concerned light cannabis, a product that differs in its composition from both recreational and medical marijuana. Thus, the entry of light cannabis retailers can be regarded as exogenous as it is not linked to the demand for illegal or medical marijuana as well as pharmaceutical. Moreover, the possibility of endogenous entry is essentially ruled out for several reasons. First, the particular nature of the unintended liberalization process rendered any anticipatory effect to be implausible. Second, the local availability in the period under investigation resembled the geographical presence of grow-shops, which are shops already specialized in the retail of industrial cannabis and which exploited large economies of scope by selling cannabis-related products and cannabis flowers. Finally, we make use of high-frequency data to focus on a very short window around the time during which the policy took effect (May 2017 – February 2018). This allows us to rule out potential changes in national and local health policies with respect to prescribed drugs and systematic changes in the prescription choices of medical doctors. This is because any change requires time to be fully operational and extensively included in medical guidelines and protocols.

More formally, our empirical analysis relies on the classical DiD's identifying assumptions in the pre-liberalization periods, that is, the existence of a common trend in drugs prescriptions. In our setting, this implies assuming that those provinces experiencing different timings in the local availability of light cannabis (treatment group) and those provinces never served by cannabis retailers in the period we consider (control group) should have observed the same pre-policy trends for all drug categories. In Section 5, we find strong support for this hypothesis by performing both placebo regressions and falsification tests based on alternative approaches to statistical inference.

4 Results

Our results are reported in Table 2 for all pharmaceuticals for which medical marijuana can be considered as a substitute or adjuvant therapy. For ease of interpretation of results, the dependent variable is expressed in logs. This allows us to interpret the DID-coefficient as the average percentage change in the monthly number of dispensed drugs resulting from local availability of light cannabis.

[Table 2 around here]

For all drugs categories, we document a significant and negative effect. Specifically, as the market availability of light cannabis becomes possible due to an entry of at least one retailer in a given province, the number of dispensed drugs sales decreased by approximately 1.6%. However, the extent of this reduction reveals a considerable degree of heterogeneity. The boxes of anxiolytics prescribed by doctors and sold by pharmacies significantly decreased by 11.4%, the sedatives consumption decreased by approximately 10%, whereas the number of anti-psychotics decreased by 4.8%. Hence, we observe the largest reduction for those drugs for which CBD is recognized as having a clinical effect, that is, to treat anxiety and psychosis (Blessing et al. 2015; CIBG 2018). This is intuitively explained by the relaxant properties of CBD, which is often used to treat sleep disorders. Moreover, the large coefficient we observe for sedatives and anxiolytics are also consistent with substitution stemming from self-assessment and self-medication, that is, the possibility to individually evaluate symptoms (i.e. anxiety and insomnia) and, consequently, to decide whether to take a pill.

More relatively nuanced yet significant reductions are instead found for other pharmaceuticals, which appear to offer a more chronic therapy. We observe a mild average monthly reduction in the number of packets for anti-epileptics (-1.5%), anti-depressives (-1.2%), opioids (-1.2%) and anti-migraines (approximately -1%). These are all drugs which require a constant and consistent therapy, often prescribed by specialists, and for which the switching to an "alternative therapy" based on self-medication may be problematic, especially for risk-averse individuals. This intuitively explains the relatively small reduction caused by the local availability of light cannabis.

Our results are in line with those found by Bradford and Bradford (2016; 2017) but with some interesting differences in terms of magnitude. They showed a much larger reduction in the number of drug prescriptions than ours, that is up to 10-20%. These differences can be attributed to a number of causes. First, whereas they focus on some population samples restricted to those eligible for either Medicare Part D or Medicaid, our data refers to the overall number of drug sales (and indeed) prescriptions without age limitation and eligibility constraints. Hence, our results may indicate that substitution effects are lower when estimated on a general population. Second, we focus on a non-medical treatment (i.e. light cannabis) that can be bought without a physician prescription. Our results, thus, indicate that the substitution driven by self-medication may be lower than the one induced by the physician. Last but not least, as the liberalization was not expected and as we focus on a very short period after the first entries in the local markets, implies that we only retrieve a lower boundary of the substitution effect between light cannabis and the drugs considered in our analysis. Yet, quite relevantly, our results anyway indicate that even a mild form of liberalization may generate a significant spillover effect on the market for pharmaceuticals.

5 Robustness Checks

To assess the robustness of our results, we present several robustness checks. First, we restrict the time before the policy to render the time windows before and after the policy more symmetric. This implies considering the time period between May 2016 and February 2018. Indeed, despite reducing the number of observations (2,332), our main results and intuitions remain unaltered. Estimates of the DID coefficients are reported in the first row of Table 3 for all drug categories we consider. Specifically, the local availability of light cannabis leads to a reduction in the number of dispensed boxes of sedatives by 11.5%, anxiolytics by 12.3% and anti-psychotics by 4.3%. Consistently with the model specification, we find a more nuanced but significant effect on other prescribed drugs: the selling of anti-epileptics decreases by 1.5%, whereas those of anti-depressives, opioids and anti-migraines by approximately 1%.

