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CANNABIS USE INTERRELATIONS : LESSONS IN MARKET DESIGN

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Abstract

Over the past few decades, the cannabis policy paradigm has been changing substantially, with most Western countries allowing its medical use. There are even experiments of full legalization with adults legally purchasing cannabis for recreational purposes in Uruguay, Canada and 21 American states. Elsewhere, the German and Maltese governments are poised to legalize cannabis for non-medical use. The basic question is no longer whether countries should legalize cannabis, but what specific policy the country should adopt in order to maximize social welfare.

Given the lack of consensus on how to optimally legalize cannabis, legal frameworks have developed idiosyncratically depending on policy goals and local contexts. While a basic legal guidance emerged from the experience of other addictive substances, cannabis regulation is a much more complex policy challenge, given its product heterogeneity and the differential harms caused by its consumption across different types of users. When it is over-consumed, it can inflict harm to the users and others by producing what economists would call negative internalities (harm to oneself) and externalities (harm to others). On the contrary, when cannabis is used as a medicine, it can improve the quality of life and become indispensable for individuals suffering from certain medical conditions. In the midst of these extreme purposes, there is the spectrum of wellness and the industrial uses of potential economic and environmental interest as substitutes of existing materials and ingredients.

The thesis explores a major distinctive feature which characterizes the legal framework of cannabis distribution: the existence of multiple interrelated markets operating with different regulations, but that can often satisfy consumer demand interchangeably. Based on the expected purpose of use, analogous cannabis-based products are supplied in different distributional channels characterized by substantially different transaction costs for consumers.

Thus far, economists have analyzed the functioning of the legal cannabis framework by focusing on the single most famous cannabis sub-market which is the illicit (or black) market. However, once an object is legitimated, there are other markets that are created whose demand is not represented by individuals who deviate with problematic use, but from patients and other consumers that find utility from its consumption. This thesis is thus the first attempt to systematically examine the legal cannabis markets comprehensively and to consider how supply architecture and taxation (or subsidies) of one market can affect the others. This deep examination is needed to identify market distortions and in turn find the regulations which produce the optimal level of economic efficiency while minimizing the public health harms.

The first chapter introduces the theoretical framework, describes the distortions present in the cannabis markets, and concludes with an overview of design options to reduce market failures. The second chapter defines the boundaries of medical cannabis by comparing the European and the American models. The third chapter examines a legal cannabis market with separate medical and recreational distribution to investigate their degree of interrelation and the conditions under which these markets can co-exist. The fourth chapter presents a supply architecture which would theoretically increase efficiency by minimizing the costs derived from this interrelation for the health systems while maximizing product diversity. The fifth chapter is an analysis of the light cannabis market in Italy and France through self-collected survey data to examine its interrelation with other cannabis sub-markets, including illicit and licit substances such as tobacco, alcohol and medications. The final chapter concludes with additional policy recommendations for cannabis reforms.

In this thesis, I set out the arguments for differential policy interventions across cannabis markets, based on expected harms, and outline directions to improve the market design through taxation, licensing and supply distribution. Considering the available evidence, I outline the challenge in finding relevant theoretical arguments to support the same regulation across cannabis markets which characterized by different purpose of use, supply chain organization and degree of preference heterogeneity. Most importantly, I conclude that there is no compelling reason to propose a binary choice in terms of medical or recreational markets, considering the large extent of users who fall in between this distinction. A recommended action would be adopting a user-controlled discrimination scheme, which targets different type of users through specific transaction costs and minimizes the illicit market and other consumption distortions.

Overall, this thesis will contribute to the understanding of how cannabis regulations affect markets and advance the economic theory of drug policy by building on microeconomic tools such as industrial organization and two-part tariffs with an institutional approach. Its contribution will extend to the institutionalization of other commodities with intoxicating potential, such as other forms of herbal medicine.

Keywords : cannabis economics, marijuana, market design, cannabis legalization, medical cannabis, light cannabis, cannabidiol, hemp, multi-purpose commodities.

Résumé

Au cours des dernières décennies, le paradigme de la politique du cannabis a considérablement évolué et la plupart des pays occidentaux autorisent son usage médical. Certains pays comme l'Uruguay, le Canada ou encore 14 États américains font l'expérience de la légalisation totale du cannabis, permettant aux adultes d'acheter ce produit à des fins récréatives. Ailleurs, les gouvernements mexicain et allemand sont sur le point de légaliser le cannabis pour un usage non médical. La question fondamentale n'est plus de savoir si les pays doivent légaliser le cannabis, mais quelle politique spécifique le pays doit adopter afin de maximiser le bien-être social.

Étant donné l'absence de consensus sur la manière de légaliser le cannabis de manière optimale, les cadres juridiques se sont développés de manière idiosyncratique en fonction des objectifs politiques et des contextes locaux. Alors qu'une orientation juridique de base a émergé de l'expérience d'autres substances addictives, la réglementation du cannabis est un défi politique beaucoup plus complexe étant donné l'hétérogénéité de son produit et les préjudices différents causés par sa consommation selon les différents types d'utilisateurs. Lorsqu'il est surconsommé, il peut infliger des dommages aux utilisateurs et aux autres en produisant ce que les économistes appellent des internalités (dommages à soi-même) et des externalités (dommages aux autres) négatives. Au contraire, lorsque le cannabis est utilisé comme médicament, il peut améliorer la qualité de vie en devenant indispensable pour les individus souffrant de certaines conditions médicales. Au milieu de ces cas extrêmes, il y a le spectre du bien-être et des utilisations industrielles présentant un intérêt économique et environnemental potentiel en tant que substituts de matériaux et d'ingrédients existants.

La thèse explore un trait distinctif majeur qui caractérise le cadre légal de la distribution du cannabis: l'existence de multiples marchés interdépendants fonctionnant avec des réglementations différentes, mais qui peuvent souvent satisfaire la demande des consommateurs de manière interchangeable. En fonction de l'objectif d'utilisation prévu, des produits analogues à base de cannabis sont fournis dans différents canaux de distribution caractérisés par des coûts de transaction sensiblement différents pour les consommateurs.

Jusqu'à présent, les économistes ont analysé le fonctionnement du cadre légal du cannabis en se concentrant sur le sous-marché du cannabis le plus connu, à savoir le marché illicite (ou noir). Pourtant, une fois qu'un objet est légitimé, d'autres marchés sont créés dont la demande n'est pas représentée par des individus ayant un usage problématique, mais par des patients et d'autres consommateurs qui trouvent une utilité à sa consommation. Cette thèse est donc la première tentative d'examiner systématiquement les marchés légaux du cannabis de manière approfondie afin de considérer comment l'architecture de l'offre et la taxation (ou les subventions) d'un marché peuvent

affecter les autres marchés. Cet examen approfondi est nécessaire pour identifier les distorsions du marché et, à son tour, trouver la réglementation qui produit le niveau optimal d'efficacité économique tout en minimisant les dommages à la santé publique.

Le premier chapitre présente le cadre théorique décrivant les distorsions présentes sur les marchés du cannabis, et se termine par un aperçu des options de conception visant à réduire les défaillances du marché. Le deuxième chapitre définit le périmètre du cannabis médical en comparant les modèles européen et américain. Le troisième chapitre examine un marché légal du cannabis qui sépare la distribution médicale et récréative afin d'étudier leur degré d'interrelation et les conditions dans lesquelles ces marchés peuvent coexister. Le quatrième chapitre présente une architecture d'approvisionnement qui, en théorie, augmenterait l'efficacité en minimisant les coûts dérivés de cette interrelation pour les systèmes de santé, tout en maximisant la diversité des produits. Le cinquième chapitre est une analyse du marché du cannabis léger (ou du CBD) en Italie et en France par le biais de données d'enquête auto-collectées afin de mettre en évidence son interrelation avec d'autres sous-marchés du cannabis, mais aussi avec des substances illicites et licites comme le tabac, l'alcool et les médicaments. Le dernier chapitre conclut en fournissant d'autres recommandations politiques pour les réformes du cannabis.

Dans cette thèse, je tente d'exposer les arguments en faveur d'interventions politiques différentielles sur les marchés du cannabis en fonction des préjudices escomptés et j'esquisse quelques pistes pour améliorer la conception du marché par le biais de la taxation, de l'octroi de licences et de la distribution de l'offre. Compte tenu des preuves de recherche disponibles, je conclus qu'il est difficile de trouver des arguments théoriques pour soutenir la même réglementation à travers les marchés du cannabis caractérisés par différents objectifs d'utilisation, l'organisation de la chaîne d'approvisionnement et le degré d'hétérogénéité des préférences. Plus important encore, je soutiens qu'il n'y a pas de raison impérieuse de proposer un choix binaire en termes de marchés médicaux ou récréatifs, compte tenu du grand nombre d'utilisateurs qui se situent entre les deux. Une façon raisonnable d'avancer serait d'adopter un schéma de discrimination contrôlé par l'utilisateur et ciblant différents types d'utilisateurs par le biais de coûts de transaction spécifiques afin de minimiser le marché illicite et les autres distorsions de consommation.

Dans l'ensemble, cette thèse contribue à la compréhension de la manière dont la réglementation du cannabis affecte les marchés pour faire progresser la théorie économique des politique en matière de drogues en s'appuyant sur des outils microéconomiques tels que l'organisation industrielle et les tarifs binômes avec une approche institutionnelle. Sa contribution s'étendra à d'autres marchandises à potentiel intoxicant telles que d'autres plantes médicinales.