Second, we include a linear time trend to capture any time-varying confounding factor which might affect our estimates. Estimates of the DID coefficient are reported in the second row of Table 3 and are identical to those reported in the main model specification. Lastly, we include province-specific time trends. This allows us to allay any concerns regarding province-specific changes in prescriptions and drugs sale. Results are reported in the last row of Table 3. We observe that, whereas results are qualitatively similar to those presented in Table 2, there is a reduction in the coefficient of anti-psychotics sales, which loses significance but remains negative. We thus suggest a more cautious interpretation of the effect on anti-psychotics.

[Table 3 around here]

To further reinforce the credibility of our estimates, we provide an additional set of robustness checks. A typical concern which arises when using a DID approach is the presence of pre-policy trends which may have driven the main results. To rule out any concern in this regard, we test whether the common trend assumption can be credibly maintained in our setting. Hence, we make a graphical inspection of the trends for provinces experiencing early (May – September 2017) and late (October 2017 – February 2018) local availability in the market and for those provinces never having local access to light cannabis during the period we consider. This allows us to verify whether provinces experiencing different timing in the entry of light cannabis retailers followed similar trends in drug sales before the introduction of the policy (May 2017). As highlighted in Figure 4, pre-policy trends are parallel and the post-policy drop in dispensed drugs is consistent with the timing of the local availability in treated provinces, compared to the controls. This supports the credibility of the common trend hypothesis in our setting.

[Figure 3 around here]

Finally, we also perform a simulation exercise by means of randomization-based statistical inference for significance tests. Hence, we simulate the effect of local accessibility to light cannabis by randomly assigning the treatment to provinces at different points in time, in place of the real one. We repeat this procedure 5,000 times in order to generate a distribution of placebo treatment effects. Figure 4 presents the non-parametric distributions of these placebo estimates for all prescribed drugs included in our study, separately.

[Figure 4 around here]

Figure 4 shows that, the average of the placebo treatments is zero and the actual coefficient, which is depicted by the red vertical line, falls far from the left tail of the distribution. As a result, this provides support that the negative and significant effect we find on drug prescriptions is very unlikely to have occurred by chance.

5.1 Event Study

In the healthcare market, patients' responses to new treatments are usually sluggish and patients are highly risk averse. Given the peculiarity of the light cannabis liberalization process that occurred in Italy, the substitutability we observe may arise at different points in time after the entry of light cannabis retailers into the local market. To shed some light on the dynamics of patients' responses to local markets availability, we also provide an event-study analysis.

[Figure 5 around here]

The event study in Figure 5 also allows us to assess the potential confounding effects of pre-existing trends and to test for possible endogeneity in light cannabis seller entry. Specifically, with reference to the time relative to the first month of light cannabis seller entry in each province, we include a series of dummies coding the month of entry and one to six months pre-entry and up to three months post-entry. One-month pre-entry is the excluded dummy for each dimension and is set equal to zero in our presentation of the results.

The evidence of the reduction in the number of drug prescriptions and sales further appears even stronger in Figure 5. We note that reductions in the number of dispensed drugs occur since the second month after the entry of local retailers and it is more pronounced from the third month onwards. Importantly, there is little evidence of systematic pre-trends affecting the results and this provides further support for the hypothesis of exogeneity in the cannabis light seller entry in each province.

6 Final Remarks

Many countries have legalized or decriminalized marijuana for recreational and medical purposes worldwide. However, the effect of such forms of liberalization or decriminalization in Europe have been investigated only with respect to their effect on crime (e.g. Carrieri *et al.* 2019; Adda *et al.* 2014). Little is known about the other potential effects stemming from the legal availability of marijuana. Recent evidence from the US has shown how access to medical marijuana can have important implications for health care policy and can generate conspicuous savings for the health system. It has been documented that local availability of medical marijuana can reduce the number of drug prescriptions and sales for several symptoms. These studies however dealt only with access to medical marijuana, which requires a doctor's prescription. Instead, access to non-clinically supported marijuana to seek relief as a form of self-medication has not received attention so far. Yet, from a behavioral perspective, abandoning a well-recognized therapy for a non-clinically supported product can be quite risky.

This paper aims to fill this gap in the literature and provides the first analysis of the "Do-it-Yourself Medicine" approach concerning marijuana consumption. We study how the easier availability of light marijuana, a non-medical cannabis-based product characterized by a high presence of CBD and which is free of psychotropic effects, impacted on dispensed drugs sales to treat anxiety, psychosis, chronic pain, insomnia, migraine and epilepsy. We provide the first evidence from Europe, a less mature market for cannabis, and we exploited an unintended yet announced liberalization of light cannabis that took place in Italy in 2016 using a unique longitudinal dataset from with high-frequency data for 106 provinces.

Using a staggered DiD model, we find that the local availability of non-medical light cannabis led to a significant and large reduction of dispensed boxes of anxiolytics and sedatives, which amounted to approximately 10%. These drugs usually treat symptoms for which CBD is often effective and for which symptoms can be easily detected by a non-specialist. We also find that the entry of a light cannabis retailer in a given province led a 1-1.5% reduction in the number of anti-epileptic, anti-depressive, opioid and anti-migraine prescriptions, whereas prescriptions for psychotic patients decreased by approximately 4-5%.

Our estimates assume more relevance when considering the very short time window we consider, that is 10 months after the policy was implemented, the lack of clinical support, and the unusual way in which light cannabis was made available as well as our focus on a very short period after the introduction of the product. As discussed, light cannabis liberalization was due to a legislative void and, for this reason, unannounced and not capable of creating an anticipatory effect. In addition, the product was not meant to be consumed. This renders it less likely that the substitutional patterns we observed were driven by medical advice. In addition to this, patient response to new drugs and therapies is usually heterogeneous and sluggish because of typical risk aversion. Nonetheless, we find a significant and negative effect on a number of drugs treating pathologies for which medical cannabis (and not light cannabis) has demonstrated some degree of effectiveness. The event study also provides additional insights into patients' response. We observe that substitutional patterns are more accentuated starting from the third month after the entry of the first light cannabis retailer in the local area. This result may indicate that individuals started substituting therapy after some weeks of experimentation or just after realizing that the new product had become locally available.

Finally, our estimates present a series of important public policy implications. First, a clear regulation for the light cannabis market may be required alongside the larger availability of medical marijuana. The substitution we identify may stem from a poorly designed distribution channel of medical marijuana in Italy.

Second, forms of self-medication should ring the alarm bells of policy-makers as individuals may not follow expert advice even when taking care of their own health. Hence, we suggest that governments should be very careful about the potential unintended effects of liberalization policies as their reaction to a new product may partly drive them away from traditional therapies to non-clinically supported ones.

Third, from a public policy perspective, we observe that that the shift in consumption from traditional drugs to light cannabis came from a non-negligible cost for a patient. This is because, unlike the drugs we consider, which are either fully reimbursed by the NHS or subject to a small co-payment from a patient, light cannabis is often sold at a cost of 8-10 euro per gram. As a result, the unintended policy liberalization had an unexpected effect on the pharmaceutical expenditures. Pharmaceutical expenditure worldwide has rapidly increased in recent years and this is equally true in Italy (Federfarma 2018). However, in the absence of any clinical validation of light cannabis, these short-term financial benefits may be outweighed by long-term public health costs. This calls for an effective regulation of the market and a proper evaluation of the use of light cannabis for medical purposes.

References

Adda, J., McConnell, B., & Rasul, I. (2014). Crime and the depenalization of cannabis possession: Evidence from a policing experiment. *Journal of Political Economy*, *122*(5), 1130-1202.

Anderson, M. D., Hansen, B., & Rees, D. I. (2013). Medical marijuana laws, traffic fatalities, and alcohol consumption. *The Journal of Law and Economics*, *56*(2), 333-369.

Bachhuber, M. A., Saloner, B., Cunningham, C. O., & Barry, C. L. (2014). Medical cannabis laws and opioid analgesic overdose mortality in the United States, 1999-2010. *JAMA Internal Medicine*, *174*(10), 1668-1673.

Blessing, E. M., Steenkamp, M. M., Manzanares, J., &Marmar, C. R. (2015). Cannabidiol as a potential treatment for anxiety disorders. *Neurotherapeutics*, *12*(4), 825-836.

Bolton, J., Cox, B., Clara, I., & Sareen, J. (2006). Use of Alcohol and Drugs to Self-Medicate Anxiety Disorders in a Nationally Representative Sample. *The Journal of Nervous and Mental Disease*, 194(11), 818–825.

Bradford, A. C., &Bradford. W.D(2016). Medical Marijuana Laws Reduce Prescription Medication Use in Medicare Part D. *Health Affairs* 35:1230–36.

Bradford, A. C., & Bradford, W. D. (2017). Medical marijuana laws may be associated with a decline in the number of prescriptions for Medicaid enrollees. *Health Affairs*, *36*(5), 945-951.

Bradford, A. C., & Bradford, W. D. (2018). The Impact of Medical Cannabis Legalization on Prescription Medication Use and Costs under Medicare Part D. *The Journal of Law and Economics*, 61(3), 461–487.

Brinkman, J., &Mok-Lamme, D. (2017). Not in my backyard? Not so fast. The effect of marijuana legalization on neighborhood crime. Mimeo.

Carrieri, V., Madio, L., & Principe, F. (2019). Light cannabis and organized crime: Evidence from (unintended) liberalization in Italy. *European Economic Review*. 113. 63-79.

Chang, T. Y., & Jacobson, M. (2017). Going to pot? The impact of dispensary closures on crime. *Journal of Urban Economics*, *100*, 120-136.