On stage we find: Rosetta, the mother, and Grandfather.
(...)
There is a knock at the door and the voice of a young man in his early twenties calling. It is Luigi, Rosetta's son.

LUIGI: (from outside) Mother, Grandfather, are you home? Come in!

GRANDFATHER: (wincing) Your son!

ROSETTA: (general commotion) And throw out 'this fag...open the window let it be current! (...)

Enter Luigi, no more than twenty years old. (...)

LUIGI: From outside I thought I heard a big commotion as if... What's that smoke?

ROSETTA: Ah, yes, Grandpa and I started smoking again... but not much.
A few cigarettes after we ate....

LUIGI: And you were sleeping and smoking a cigar?

ROSETTA: That's it, good Luigi, you tell him, too, that it's dangerous to smoke when you're asleep!
But he won't! He'll set our house on fire! He says smoking helps him fall asleep....

LUIGI: But no, this doesn't smell like a cigar, a smell I know... this smell like hash!

ROSETTA: Smell of what?

LUIGI: But yes... Can't you smell this background like licorice mixed with horse dung?

ROSETTA: Dad, did you smoke a horse dung cigar?

GRANDFATHER: Maybe... you know nowadays they put everything in cigars, even tobacco.

LUIGI: Come on, grandfather, that's enough! And you too, mom! Let's cut it out!
Here, someone has smoked hash.

ROSETTA: What?! And who would that "someone" be? I mean, are you crazy?
Now it turns out your mother and grandfather are on drugs? Look at the way you talk, you know!
If you came to the house to throw dung on us -- and not just horse dung....
You stay out ten days, you don't even give notice....
you do your own thing, and then you come home to offend!
But who do you think you're talking to, your friends of the gang...?
Maybe with those jaded groupie hats?

LUIGI: There you go, the usual racism against the big hats! (...)

GRANDFATHER: Look, don't be a smart ass. Besides ... you've offended us ...
you said your horse shit drug bullshit... at least admit it!

LUIGI: Sorry... Whatever, I must have been wrong...
maybe you burned something that smelled like it. (...)

ROSETTA: Rather how come that you know all this stuff about the smell of hashish?

LUIGI: Well, I smelled it a few times in the factory, in the toilets...
there was a guy who always went to smoke there. He smoked marijuana, too.

ROSETTA: A worker?!

LUIGI: Yes.

ROSETTA: A debauched worker?

LUIGI: What a weakling! a very good comrade, one of the works council!

ROSETTA: And he smokes hash and marijuana?!

LUIGI: Yes.

ROSETTA: What's this, a new requirement for making a union? Ah, that's what Lama smokes in that pipe he always has in his mouth: he rallies and pipes, he talks on television and pipes;
he even pipes when he makes love, what a union junkie!

LUIGI: Mom, cut it out with this "junkie"! You tar everyone with the same brush!
I already told you last time when we had the discussion: the word "drug",
the bosses invented it and they use it whenever it suits them....
When it suited them, they even called chocolate a drug.
A few centuries ago in England and Spain they put in jail as drug addicts
everyone who drank coffee because they needed a certain game....
and in Russia, in the time of the czars, peasants who got caught smoking a cigar
they would cut off their lips with vine shears! (...)

LUIGI: And now they need the drug game to make a fuss inside the crisis
and sting us better in the factory.

ROSETTA: Is it possible that everything has to be thrown into politics, you?

LUIGI: Of course politics! How come they make such a fuss about marijuana
and they don't say anything or almost, about the 70,000 deaths from tobacco
and the 30,000 from alcohol.... not to mention all the alcoholics in asylums....
And how come they don't say anything about legalized barbiturates:
eight hundred and fifty deaths a year? Those are drugs you don't touch, huh? (...)

LUIGI: Crazy that someone like you, Mom, who still falls for these scientific hoaxes!
I mean, you're a nurse.... At least about the fact that it does worse to your health a bottle of whiskey
than a joint of marijuana...you should know that!

ROSETTA: Of course, I must say that in hospitals, on 'this drug thing there is a great confusion (...)
Even the professors don't know much about it : they say.
"a complex subject...psychotropic drugs, hallucinogens....
very interesting, but complex..." and away they go.

Dario Fo (1975), Nobel Prize winner in Literature

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Summary

CHAPTER ONE

1. THE CANNABIS MARKET INTERRELATIONS

Abbreviations

CSC	Cannabis Social Clubs
C-light	Light Cannabis
CBD	Cannabidiol
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
MC	Medical Cannabis
THC	Tetrahydrocannabinol
UNODC	United Nations Office on Drugs and Crime

1.1. Cannabis plants and their emerging markets

Cannabis is the most widely-used illegal substance in the world. However, it remains surrounded by confusion. The term is commonly used to refer to the dried flowers and the leaves of the species *cannabis sativa,* but also to the plant itself. Its seeds and fiber have been used for centuries to produce food and industrial products, including rope, textiles, shoes, paper. More recently, it has been also used for bioplastics, biochemicals, energy and insulation. In the previous century, scientists found that its flowers and leaves contain concentrated amounts of psychoactive chemicals known as cannabinoids, whereby the amount and intoxication properties vary with the genetic. It may have euphoric effects, or it may just relax your muscles. It might work as a depressant or as a stimulant. Its effects can lower the labor productivity of some users, whereas some children consider it indispensable for treating the symptoms of their epilepsy.

Besides cannabinoids, leaves and flowers are the source of other active ingredients, such as terpenoids and flavonoids. These compounds are not intoxicants, but they characterize the aroma and are important for the overall effect perceived by consumers. Furthermore, there are potential synergistic effects between the various chemical entities present in the flowers. These have been defined as the entourage effect: the summation of effects from different compounds is greater than the sum effect of the individual molecule. In other words, clinical observations have suggested that whole plant extracts have higher efficacy and/or lower side effects compared to the sum of isolated compounds extracted from plants or synthetically produced (Gallily et al., 2015; Blasco-Benito et al., 2018; Pamplona et al., 2018; Russo, 2019). Other studies have shown also that cannabis users are affected differently by the same cannabis chemotype (Atakan, 2012; Brunt et al., 2014), but also that different chemotypes have different rates of efficacy across the same medical condition (LaVigne et al., 2021).

In table 1, we distinguish four types of legal cannabis markets with distinct characteristics: first, the market for industrial hemp, which uses fibers to produce raw materials for industrial uses; second,

the medical (or therapeutic) market for patients, which comprises of flowers or other cannabis derivatives that may have intoxicating properties and whose access requires a prescription or a recommendation from a physician; third, the well-known market for adults, which identifies the use of flowers or derivatives with intoxicating properties; and lastly, the market for light cannabis (C-light), which identifies the use of seeds or flowers with non-intoxicating properties for human consumption[1].

C-light contains low levels of THC, but high content of non-intoxicating compounds – such as cannabidiol (CBD) - with a plethora of potential benefits for humans (White, 2019). The emergence of the C-light market was unexpected, as low-THC flowers were not considered an attractive substance until being classified as tobacco substitutes in Switzerland (Zobel, 2019). In the EU, their sale is generally not prohibited by drug laws, unless its THC content is higher than the legal threshold. C-light is often branded as 'legal cannabis', and this institutional legitimation triggered the development of a new industry that provides a range of CBD-based products, such as oils, cream and lotions. Currently, C-light products are sold by specialized hemp shops, tobacco shops and other retailers across Europe (EMCDDA, 2020). Overall, the creation of this market came as a result of the constant evolution of the cannabis industry, which is in turn changing the nature of the product by adapting to evolving regulation in order to satisfy consumer preferences.

TABLE 1
The cannabis markets

Type of Market	Expected Demand	Intoxicating potential	Entourage Effect	Type of good	First Regulation
Industrial hemp	Transformation firms	No	Does only apply to human use	Search good	Never banned in certain countries
Light (or CBD)	Humans	No	Sometimes	Experience good with credence quality	Switzerland (2016)
Medical (or therapeutic)	Patients with physician's prescription or recommendation	Sometimes	Sometimes	Experience good for *medical patients*. Experience good with credence quality for *therapeutic patients*	California (1996); EMA's cannabis-based medication (2019)
Adult (or recreational)	Adults	Yes	Yes	Experience good	Uruguay (2013)

Notes: The type of goods are defined using classification *a là* Phillip Nelson's (1970), Darby and Karni (1973) and McCluskey (2000)

[1] As of 2022, the legal boundaries of industrial hemp and the C-light market overlap in most countries (e.g. US).

1.2. From prohibition to regulation: the new policy paradigm

Over the last 50 years of prohibition, most countries that signed the UN Single Convention have taken a softer approach towards the substance. This occurred not only through lower law enforcement, but also through radical market reforms. A growing number of jurisdictions have decriminalized the possession of small quantities in varying degrees by removing criminal penalties[2]. In 1996, Californians voted to allow patients to use cannabis for certain medical conditions. Following this, at least 50 countries have legalized the use of medical cannabis (MC) in some forms with sales to patients, whose conditions varies from severe to completely fictional, in most jurisdictions across the Americas and Europe. In 2020, the medicinal and therapeutic properties of cannabis were recognized by the UN through its descheduling. Since 2012, two countries and 21 US states have legalized the sales of recreational cannabis, resulting in at least 150 million individuals experiencing a fully legal regime.