CIBG (2018). Report on Medical Cannabis in the Netherlands. Office for Medical Cannabis. Available at: https://english.cannabisbureau.nl/medicinal-cannabis/documents/circulars/2018/02/20/patients-guide-medicinal-cannabis

Dragone, D., Prarolo, G., Vanin, P., & Zanella, G. (2018). Crime and the legalization of recreational marijuana. *Journal of Economic Behavior & Organization*. *Forthcoming:* https://doi.org/10.1016/j.jebo.2018.02.005

Federfarma (2018). La spesa farmaceutica nel 2017. Analisi dell'andamento della spesa farmaceutica convenzionata a livello nazionale e regionale.

Gavrilova, E., Kamada, T., &Zoutman, F. (2017). Is legal pot crippling Mexican drug trafficking organisations? The effect of medical marijuana laws on US crime. *The Economic Journal. Forthcoming:* https://doi.org/10.1111/ecoj.12521.

Hansen, B., Miller, K., & Weber, C. (2018). Early evidence on recreational marijuana legalization and traffic fatalities. *Economic Inquiry.Forthcoming.*

Nicholas, L. H., & Maclean, J. C. (2019). The effect of medical marijuana laws on the health and labor supply of older adults: Evidence from the Health and Retirement Study. *Journal of Policy Analysis and Management. Forthcoming.*

Liang, D., Bao, Y., Wallace, M., Grant, I., & Shi, Y. (2018). Medical cannabis legalization and opioid prescriptions: evidence on US Medicaid enrollees during 1993-2014. *Addiction. Forthcoming.*

Lynne-Landsman, S. D., Livingston, M. D., & Wagenaar, A. C. (2013). Effects of state medical marijuana laws on adolescent marijuana use. *American Journal of Public Health*, *103*(8), 1500-1506.

MBJ (2018), Italy addresses 'systematic' medical marijuana shortage with help from Canadian companies. Marijuana Business Daily. 22 January, 2018. Available at: https://mjbizdaily.com/italy-addresses-systematic-medical-marijuana-shortage-canadian-imports/

Mercuri, A. M., Accorsi, C. A., & Mazzanti, M. B. (2002). The long history of Cannabis and its cultivation by the Romans in central Italy, shown by pollen records from Lago Albano and Lago di Nemi. *Vegetation History and Archaeobotany*, *11*(4), 263-276.

Pacula, R. L., Powell, D., Heaton, P., & Sevigny, E. L. (2014). Assessing the Effects of Medical Marijuana Laws on Marijuana Use: The Devil is in the Details. *Journal of Policy Analysis and Management, 34(1), 7–31.*

Powell, D., Pacula, R. L., & Jacobson, M. (2018). Do medical marijuana laws reduce addictions and deaths related to pain killers?. *Journal of Health Economics*, *58*, 29-42.

Sabia, J. J., Swigert, J. & Young, T. (2017). The effect of medical marijuana laws on body weight. *Health Economics*, *26*(1), 6-34.

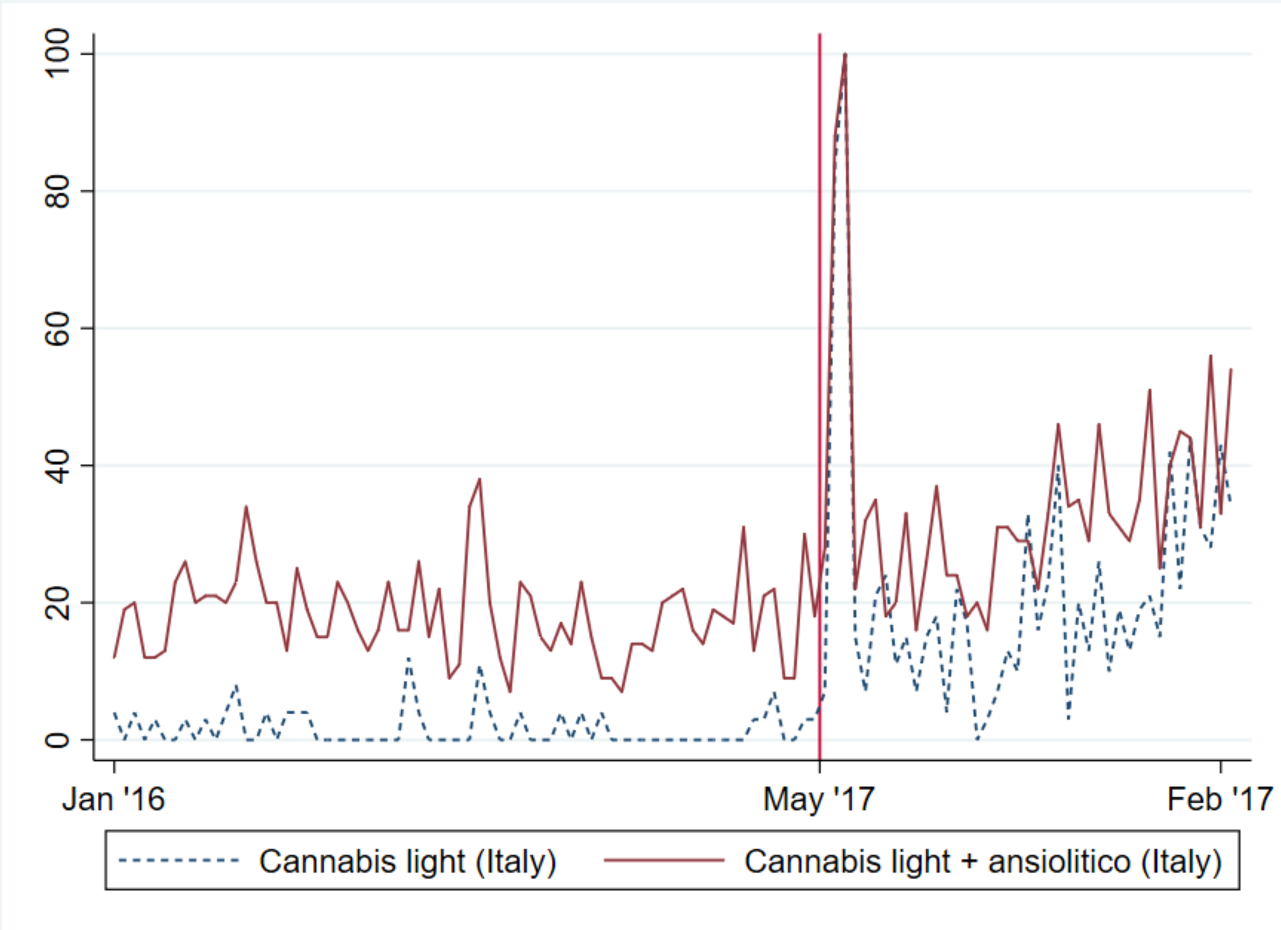
Sarvet, A. L., Wall, M. M., Keyes, K. M., Olfson, M., Cerdá, M., &Hasin, D. S. (2018). Self-medication of mood and anxiety disorders with marijuana: Higher in states with medical marijuana laws. *Drug and Alcohol Dependence,* 186, 10-15.

Shi, Y. (2017). Medical marijuana policies and hospitalizations related to marijuana and opioid pain reliever. *Drug and Alcohol Dependence*, *173*, 144-150.

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. *Journal of Health Economics, 42*, 64-80.

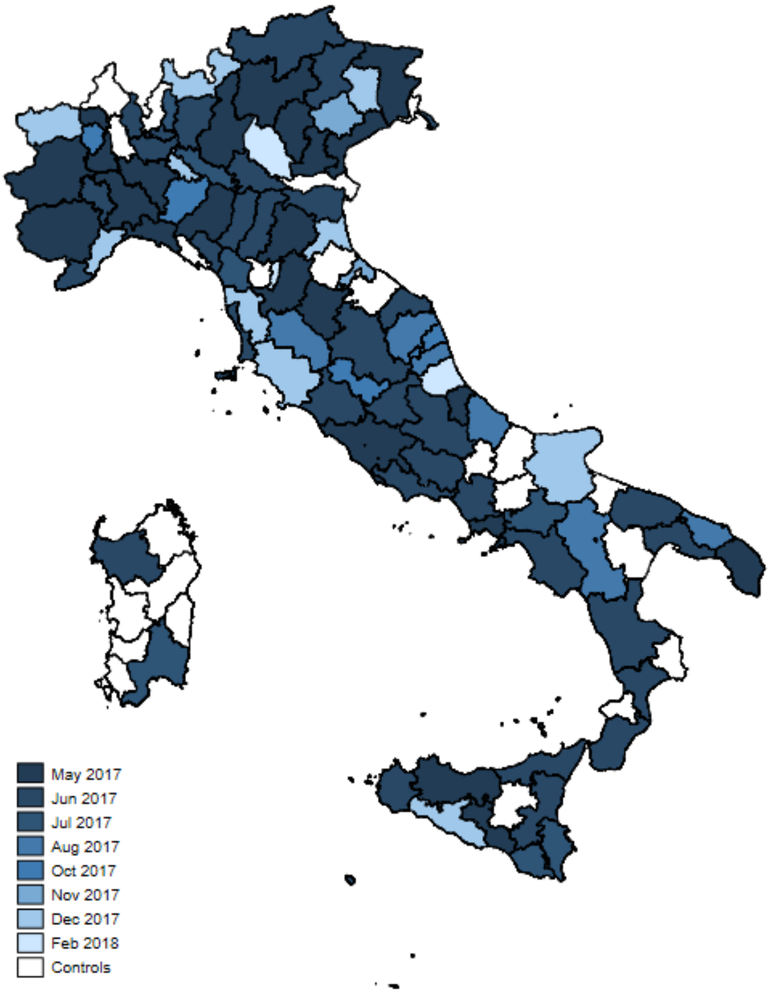
Figures and Tables

Figure 1. Google Trends Queries on "cannabis light" and "cannabis light + anxiolytics" in Italy