While cannabis is still illegal at the federal level in the US, the adult market has been mostly legalized through citizen-initiated referenda[3]. Policymakers had to implement the ballot proposal, which imposed the adoption of a commercial system, with sales allowed in specialized licensed stores[4]. The for-profit model has been designed with reference to the existing MC market which operates in parallel with the recreational in most states. Globally, only two countries have legalized the recreational market for cannabis, but have chosen different models to regulate its supply[5]. Uruguay was the first to remove the prohibition by choosing two middle-ground options: pharmacies and Cannabis Social Clubs (CSCs) (Cerdá and Kilmer, 2017).

CSCs are a non-commercial supply model, which exist in different forms in other South-American as well as European countries. In Canada, provinces and territories are responsible for their retail model, with distribution through government-operated and/or licensed retail stores. In most jurisdictions, two additional supply channels are available: domestic small-scale cultivation and online sales. Both of them are allowed in Canada, whereas Uruguay and most American states only allow home cultivation — up to a certain number of plants (Lancione et al., 2020).

[2] See Stevens et al. (2019) for a review of the alternatives to criminalization for drug possession.
[3] Only recently, New York, Connecticut, Illinois, Rhode Island, Vermont, Virginia and New Mexico have legalized cannabis through the legislative process. See Obradovic (2021) for a review of the legalization process across states.
[4] See Lancione et al. (2020) for a review of the differences in recreational cannabis regulations across US states.
[5] See Kilmer and Pacula (2017) for a review of cannabis supply legislation.

Scholars argue that the legal classification of a drug as 'narcotic' is a function of its social and cultural determination, rather than its inherent properties (Bergeron and Nouguez, 2015). Today, dispensaries have opened in most US states with MC reforms, whereby adults may legally purchase 'cannabis' products with an appropriate referral from an accredited health care provider. The legitimacy of MC has fundamentally undermined the rationale of prohibition, which is that cannabis use is harmful to health at any intensity. As a consequence, cannabis has become normalized in Western society, evolving from a *drug* to a *medicine* (Duff, 2016). Indirectly, these reforms additionally affect the market for industrial hemp by removing the red tape caused by its resemblance to intoxicating cannabis. Given its environmental potential, hemp may get back to its historical status as *agricultural commodity* competing as an input for different industries. Considering the powerful influence of the US in global drug policy and the increased acceptance of adult cannabis use, policymakers are being increasingly challenged to re-evaluate the current prohibitionist approach.

Since the share of citizens asking for a cannabis market reformation has become the majority in some jurisdictions, the status of cannabis is moving towards unexplored fields. Cannabis was used mainly as a medical plant, and its subsequent prohibition is a phenomenon common to other contested commodities throughout recent history[6]. First, there is a free market for the product; second, the adverse effects of free market lead to a regulation, which eventually becomes a full prohibition[7]. What has happened over the previous decades is therefore quite unique[8]. There is a reversal of the phenomenon, and the status of cannabis is in fact being re-institutionalized as legal not only medically and recreationally, but even for wellness purposes (Subritzky, 2018).

1.3. A potentially harmful multi-purpose commodity

> *Cannabis now describes at least three objects: a medicine, a commodity and a poison, then legal, social, political and medical responses to the drug arguably need to adopt more tailored responses to each of these different entities (Duff, 2017; p. 688).*

To some extent, the consumption of almost any good can be harmful. Too much eating leads to obesity, driving cars leads to accidents, alcoholism leads to liver damage and smoking tobacco leads to lung cancer (Pudney, 2010). Opioid misuse is considered as the major factor decreasing life expectancy in the US (Muenning et al., 2018). Given the potential public health risks stemming from

[6] For instance, imports of ivory in Western countries were banned after a dramatic reduction in most African elephant populations caused by poaching to supply the international trade (Barnes, 1996).
[7] For psychoactive substances, concerns related to free trade mostly stem from the lack of product safety controls, the risk of overdose and the potential abuse.
[8] The phenomenon is only slightly comparable with alcohol prohibition in America, as that ban lasted only 13 years.

their abuse, the market of these 'sin goods' is strictly regulated using policy instruments that impose greater transaction costs (e.g. taxation, entry barriers) to minimize their over-consumption.

Regulators have treated cannabis similarly, with approaches taken from the alcohol industry – the benchmark framework for addictive substances (Hall, 2017). The intoxicating properties of cannabis have attracted many individuals to its recreational consumption and might be considered similar to those of alcohol and other illicit drugs[9]. Nevertheless, the multi-purpose nature of cannabis makes it a different type of commodity. The plant is used medically as the cannabinoid system – a group of cannabinoid receptors and their ligands – may be modulated by exogenous cannabinoids. This system has been found to be involved in a variety of physiological processes and brain functions, including appetite, pain-sensation, learning, memory, emotion, and motivated behavior and metabolic disorders (National Academies of Sciences, Engineering, and Medicine, 2017). As a consequence, there has been an explosion of scientific research on MC potential, concluding that a functional cannabinoid system is essential for health (Treister-Goltzman et al., 2018; Ng and Chang, 2022). Besides its therapeutic purposes, there is a whole spectrum of wellness and technical uses derived from industrial hemp, a non-intoxicating type of *Cannabis sativa* L[10]. The thousands of potential uses for the output of cannabis plant make its regulation extremely complex. The same plant may be harvested for extremely different purposes, such as seeds for foodstuffs or wall paint; hurdles for animal bedding; flowers and leaves for food supplements or pharmaceuticals; and fiber for cellulose pulp or industrial manufacturing. Conversely, the plants used to obtain alcohol and tobacco are harvested mostly to obtain intoxicating outputs (e.g. wine, beer, cigarettes)[11]. Overall, the existing regulation related to cultivation practices and quality standards is failing to recognize the relevance of the expected purpose of use. Together, regulatory models that fail to consider the multi-purpose nature of cannabis will be unable to optimally regulate the market.

Industrial hemp has been historically most affected in the legal market by the existence of a parallel market for cannabis. Regulations often do not take into account that the intoxicating potential of hemp is only comparable to products freely accessible at an herbalist. As a result, it is common to hear law enforcement agencies celebrating dozens of kg seized from illicit traffickers which will later be classified as legally produced C-light[12]. In the EU, the legal status depends on the variety of hemp seeds used in cultivation, which need to be certified to produce an output with a THC content lower than the legal limit of 0.2%. This type of classification, based on both certified varieties and THC

[9] Becker (1963) considers the desire of change in perception as an aspect of human nature.
[10] See Fortenbery and Bennett (2004) for a review on the economics of industrial hemp.
[11] Sometimes includes foodstuffs (e.g. vinegar).
[12] This occurred both in France (LaProvence, 2020) and in Italy (MattinoPadova, 2019).

threshold, is generally used only in the EU, with only the latter being considered abroad. This system incentivizes oligopolistic behaviors, as it restricts the varietal choice of farmers (Parenty, 2018). In parallel, the United Nations Office on Drugs and Crime (UNODC) (2009) have been recommending that a distinction be made between cannabis with a psychotropic effect and industrial hemp on the basis of indices concerning the reciprocal levels of THC, CBD and cannabinol.

Compared to other agricultural multi-purpose commodities (e.g. wheat, corn), industrial hemp has the unique issue of being affected by the stigma derived from being generally identical in appearance to the intoxicating type of cannabis and with similarly smelling flowers. Nevertheless, when the concentration of THC is below the intoxicating threshold, the product may be considered similarly to any non-alcoholic beverage, given its expected lack of psychotropic properties. Despite this, most countries which allow industrial hemp have a set licensing system for legal cultivation.

There is another major characteristic that differentiates cannabis from both traditional commodities and other legal psychoactive substances – the latter have no apparent medical utility. In contrast, cannabis is considered clinically and anecdotally as a broad-spectrum painkiller – one that could safely be used to treat multiple chronic-pain conditions[13]. Recently, it has been found that C-light can be as effective as intoxicating cannabis in many medical conditions without the intoxicating effect.

While no apparent harms are associated with the market of C-light and MC, the opposite is true for the non-medical consumption of cannabis. The existing evidence is consistent with claims that it may entail either externalities through the interactions of users with others, or internalities when users are unaware of harm their future health. For example, external social costs may be imposed on individuals who do not consume cannabis such as second-hand smoke, impaired driving and higher healthcare expenditure. Moreover, there may also be internalities stemming from heavy cannabis use. In addition to leading to cognitive and motor impairment, it also appears to negatively affect both school performances and brain development on adolescents (Crean et al., 2011; Marie and Zölitz, 2017; Prashad and Filbey, 2017; Volkow et al., 2014; Wright and Krieg, 2018). Another potential harm to physical health includes lung disease as a consequence of smoking, particularly in combination with tobacco. Other reasons of concern relate to mental health, which appears to be poorer in a individuals using cannabis in comparison to the general population. The evidence linking cannabis use to the onset of psychosis is still unclear, as predisposing genes appear to be of significant importance (Di Forti et al., 2019). There is, however, consensus in relation to the differential risk among cannabis

[13] See Hall (2019) for a review of the clinical evidence on medical cannabis. As of 2022, more than 5 million Americans have a recommendation from a physician to use MC. https://www.mpp.org/issues/medical-marijuana/state-by-state-medical-marijuana-laws/medical-marijuana-patient-numbers/

varieties. Risk of psychosis increases exponentially with high-THC flowers, and decreases with higher CBD content (Schubart et al., 2011). A number of studies have shown that CBD has the opposite effect of THC, both behaviorally and pharmacologically (Wall et al., 2019). Nevertheless, based on expert opinion on both internalities and externalities, Nutt et al. (2010) ranked cannabis as both less harmful as well as less addictive than other legal substances, such as tobacco and alcohol.

From a theoretical standpoint, rational addiction continues to be the benchmark model of demand for addictive goods (Becker and Murphy, 1988). It assumes that users recognize their addictive nature, therefore the decision to initiate and continue consumption maximizes their discounted utility. In view of behavior bias, however, economists have become more and more skeptical towards its theoretical validity (Rogeberg, 2020). The model has been extended over time to consider other instances of bounded rationality, such as social environment (Bernheim and Rangel, 2005). Certain consumers may indeed fail to consider the effect of their current consumption on future cannabis consumption, de facto justifying substantial regulation to reduce internalities. In particular, while the rational addiction model implies that the optimal taxation level should depend only on the externalities that their consumption imposes on society, subsequent models that take behavior biases into account suggest the setting of a higher tax dependent also on the internalities that its consumption imposes on certain users (Gruber and Koszegi, 2001).

1.4. The market interrelations of a multi-purpose commodity

Since the 90s, a number of countries have authorized the cultivation of industrial hemp, and the market of C-light has recently emerged alongside the interest of consumers for its compounds. Increasingly, countries have regulated the consumption of cannabis for medical purpose, with certain countries permitting the operation of the cannabis market for adults. Together, the new legal cannabis market can be significantly influenced by its interrelations with existing markets and by the relation between different cannabis sub-markets.

Market interrelations were not considered an issue when the cannabis trade was operating in a single illicit market. Before full legalization, the legal competition with the illicit market has been occurring through the institutionalization of two markets. The *first legal market* aimed to establish a supply side of MC for patients. Theoretically, only those suffering with a condition for which cannabis is effective can access this market through a physician's prescription or recommendation[14]. The *second legal*

[14] Even in US states that allow access to MC, physicians cannot prescribe and pharmacies cannot dispense MC. Instead, doctors provide recommendations to their patients, who then obtain MC through cooperatives and other dispensaries, or by growing it themselves or having a caregiver grow on their behalf. "Recommendations" tend to be far less specific than prescriptions, reflecting the limited knowledge in the area as well as complicated legal rules. It is rare for the recommendation to specify which materials should be used, in what quantity, and how often (Caulkins et al., 2016).

market competing with illicit cannabis traders was formed in Europe for C-light. Although drug laws have never explicitly banned it, its inherent properties were unknown by most consumers and suppliers. Hemp farmers have been long minimizing the utilization of flowers to differentiate their output from the intoxicating plant. Their aim has been to maximize the ability of law enforcements to distinguish their legal activities from those of illicit market players. In certain EU countries, hemp flowers still need to be discarded to obtain agricultural subsidies. The waste of a valuable part of the crop has been the result of the poor design of the cannabis marketplace, which has long impeded for market efficiency[15].

The International Standards Organization advises the adaptation of quality standards for cannabis based on the expected purpose of use. The lowest standards should be required for industrial use, while the highest standards should be upheld for the products used by patients for medical purposes. The requirements for other wellness purposes (e.g. food, cosmetics) should fall in the middle[16]. From a legal perspective, countries take a simpler classification by distinguishing between two types: non-intoxicant, which characterizes the output of hemp, historically grown for its seeds and fiber for industrial and food purposes, but sometimes also for the flowers to produce C-light; another intoxicating, which characterizes cannabis with high THC, used in the highly regulated medical and recreational market. Flowers from both types can have therapeutic effects, with efficacy varying according to the condition of the consumer (EMCDDA, 2018; Baram et al., 2019). As a result, the size of MC market will be influenced by the regulation not only of the recreational market, but also by the regulation of the market of C-light.

Taken together, the major distinctive feature of the newly legal cannabis market is the existence of multiple interrelated marketplaces, which operate with different legal frameworks and can often satisfy consumer demand interchangeably. Accordingly, the institutional reformation of cannabis markets and their delineation is not only a function of the final purpose of the product, but also of adjacent legal markets (Kjellberg & Olson, 2017).

C-light is the perfect example of this unique phenomenon. It can be classified into several categories, namely agricultural commodity, tobacco substitute, medicine, foods, narcotics, recreational drugs, or cosmetics. It can thus be purchased with different taxation and quality requirements in each legal market (EMCDDA, 2020).

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[15] At the beginning of prohibition, the inability to discriminate between intoxicating and non-intoxicating cannabis was the major reason for the drastic reduction of the areas cultivated worldwide. Once technology provided an efficient signalling device, the cultivated area has increased substantially, supported by customize machineries (Schluttenhofer and Yuan, 2017).

[16] Final recommendation of the ASTM symposium in Rome, 19th February 2019.

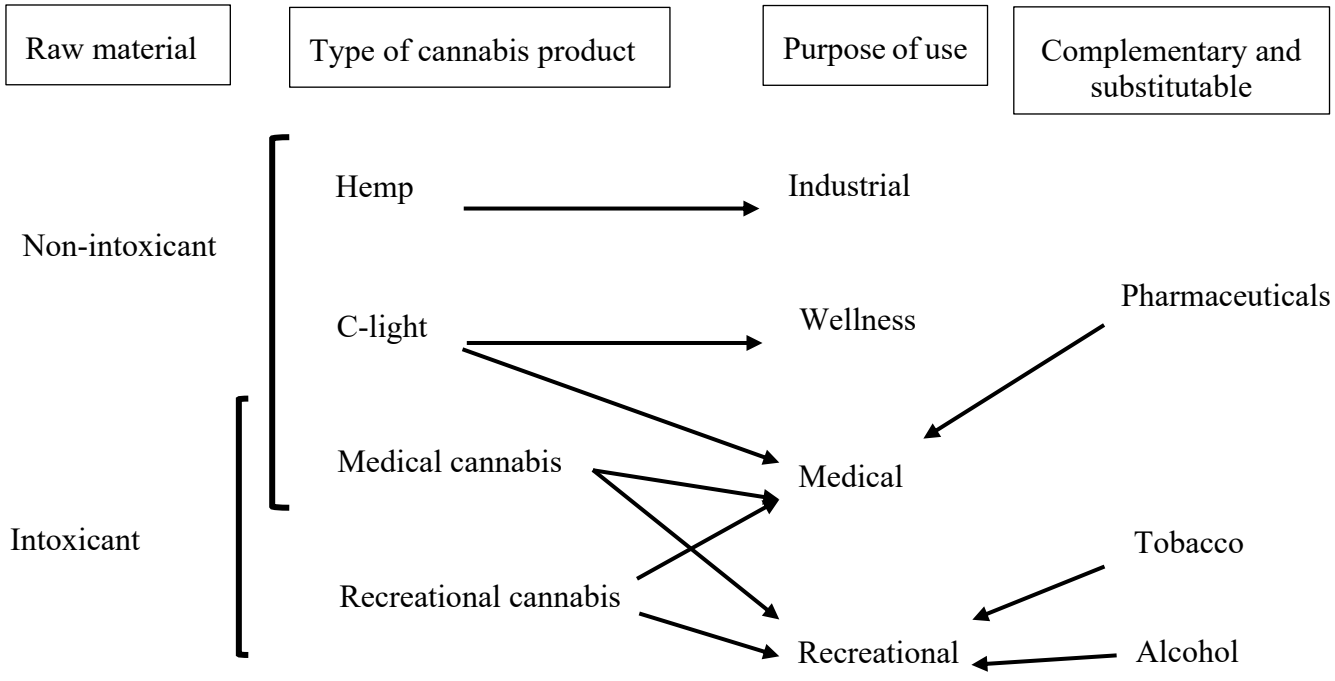
The multi-purpose nature of cannabis increases the adversity of its market formation, as it involves several interest groups with opposing interests. The substitutability across cannabis sub-markets, combined with the profit motive, leads industry groups to lobby to not only maximize the range of products that can be sold in their specific segment, but also to restrict the scope of other potentially competing markets. On the opposite side of the production, we find small hemp farmers and the pharmaceutical industry, with the latter lobbying for the highest requirements of product certification and to avoid its sale in herbal form; while farmers' prefer policies with a lower level of red tape. On the distribution side, there are numerous special interest groups which would like to sell cannabis products to the public, including herbalists, specialized shops, pharmacists, tobacco shops, and even supermarkets.

Beyond the differing cannabis segments, other industries for addictive substances have become involved in the cannabis sector, including alcohol, pharmaceuticals, and tobacco (Forbes, 2018). Kjellberg and Olson (2017) argue that these markets influence market reformation: first, the regulatory design (e.g. sin taxes, age restrictions, retail licenses, seed-to-sales tracking) and the necessity to monitor social costs are borrowed from the legal markets of these addictive substances; second, the black market is referenced as an inspiration on how to structure production to avoid "Big Cannabis". Interrelations are also enacted by claiming a potential effect of the legal cannabis market towards other exchanges. Its impact will be positive for certain markets (e.g. labor, cultivation equipment) and negative in others (illicit cannabis, alcohol, tobacco, pharmaceuticals).

Overall, the identification of specific interrelations is fundamental to optimizing the market design. In figure 1, the interrelation between raw material, type of product, purpose of use and other markets are presented. The types of products that can be derived from the plant *Cannabis sativa L.* are industrial hemp, C-light, medical cannabis and recreational cannabis[17]. The major interrelations arise from: the raw material (type of plant) used to produce them; the purpose of use (industrial, wellness, medical, recreational) and the legal framework (legal/illegal). Interrelations with other products that can play the role of complement or substitute (tobacco, alcohol, pharmaceuticals) will be also considered.