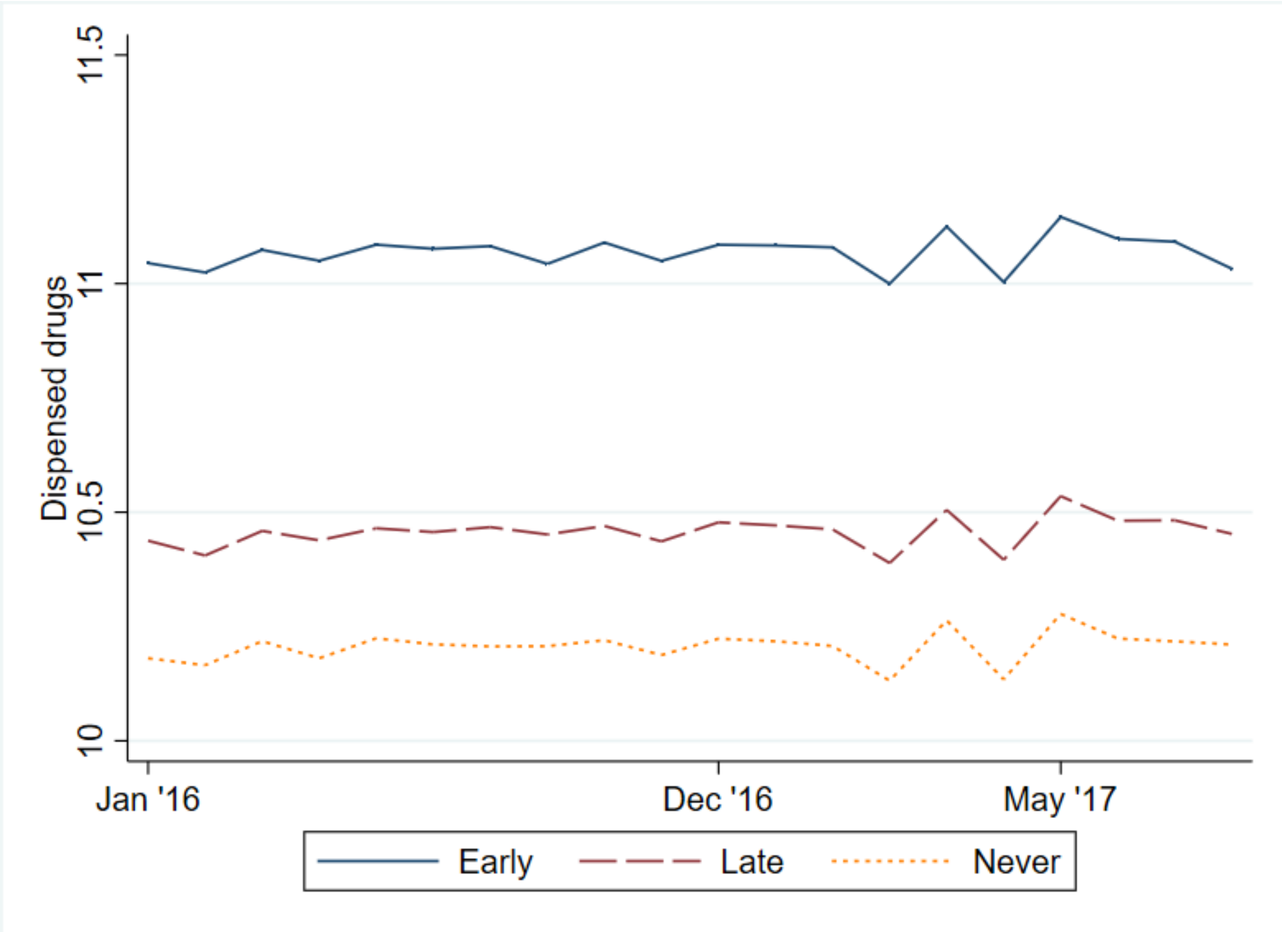
The figure presents the number of Google Search queries on "cannabis light" and "cannabis light + ansiolitico (anxiolytics)" in Italy during the period we considered. In May 2017, when the product was announced, the number of queries peaked and the number of queries remained at a higher level in the subsequent period.