[17] http://www2.assemblee-nationale.fr/15/missions-d-information/missions-d-information-communes/reglementation-et-impact-des-differents-usages-du-cannabis/(block)/65681

FIGURE 1
The Cannabis Market Interrelations



1.4.1. Interrelations stemming from the raw material

The recent appeal of C-light to consumers has driven a parallel interest in the cultivation of industrial hemp. Despite the plant being traditionally cultivated for seeds and fiber, flowers have become the most valuable portion of the hemp plant. Some jurisdictions are indirectly recognizing the specific value of C-light flowers; however, this often occurs in a counterproductive manner. In certain EU countries, restrictive interpretations of hemp regulation based on the harvested part of the plant has discriminated flowers from the traditional output, requiring them to be discarded. In France, for example, the final purpose of use has become one of the indicators that identifies its legal status. In 2018, the Interministerial Mission for Combatting Drugs and Addictive Behaviors issued a precise reminder of the law which prohibited the sale of C-light flowers, in effect defining one-third of the plant as waste[18].

In 2019, even the Portuguese government began treating the cultivation of industrial hemp for flowers differently from other outputs by requiring an additional MC cultivation license[19]. In the Portuguese case, the increased red tape may exist because licensed MC producers want hemp cultivation to be

[18] https://www.drogues.gouv.fr/actualites/cannabidiol-cbd-point-legislation
[19] https://hemptoday.net/portuguese-suffer-licensing-problems/

located far apart to avoid cross-pollination of the two varieties (Malone & Gomez, 2019). In 2018, the legislation on MC restricted the potential outputs that can be grown from hemp farmers without a license.

It should be noted that hemp flowers are a much more complex output compared to the other commodities obtained by hemp (e.g. fibers and seeds), given the multitude of potential combinations of cannabinoids, where consumer preferences appear to be very heterogeneous. As a result, new varieties are continuously introduced into the market to increasingly match consumers' tastes (Russo, 2019). To facilitate innovation, legal status depends only on the THC content in most jurisdictions regulating hemp. On the contrary, the EU regulatory framework has the additional requirement that each variety must be registered to be legally cultivated. These requirements are applied regardless of whether it is used as an input for industrial uses by other firms or is sold directly to the final consumer[20]. The problem is that the genetic diversity and the type of demand differs substantially when hemp is used as a raw material for food or industrial use *and* when is used for herbal purposes due to plant breeding[21] (Dufresnes, 2017; Gilbert and DiVerdi, 2018).

De facto, the European system imposes a competitive disadvantage to farmers, particularly because the registration in the common catalogues of varieties of agricultural plant can take up to five years[22]. This catalogue lists the varieties that can be marketed across the EU countries and includes the plant varieties registered after being technically examined to meet standards on distinctness, uniformity and stability.

1.4.2. Interrelations stemming from the purpose of use

1.4.2.1. Medical and Recreational cannabis

"It would be like leaving a diabetic patient without insulin because it is illegal"
(Andrea Trisciuoglio, patient using cannabis as a treatment for multiple sclerosis).

The institutional framework of the legal cannabis market influences the access of patients to MC. Thus far, most jurisdictions which have amended their legislation only enacted policies which allow for its medicinal or therapeutic use. This trend is the outcome of two major scientific and legal

[20] https://ec.europa.eu/food/plant/plant_propagation_material/plant_variety_catalogues_databases_en
[21] Plant breeding uses principles from a variety of sciences to improve the genetic potential of plants. The process involves combining parental plants to obtain the next generation with the best characteristics. Breeders improve plants by selecting those with the greatest potential based on performance data, pedigree, and more sophisticated genetic information.
[22] Currently, registered EU hemp varieties are inaccurately referred to as "CBD rich" as they are generally poor source of cannabinoids. Varieties reaching high levels of CBD exist, but are not registered yet in the European list. The registration time was provided from G. Grassi, agronomic researcher at the Research Centre for Industrial Crops (Peripheral Operative Structure in Rovigo, Italy).

considerations of policymakers. First, there is a growing body of clinical evidence on its medicinal value (Ng and Chang, 2022). Second, international controls dictate that cannabis must be considered separately for medical and recreational use (Subritzky, 2018). In practice, the separation between medical and recreational market is controversial and hard to enforce, given that a large portion of cannabis consumption takes place between these intentions of use (Hakkarainen et al., 2017; Pacula et al., 2016). Before full legalization, Thurstone et al. (2011) showed that the leaking of MC from legal patients or dispensaries was common, due to the higher product quality of the MC market in comparison to the illicit market.

As we will see in the third chapter, the existence of a price differential in fully legal markets might lead to the diversion of a significant portion of MC sales to recreational users. This happens not only because the benefits of accessing MC outweighs the required transaction costs for a segment of recreational users, but also because of the difficulty for physicians to discriminate these users from real patients. Contrary to other medications, whereby physicians are the agent who decides which medicine should be used to treat a medical condition, the choice of using MC is generally determined exogenously from the medical system. Most often, the patient is the agent who requests MC therapy. Although eligibility criteria is required for physician's MC prescription (or recommendation), a large number of physical and mental conditions may respond to treatments with cannabis, such as pain, appetite, insomnia, anxiety, and depression. Some of these are difficult to diagnose, and it is thus possible for the patient to influence the outcome and obtain a recommendation, even in the absence of a true medical reason[23]. In outlets providing MC, patients can choose among many types of products (e.g., dried herb, edibles, oils) with different combinations of active ingredients. Some of these offerings will have euphoric and uplifting properties, thus they can be used for recreational purposes, either for the patient themselves or for others.

In view of this and of other local factors, legal provisions regulating MC access and supply differ substantially across – and sometimes within – countries (Pacula et al. 2014a; Bifulco & Pisanti, 2015). In the US, older and less medically oriented MC programs tend to have higher enrollment rates compared to those designed recently (Williams et al., 2016). In view of the risk of diversion, some jurisdictions (e.g., Washington State, Canada) decide to integrate the existing medical market with the recreational system. In the EU, the existence of a reimbursement policy has raised even greater concern for a potential waste of public funding to finance recreational cannabis use. In this context, the regulatory objective is clearly to ensure that MC is appropriately prescribed without being

[23] For instance, chronic pain is the declared condition for more than 9 out of 10 patients in Colorado and Oregon. Pain is often not medically identifiable, given the lack of clear biomarkers (Marchi et al., 2009).

diverted to non-medical users or overconsumed by patients (Belackova et al., 2018).

1.4.2.2. Medical and Light cannabis

> *"One of the issues that might be interesting is how 'medical cannabis' and more 'medicinal cannabis', as available in CBD stores, will co-exist" (Zobel, 2019; p.10).*

In recent years, the use of C-light and its derivatives has increased substantially due to the scientific evidence, anecdotal accounts, and media coverage reporting on the benefits of non-psychotropic cannabis compounds[24]. Austria, Belgium, Switzerland and Luxembourg classified C-light as a tobacco substitute with the same warnings and a taxation similar to cigarettes[25]. When CBD products are sold as food products, however, they might not be fully legal, and a repression of non-smokable products might be enforced in the future. The first legal clash occurred when a shop chain called itself a 'cannabis pharmacy', leading to an official complaint from the association of Swiss pharmacies, who argue that these products cannot be advertised as therapeutic (Zobel, 2019). In contrast, the fifth chapter will show that a significant group of C-light consumers report using this product to treat a disease diagnosed by a physician, and one that is generally associated with pain or mental health problem. Although the majority of users also consume intoxicating cannabis, there are elderly individuals who consume CBD oil for health issues without ever having tried the illicit drug (Zobel et al., 2019).

In the EU, C-light has not been regulated for inhalation, although this clearly appears to be the main purpose of use. The EU parliament considers certain CBD products as "novel foods" which require a registration to be sold[26]. As national regulatory bodies decide the market placement of a product, C-light could potentially be distributed in markets with different quality standards and legal framework. Based on origin, chemical composition, declared/implied/expected purpose and viability of conversion in narcotic, it could be classified as medicine, food (novel, supplements, flavoring), agricultural commodity (e.g. biomass for extraction), tobacco substitute or a consumer product, depending on the country (EMCDDA, 2020). Law enforcement on C-light depends on sector-specific arrangements and the interpretations by national authorities. In Switzerland - and perhaps other countries - the overproduction of C-light and the consequent fall in prices appear to have convinced

[24] See Izzo et al. (2009) for a review of the therapeutic potential of non-psychotropic cannabinoids.
[25] In Switzerland, this classification came as the outcome of the positive response of the Federal Office of Public Health to the request of cannabis entrepreneurs to register and sell their C-light flowers as a tobacco substitute (Zobel, 2019).
[26] A novel food can be a new kind of food, including a plant-based food or additive, a food produced using new technologies, agricultural products from third countries or food derived from new processes that has not been consumed to a significant degree by humans in the EU before 15 May 1997.

certain legal producers to sell to the illicit market to combine with high-THC cannabis (Zobel et al., 2020) or contaminate with synthetic cannabinoids (Oomen et al., 2021) .

Italy is currently the most developed EU market for the production of C-light, thanks to a reform which incentivized industrial hemp cultivation by removing red tape and increasing the THC threshold[27]. Nevertheless, C-light is not considered an inhalable product and the labelled purpose of use is often 'technical', which indirectly allows even purchase by minors. The industry's popularity led to an expansion of C-light retailers beyond specialized hemp shops to herbalist shops, tobacco shops and even pharmacies. The emergence of the C-light market has had significant spillover effects on the pharmaceutical market for traditional drugs and MC. Looking at the local availability of shops selling C-light across Italian provinces, Carrieri et al. (2020) found that an increased accessibility led to a reduction in the consumption of other prescription drugs, especially sedatives and anxiolytics. In other words, C-light users are autonomously deciding to switch their traditional therapy for C-light without neither physician's prescription, nor clinical support. Indirectly, this means that the evidence of increased self-medication behavior in US states with MC laws is valid also for jurisdictions which simply liberalized C-light (Sarvet et al., 2018).

This substitution effect for prescription drugs sold into pharmacies appears to not only be confined to traditional prescription drugs. There is anecdotal evidence from Italian pharmacists that the emergence of the C-light market has reduced the market expansion of the MC variety sold in pharmacies under prescription with the lowest level of THC (called Bedrolite®)[28]. Although C-light products are more difficult to dose, given their lower degree of standardization compared to the pharma-grade counterpart, the lower price and the easier access appear to be the reason for the substitution pattern. It is conceivable that the substitution effect of C-light on MC will occur also for other varieties of pharma-grade MC, if they are used to treat conditions for which CBD appears to be effective, or if the C-light market provides a combination of non-intoxicant compounds (e.g. cannabinoids, terpenes) in their products which cannot be found in pharmacies.

Overall, the size of the C-light market will depend substantially on the specific design of the MC program. A model restricting the prescription for a limited number of conditions will increase the size of the C-light market. This will indeed become the only channel where patients outside the MC

[27] The maximum legal threshold of THC varies across EU countries between 0.2% in France and 1% in Czechia. Switzerland became the first country which increased its limit to 1% to reduce the number of false positive cases in industrial hemp that occur when the THC level is above former limit of 0.2%. There is no scientific basis for these limits and the maximum level of THC for C-light is outside the scope of this dissertation.

[28] From a conversation with Antonio Contin, compounding pharmacists and lecturer at the post-graduate course on medical cannabis at University of Padua. Bedrolite® has a THC level lower than 1% and would be considered C-light in Switzerland.

program can legally purchase a medication based on non-intoxicating cannabinoids. In parallel, C-light is likely to be more affordable for the majority of medical users who do not obtain a reimbursement from the health system.

Nevertheless, there are issues when consumers substitute MC with C-light, due to the lack of coherent regulation. First, today's quality standards of C-light are lacking, as many products in the market are characterized by unsubstantiated claims and are often unsafe and inconsistent[29]. This underlines the importance of developing a regulation framework that considers the expected purpose of use. Second, C-light retailers should have expertise on the product and the therapeutic potential of non-intoxicating cannabinoids. Compared to tobacco shop owners, those selling in specialized C-light shops may be more likely to provide the necessary information to users and discourage the co-use of tobacco, given their lack of conflict of interest. Third, the potential market size of a medication has a critical role in increasing the entry of new drugs (Acemoglu and Linn, 2004). Accordingly, the larger the size of the C-light market relative to MC, the lower the number of clinical research on MC.

1.4.2.3. Interrelations with other legal markets

The interrelation between the markets of legal addictive substances and cannabis is based on either product substitutability and complementarity, or on the reliance on common regulatory frameworks (Kjellberg & Olson, 2017).

In term of consumption spillovers, the legalization of MC reduces opioid-related harms (Powell et al., 2018), whereas the evidence of its effect on alcohol[30] and tobacco consumption is mixed, depending on specifications and data sets (Anderson et al., 2013; Choi et al. 2019; Smart and Pacula, 2019; Baggio et al., 2020). The early evidence on the effect of full legalization on alcohol and tobacco are also mixed with one study which finds substitution spillovers (Miller and Seo, 2021) and another which found no effects (Veligati et al., 2020). In regards to C-light, it has been shown that its major component (CBD) can help in reducing the addiction to other substances, such as tobacco (Morgan et al., 2013; Prud'homme et al., 2015; Hindocha et al., 2018). In spite of this, scholars have not investigated the impact of legalization of C-light on the use of alcohol, and the only evidence on tobacco spillovers shows that some users of C-light may reduce tobacco consumption (Zobel et al., 2019). Overall, players operating in the existing industry of tobacco, alcohol and pharmaceuticals have vested economic interests in maintaining the size of their market. Accordingly, they will attempt

[29] Compared to the content state in the label, a significant share of C-light products has been found to have lower (or absent) CBD and higher THC concentrations. Even concentrations of heavy metals were found to be above regulated levels for edible plants (Gallastegi et al., 2019; Gurley et al., 2020).
[30] See Subbaraman (2016) for a review of the relation between alcohol and cannabis.

to minimize or maximize the size of the cannabis market through lobbying if its legalization proves to be substitute or a complement, respectively.

Regarding regulatory frameworks, scholars are concerned about the emergence of *Big Cannabis*, an oligopolistic industry adopting techniques similar the tobacco industry to avoid regulations that would not maximize their profits[31]. Some economists believe that either illicit market suppliers will turn legitimate, or the tobacco and alcohol companies will take the control of the supply. According to Kennally (2001), this market is characterized by an oligopolistic nature created by a problem of free riding. Given that firms do not fully appropriate the profits stemming from introduction strategies aimed to increase the cannabis market size, agglomeration is considered as the only way to internalize these costs. More recently, Caulkins et al. (2016) claims that trajectory of the cannabis industry will depend mostly on the chosen supply architecture. In a regulated-like-alcohol industry, the authors would expect that considerable product innovation combined with declining production costs and greater marketing would increase the firm size. In parallel, they admit it is too difficult to say whether a mature cannabis industry will look more like the wine sector or Big Tobacco.

1.4.3. Interrelations stemming from the legal status

1.4.3.1. The grey market of light cannabis

The different regulatory frameworks across adjacent markets have led to a potentially illicit phenomenon of interstate smuggling: the export of non-compliant Swiss C-light to other European markets. The different regulations indeed result in a portion of the Swiss C-light being considered an illicit drug in other European countries. Not only where forms of C-light (e.g. flowers) have been banned, but also in other EU countries with a legal market for C-light. When the varieties used in the cultivation are not included in the EU list, even if the content of THC is lower than the legal threshold, they might be controlled under the drug laws which makes them de facto illegal. To minimize this diversion, the Italian Health Minister has issued a circular to the customs agency which blocks the import of C-light from Switzerland[32].

This 'grey market' has been created by the differential laws, but it might be unavoidable even if the Swiss harmonize their legislation with the EU legal framework. Unless registered varieties will be able to qualitatively compete with Swiss genetics (or cultivar), the consumer preferences will provide a strong incentive for C-light producers to cultivate within this grey market while respecting the THC

[31] Subritzki et al. (2016) noted the industry is not only targeting heavy users with marketing plans which would appeal to their preferences, but also weakening regulations regarding pesticide levels.
[32] https://freeweed.it/ministero-della-salute-blocca-le-importazioni-canapa-industriale-dalla-svizzera-tutti-dettagli/

threshold. It must be considered a critical issue for law enforcement in monitoring the legal status of C-light products. It is not possible to easily tell the difference between Swiss and EU compliant C-light varieties. Not only can they not be visually distinguished, but simple methods for testing the THC content will not be sufficient to determine the original genetics. Genetic analysis is the only accurate signal, but the substantial signalling costs discourage law enforcements from pursuing this analytical process. If, in contrast, the regulatory framework only requires that the content of THC is below a certain threshold, the detection and verification of the violations would become cheaper and thus enforceable. Together, the most efficient way to harmonize EU laws is to use the THC content as the unique signal to determine the status of legality and thus minimizing the grey area of illicit varieties.

1.4.3.2. Illicit and light cannabis

Recently, adulteration of C-light with synthetic cannabinoids was found in eight European countries within flowers and resins (Oomen et al., 2022). In other words, adulterants with much stronger psychoactive effects than THC (De Morais et al., 2020) may be added to increase the potency of C-light, de facto transforming legally produced raw material in intoxicating cannabis to be sold through the illicit market. This new phenomenon is likely to continue if it is profitable for the illicit market, namely as long as the wholesale price for illicit cannabis is higher than the cost of producing and contaminating C-light products with intoxicating adulterants.

1.4.3.3. Illicit and legal cannabis

When considering the legal cannabis market as a whole, their largest market interconnection is with the black market for illicit cannabis. During prohibition, the existing cannabis demand was satisfied only in small part by consumers self-growing the plant domestically, as the majority of the product was supplied by local dealers, and sometimes involved with organized crime (Jansen, 2002). These final retailers generally earn small mark-ups, whereas extremely high profits are captured by a relatively small number of wholesale and international traffickers (Carpentier et al., 2015).

Even the existence of a legal distribution system for C-light products has a significantly negative impact on the illicit cannabis market. Looking at the opening of C-light shops across Italian provinces, Carrieri et al. (2019) found a decrease in the number of cannabis seizures, estimating a disruption of the illegal market in the range between € 90 and 170 million per year. Predictably, the emergence of the market for high-THC cannabis has a larger impact. The entry of legal competitors reduces the demand for illegal cannabis, and in turn the size of its black economy (Huber et al., 2016; Gavrilova et al., 2017; Brinkman and Mok-lamme, 2019; Dragone et al. 2018; Xiong, 2018). Contrary to mere

decriminalization, the legalization of the market for medical or recreational purposes has a substantial supply-side effect by allowing commercial production, distribution and often even home cultivation (Pacula et al., 2010). This effectively creates a new legal competition for the incumbent suppliers, which diminishes their risk premium (Huber et al. 2016).