Figure 2. Timing of local availability of light cannabis



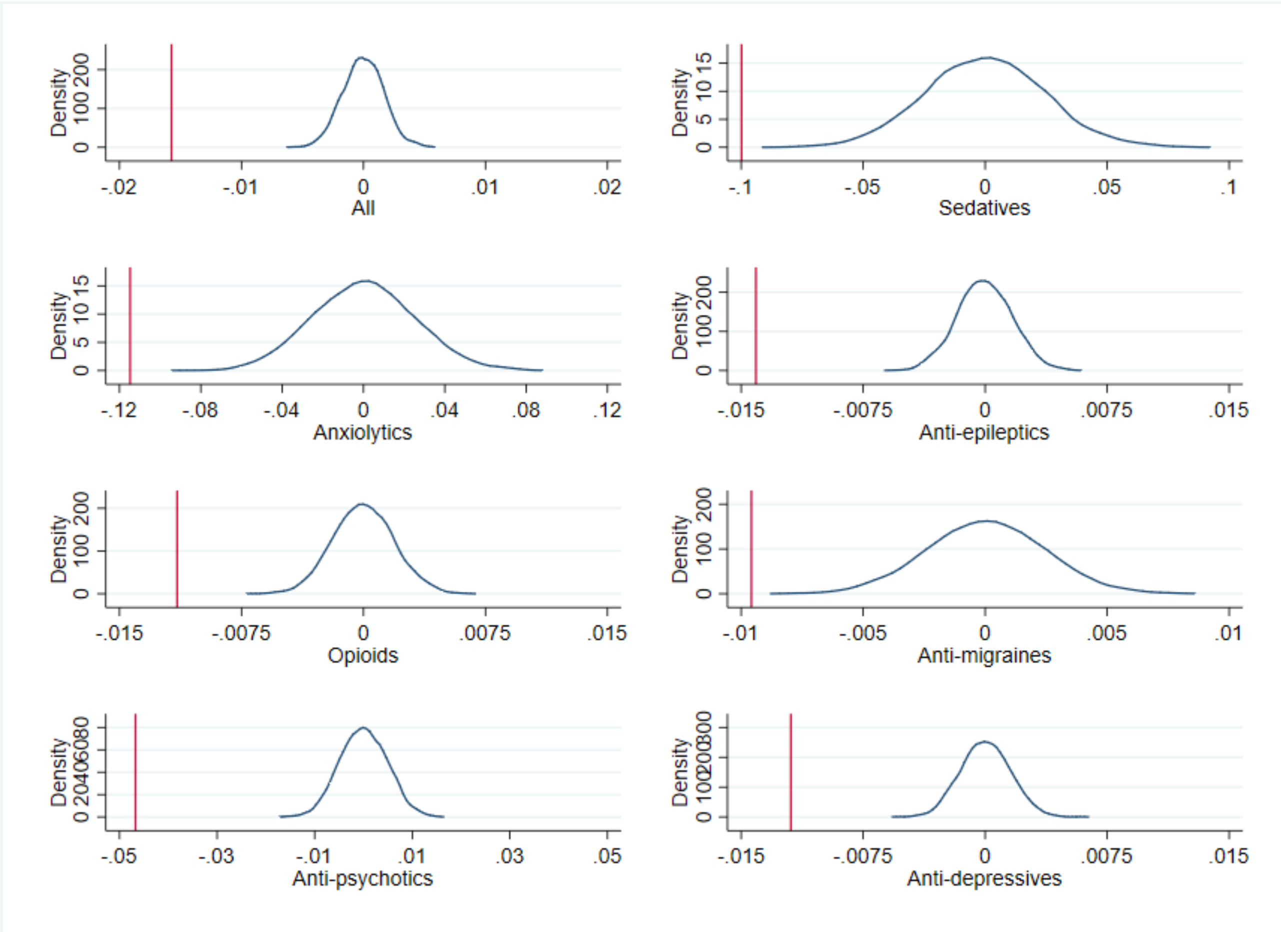
The map reports the different timing of local availability of light cannabis in the 106 provinces we consider starting from May 2017. Data are retrieved from the Internet Wayback Machine Archive.

Figure 3. Common trend



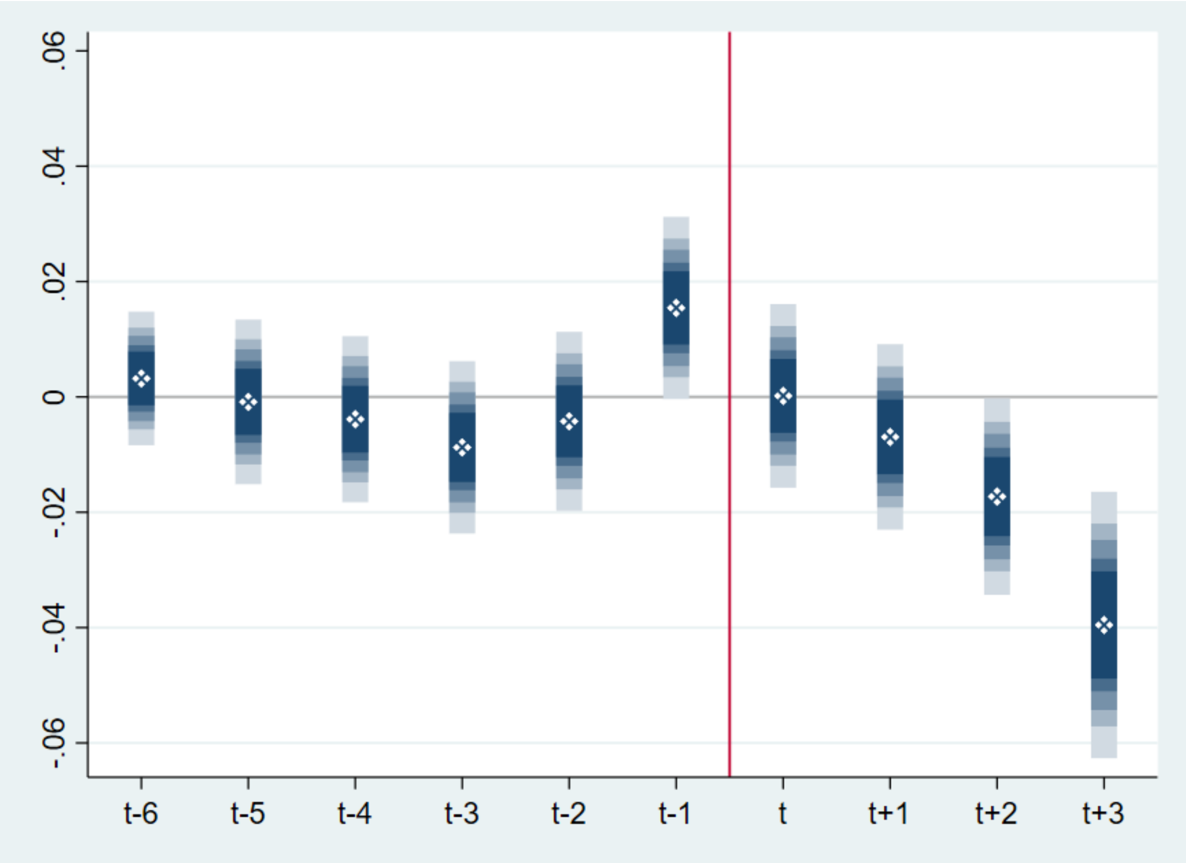
The figure presents the trends in all dispensed drugs for provinces exposed to early, late and no local accessibility to light cannabis. Early entry refers to local availability during the first 5 months after the first entry (between May and September 2017). Late entry refers to local availability during the last 5 months we observe, that is between October 2017 and February 2018.