A regulated product may be treated as a superior commodity not only as it avoids the 'costs' of being illicit, but also because of the benefits of quality control and known cannabinoid levels (Amlung et al., 2018)[33]. This perception combined with increased efficiencies in legal production leads to a reduction in price level in the illicit market (Anderson et al. 2013; Xiong, 2018). Those involved in the illicit cannabis trade end up finding themselves in a worse economic environment characterized by increased competition and lower mark-ups which erodes the available rents (Miron and Zwiebel, 1995).

Accordingly, the major success of cannabis market liberalization has been to reduce those mark-ups and to successfully transform illicit cannabis profits into tax revenues. Allowing the newly legal cannabis market to thrive, while trying to eliminate the illegal market, provides a unique challenge for governments. In a legal framework, law enforcement priorities become the restriction of sale to minors illicit sales from organized crime, interstate trafficking and use of legal cannabis retailers for other criminal activity (Kleiman, 2015). Together, the specific regulatory regimes for cannabis will make a significant difference to their ability to disrupt the illicit market.

1.5. The challenges of market design

> *"Legalization" does not specify a policy. Cannabis could be made available for use by adults under a wide variety of conditions: cheap or expensive, offered by for-profit enterprises, by not-for-profits (including consumer co-operatives), as a state monopoly (for production or sales or both), or even on a "grow-your-own" basis. It could be cheap (as it would be in a free market) or expensive (due to taxes or minimum pricing). Marketing efforts could be free or restrained. Users could be "nudged" toward temperate use – for example, through a system of user-set but enforceable periodic purchase limits – or left to their own devices.*
> *(Kleiman and Ziskind, 2019; p.1)*

1.5.1. Defining policy objectives

Nobel Prize winner Alvin E. Roth (2018) argues that economists should have a role in building new marketplaces or repair those that are broken. He considers market design as a "new part of economics

[33] For example, cannabis cultivated according to strict organic farming techniques and sold in a legal outlet does not have the same perceived qualities of illicit cannabis.

that strives to understand how the design of marketplaces influences the functioning of markets" (p. 1609). Cannabis is a practical case of an inefficient market as its transactions have been criminalized for long time contributing to the design of the illicit market. The problem is that while some people want to engage in this market in spite of its potential internalities, others want to prohibit it in fear of its potential negative externalities. The ex-ante impossibility of measuring these externalities, along with acknowledgement of the costs and loss of tax revenues caused by prohibition, have led economists to argue that the legalization of cannabis will increase welfare, but that the magnitude of the increase will mostly depend on its legal regimes (Rogeberg, 2018: Ben Lakhdar & Kopp, 2019) as well as specific policy details.

While some believe that legalization is equal to liberalization, the reality is the contrary. There will be more regulation than other markets as there is uncertainty regarding the harms associated with its use. Kilmer (2019) listed 14 design options which need to be considered in the debate; namely, production, profit motive, promotion, prevention, policing, penalties, potency, purity, public use, permanency and price. The chosen market design will derive principally from the different political priorities behind legalization. Public health is not the only goal, as many policymakers want to achieve other objectives which are in potential conflict, such as tax revenues, illicit market disruption, economic development or maximization of patient access[34].

Hudak (2014) considers successful implementation to be when rules, institutions and processes produce a system consistent with policy goals. In other words, what defines a good design depends on the objective one chooses. In most US states, rather than minimizing heavy use, the legalization ballot was based on the objective of generating revenues for the state coffers by choosing a commercial alcohol-style model (Hall and Kozlowski, 2017). In Uruguay, the president aimed to fight against organized crime and protect users, especially minors: the choice was made to rely on a highly controlled supply architecture where consumers must be registered to access cannabis and the government set the retail price (Gandilhon et al., 2018). As for Canada, the objectives have varied from one province to another; the federal state has defined the rules of the game[35], but distributional system has remained the responsibility of each province.

[34] Since the retail price will have implications for consumption, government budgets and the size of the illicit market, tension exists between imposing high taxes to discourage heavy use and minimizing taxes to reduce the illicit market. Calkins and Kilmer (2016) summarize this conflict in the decision on whether to design a regime to serve the majority of controlled users or to protect the minority whose use turns problematic.

[35] Health Canada (2016) recommended cannabis policies to minimize harms of use, to establish a responsible supply chain, to enforce public safety, and to maintain medical access.

Irrespective of the stated goal, any legalizing jurisdiction has implemented regulations involving public health considerations. Indeed, Pacula et al. (2014b) recognize the following goals as a common ground between advocates and opponents to legalization: (1) minimizing access, availability and use by youth, (2) minimizing drugged driving (3) minimizing consumption of products with unwanted contaminants and uncertain potency, (4) minimizing concurrent use of cannabis and other addictive substances, and (5) minimize addiction. To achieve the first two goals, almost every jurisdiction has imposed the same legal age for cannabis possession and drinking, as well as banned marketing towards the youth (e.g. banning retail display, adopting plain packaging) and cannabis-impaired driving[36]. To ensure appropriate quality standards and control THC content, most legal framework requires product testing and seed-to-sale tracking (Martinez et al., 2022). To better monitor the production, jurisdictions can adopt a government-run monopoly or a licensing system requiring vertical integration[37]. To avoid poly-drug use, it is advised to ban "bundling" with other substances as well as public consumption (Pacula et al., 2014b). To reduce cannabis addiction and limit the harm of consumption, Hall et al. (2019) propose supplying it through a public monopoly, discouraging heavy use through taxation, increasing the CBD content of cannabis, targeting vulnerable individuals for intervention (e.g. heavy users, those diagnosed with schizophrenia) and educating consumers about how to minimize harms (e.g. discouraging combustion).

If the policy objective is to maximize access to those who use cannabis medically, the established system must involve minimum transaction costs to obtain a prescription from physicians, maximize the availability of MC varieties at a competitive price (possibly reimbursed) and allow home cultivation. Other objectives such as revenue generations, economic development and minimization of the black market can be achieved with every legal regime, but much will depend on the combination of number of players, corrective tax rate as well as the level of resources dedicated to enforcing regulation and pursuing illegal producers (Caulkins et al. 2015).

This dissertation will mainly investigate three aspects of the cannabis market: taxation, supply architecture and type of cannabis-based product available through different cannabis markets. The objective is to maximize the social welfare of each cannabis sub-market by considering them comprehensively, and in parallel to reduce the demand for more harmful substances. To do so, the analysis will take into account the trade-off between efficiency and diversity of each market based on

[36] To identify impaired driving, different thresholds of THC are adopted, but there are substantial challenges in its enforcement (Hall et al., 2019).
[37] Vertical integration limits the complexity in size and activities of participants and minimize diversion by facilitating traceability.

its expected purpose of use. The major microeconomic tools to analyze these aspects are industrial organization, nudging and price discrimination.

1.5.2. Tools to regulate "sin goods" with negative externalities

The neoclassical economic approach to regulation assumes individuals are well informed and respond optimally to the benefits and costs of their available choices. Behavioral economists agree that consumption is driven by utility, but they point to the fact that the decision-making process can be suboptimal, for instance in the case of sin goods. Their current consumption may indeed have health consequences for the user in the future, and consumers may have difficulties properly considering these if they, for example, are subject to issues of self-control problems. (Gruber and Koszegi, 2001). In such cases, consumers may make decisions against their own best interest and overconsume. Aside from overlooking some costs in terms of harms to one's self (or internalities), the consumption of certain sin goods can also cause harms to others (externalities). Thus, the excessive consumption of sin goods with negative externalities may have unanticipated harmful consequences not only for themselves, but also for society. This is certainly the case for a portion of the demand for recreational cannabis, although these harms may be seen as modest (Caulkins et al., 2015).

To regulate internalities, Allcott and Sunstein (2015) propose some basic principles. First, intervening using subsidies and taxes, rather than banning or mandating, to take into account the differences across consumers. Second, to target distortions through nudges or information to assist misinformed or inattentive consumers without affecting non-problematic ones. Accordingly, private companies, physicians and public institutions could reduce consumer misconceptions by informing them about the harm of sin goods (Maclean and Buckell, 2021). Nevertheless, the provision of informative advertising, such as health warnings, may be difficult in a context characterized by uncertainty within the scientific community. Companies could hypothetically self-regulate by adjusting prices so that consumers with self-control problems can fully internalize the future consequences of consumption. Nevertheless, these market-based mechanisms are unlikely to be effective in a non-monopolistic framework (Koszegi, 2005).

Accordingly, government intervention is necessary with economic tools such as quantity control or corrective taxation. Quantity regulations include quota, targets, minimum quality standards, minimum unit pricing, sin licenses and even banning an activity. Glaeser and Shleifer (2001) argue that the major advantage of this instrument relates to the lower cost for law enforcement in identifying the violation compared to taxation thanks to the private enforcement of neighbours and competitors[38].

[38] For instance, if you want to discourage evening sales of cannabis, an incremental tax after a certain hour would enable people who value the ability to purchase cannabis in the evening to pay more, but would be subject to possible

Therefore, they recommend using these policies when accurate tax collection is expensive, or taxation provides inappropriate incentives for law enforcers. The major limitations of quantity control relate to (1) the inability to estimate the optimal quantity which should be produced (Kopp, 2004); (2) the indirect effect of the restriction on some socially efficient transactions; and (3) the incentive for rent-seeking behavior by incumbent firms that wish to deter entry (Buchanan and Tullock, 1975).