Figure 4. Randomization inference



The figures show the distributions of the placebo estimates based on 5,000 permutations for all out outcomes, separately. The vertical red lines represent the estimated coefficients in our baseline specification in Table 2.

Figure 5. Event study



The figure presents an event study of the effects of local availability (represented by the red vertical line) on all dispensed drugs. One-month pre-entry is the excluded dummy for each dimension and is set equal to zero.

Table 1. Descriptive statistics

Variable	*Description*	*Mean*	*Std. Dev.*
Sedatives	Monthly number of dispensed sedatives and hypnotic drugs per province (boxes)	28.20	109.73
Anxiolytics	Monthly number of dispensed anxiolytics per province (boxes)	72.52	359.45
Anti-epileptics	Monthly number of dispensed anti-epileptics per province (boxes)	18,459.67	21,474.39
Opioids	Monthly number of dispensed opioids per province (boxes)	12,610.91	13,065.20
Anti-migraines	Monthly number of dispensed anti-migraines per province (boxes)	2,504.26	2,626.09
Anti-psychotics	Monthly number of dispensed anti- psychotics per province (boxes)	4,802.44	5,903.55
Anti-depressives	Monthly number of dispensed anti-depressives per province (boxes)	27,198.25	26,290.68
Nr. Observations	106 provinces X 26 months	2,756	

Note: data are made available by Federfarma for all "Classe A", category "N – Nervous System" drugs dispensed by the Italian NHS.

Table 2. Differences-in-Differences regression

	(1) All	(2) Sedatives	(3) Anxiolytics	(4) Anti-epileptics	(5) Opioids	(6) Anti-migraines	(7) Anti-psychotics	(8) Anti-depressives
DiD	-0.016***	-0.095*	-0.114**	-0.015***	-0.012**	-0.009*	-0.048**	-0.012***
	0.004	*0.053*	*0.055*	*0.004*	*0.005*	*0.005*	*0.018*	*0.003*
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes	yes	yes	yes
Province FE	yes	yes	yes	yes	yes	yes	yes	yes
N	2,756	2,756	2,756	2,756	2,756	2,756	2,756	2,756

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

Table 3. Robustness checks: parameter estimates

	(1) All	(2) Sedatives	(3) Anxiolytics	(4) Anti-epileptics	(5) Opioids	(6) Anti-migraines	(7) Anti-psychotics	(8) Anti-depressives
Shorter time window	-0.016***	-0.115**	-0.123**	-0.015***	-0.011**	-0.010**	-0.043**	-0.012***
	0.003	*0.054*	*0.058*	*0.004*	*0.004*	*0.005*	*0.018*	*0.003*
Linear trend	-0.016***	-0.100*	-0.115**	-0.014***	-0.011**	-0.010*	-0.047**	-0.012***
	0.004	*0.052*	*0.055*	*0.004*	*0.005*	*0.005*	*0.018*	*0.003*
Province-trend	-0.017***	-0.186**	-0.157*	-0.018***	-0.019***	-0.012**	-0.020	-0.011***
	0.003	*0.076*	*0.093*	*0.003*	*0.004*	*0.005*	*0.013*	*0.003*

Log transformation of the dependent variable. S.E. clustered at the province-level in italics. ***, **, * indicate statistical significance at 1%, 5% and 10%, respectively. The first row reports the estimates of the DID coefficient considering a shorter time window (May 2016 – February 2018). The second row reports the estimates of the DID coefficient in presence of a linear trend. The third row reports the estimates of the DID coefficient in presence of a province-specific trend.