Various forms of quantity regulations are common in the design of cannabis markets. The most pervasive is the establishment of licensing systems, but many jurisdictions include zoning restriction, laws prohibiting sales in certain days or hours, anti-smoking and anti-trust laws. Some US states have also implemented a form of permit scheme using an annual production quota, which is monitored through the seed-to-sale tracking system (Martinez et al., 2022). However, as information required to determine the optimum allocation of quantities is often not available to regulators, a corrective taxation scheme can help mitigate potential harms[39].

Generally, economists prefer corrective taxes to quantity controls for sin goods with negative externalities, as they place control directly in the hands of individuals. Pigou (1920) suggests levying an excise tax to drive people towards optimal consumption. With homogenous consumers and no internalities, the level of the tax rate should be equal to the magnitude of the harm caused by the externality. Despite potentially different implications, there is no formal guidance on how to estimate the level of taxation in the presence of both internalities and externalities (Allcott et al., 2014), as in the case of cannabis consumption. Internalities pose the unique challenge of distinguishing costs that consumers recognize from those which are overlooked (Marron, 2015). The literature on paternalistic policies to tackle internalities highlights the importance of a specific form of corrective taxes – referred as sin taxes. O'Donoghue and Rabin (2003, 2006) studied their optimal level by considering this as a mechanism-design problem, whereby certain agents are irrational. They demonstrated that, even when individuals differ in their degree of self-control, taxes on sin goods can result in an improvement of social welfare. Accordingly, a uniform tax was shown to yield Pareto improvements by reducing over-consumption by irrational consumers while redistributing income to consumers without problematic self-control. The specific welfare effect would depend on the elasticity of demand, on the extent of self-control problems and on the marginal harm caused by consumption (Kotakorpi, 2008). The likelihood that a tax on internality would improve the social welfare of

evasion as vendors might record these high-tax sales as occurring in the afternoon. If, in contrast, there is a restriction against all cannabis sales in the evening, the detection and verification of the violation would be cheaper, not only as the inspector would only need to drive to the store, but also because any citizen can complain when finding a cannabis store open in the evening.

[39] For example, rather than set a quota in the number of cigarettes that can be consumed annually, policymakers tax tobacco to increase the price of cigarettes and reduce their quantity.

consumers increases when demand is highly responsive to prices, overlooked costs are large, and a substantial fraction of revenues is returned to sin taxpayers (Marron, 2015). Assuming that the intensity of consumption is proportional to the marginal internality, Haavio and Kotakorpi (2011) show that the second-best optimal sin tax is likely to exceed the average distortion caused by irrational consumers[40]. Still, these individuals would be better-off with these taxes, as they could positively influence their consumption. The authors also show that when harmful health effects are mild (as may be said for cannabis), sin taxes align the median voter's preferences with those of the social planner.

Arnabal (2021) extends the analysis on the optimal sin tax by considering the interaction with other non-taxable sin goods, such as illicit drugs. The author argues that the existence of such alternatives should be taken into consideration when setting sin tax level. Its corrective role on consumer behavior would be undermined if agents are driven towards the consumption of products that are considered more harmful than the targeted sin good. In the case of legal cannabis, its substitutability with illicit cannabis would mean that the marginal benefit of the sin tax would be lower. The failure to recognize the competition from the illicit market, as well as the inability to compare its harms to those derived from the legal market, have led scholars to consider the taxation system in California and Canada as suboptimal (Childs and Stevens, 2021).

Other authors argue for a differential taxation across products, based on the expected harms when consumers differ and how strongly internalities affect their purchase decisions (Chaloupka et al., 2015 for tobacco; Griffith et al., 2019 for alcohol). They argue that the tax system should target consumption that generates high harms. They show that the variation across tax levels is based on the correlation between the marginal harms (externality and internality) of the specific products, and how strongly the tax induces consumers to switch away from the intoxicating ingredient. Accordingly, a tax is considered effective when it discourages the most socially harmful form of drinking, while leaving the decisions of non-problematic drinkers relatively unaffected.

Other scholars acknowledge that the level of taxation should consider the heterogeneity of harms among users, and have recommended minimum unit pricing (Shover and Humphreys, 2019). This policy lever consists in a floor price, below which a certain cannabis product would not be sold. The advantage of this tool is that it targets consumers who are inclined to over-consume the product. Accordingly, its implementation for alcohol has demonstrated reductions in emergency room admissions, injuries, alcohol-related arrests, and deaths (Purshouse, 2010).

[40] The first-best (individualized) taxation is not applicable as authorities cannot observe personal consumption levels.

Among all possible personalized schemes of quantity control, economists have been studying the potential role of sin licenses for irrational consumers. O'Donoghue and Rabin (2003) speculate that charging a one-time (or few-time) fee for the right of purchase a sin good would be more efficient than any taxation scheme. They argue that it would achieve the first-best outcome, by helping people who make mistakes with minimal impact on those who are fully rational. Haavio and Kotakorpi (2016) reconsider this form of personalized taxation as an upper limit on sin goods consumption that is able to combine market mechanisms and government intervention. In other words, sin licenses would be a low-cost way to help consumers with self-control problems commit to a given level of future consumption. Each consumer may choose a quota of goods for future purchase that are subject to a lower sin tax. When exceeding this quota, a higher tax level will be incurred.

Overall, the welfare comparison between sin licenses and sin taxes depends on (1) the distribution of self-control problems; (2) the existence of secondary markets for sin goods; (3) the presence of consumers who see no benefit in commitment devices; and (4) administrative costs. The authors argue that, in order to improve welfare, sin licenses should complement the uniform sin tax without reducing tax revenues. Interestingly, Haavio and Kotakorpi (2016) demonstrated that sin licenses would be the favourite type of non-linear personalized scheme for individuals with self-control problems.

1.5.3. Design difficulties caused by market interrelations

While scholars have been focusing on regulatory details related to either the medical (EMCDDA, 2018) or the recreational market (Caulkins & Kilmer, 2016), this dissertation aims to shed light on the existing interrelations across these and other cannabis markets, and argues for increasing their segmentation through appropriate regulation of each supply channel. As market design can be considered a form of economic engineering, taxation, supply architecture, and transaction costs matter.

As an economist, my objective is to maximize economic efficiency and minimize market distortions. A market distortion is a feature of the economy that results in prices failing to reflect marginal social valuations. It occurs when the market price for an item is substantially different from the price that a market would achieve while operating under conditions of perfect competition. This market failure will result in a competitive equilibrium which is not Pareto-efficient, contributing to distortions in the allocation of resources and inefficiencies. As a result, the market design will fail to maximize social welfare. Beyond monopoly powers, these inefficiencies can be produced by government policies. In the design of the cannabis market, my focus will be on distortions created by government interventions, such as taxation, subsidies and licensing.

1.6. Examples of cannabis market design difficulties

1.6.1. Balancing sin taxes for recreational users and subsidies for patients

Sin taxes are imposed to reduce internalities that exist when a segment of users has problems with self-control. Nevertheless, taxing recreational cannabis is different from taxing tobacco and alcohol, as users can buy the good in the MC market after obtaining a prescription from a physician. For the European healthcare system, the hypothetical combination of subsidies for patients and taxes for recreational users creates a strong incentive for regular non-medical users to purchase the product in a secondary market for a price which does not reflect the social costs of recreational use[41].

Furthermore, different physician populations have been found to hold different attitudes towards MC. Factors beyond experience and clinical practice are likely to impact their prescription decision (Zolotov et al., 2019). For instance, compared to the oncology field, the prescription of MC was found to be more contested in the chronic pain field, likely for lack of a clear biomarker for chronic pain – which is the most common condition underlying MC use. In a fully legal cannabis market where physicians hesitate to prescribe MC to patients with legitimate needs, these individuals may have to purchase from the recreational market and incur in a sin tax – creating another distortion[42].

Together, the setting of a Pareto-improving sin tax in the cannabis market is difficult, as the personal level of consumption is not observable by tax authorities. Moreover, there is no one-to-one relation between the amount of cannabis consumed and the intensity of the self-control problem, as many regular users may be patients who experience a net benefit from its use. One may have to disadvantage medical users (with a sin tax) to help regular users who experience problems with self-control.

The solution found by the Canadian government to avoid the distortion related to recreational users purchasing MC was to apply the same tax rate on cannabis, regardless of its purpose of use. This, in turn, creates another distortions as there is a deviation between the market price of cannabis and its marginal social benefit[43].

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[41] Considering this problem more formally, there is a two-sided information asymmetry between the patient and the physician. Both have private information, which results in moral hazard and adverse selection. On the one hand, only the patient knows their own condition, and they can withhold this information to obtain cannabis for a lower price. On the other hand, the physician's effort depends negatively on their experience with the treatment and the ability to identify the health condition, and positively with the potential drug diversion that is typical of psychoactive substances. See Bawin et al. (2021) for a review of diversion of prescription drugs.

[42] The price paid by individuals suffering from a health condition would therefore not reflect the social benefit of a medication. Those medical users unable to buy cannabis in the recreational market may then resort to the illicit market when it is more affordable.

[43] The greater marginal social benefit of using cannabis for patients – compared to recreational users – would justify a lower monetary cost. In other words, social welfare would increase with a lower level of taxation for medical users.

1.6.2. Maximizing the harm reduction potential of light cannabis

Sin taxes are applied to make unhealthy goods more expensive on a relative basis. In view of the lack of evidence of a negative health impact, it is difficult to find the rationale to apply the same sin tax on C-light, cannabis or tobacco[44]. The application of the same tax burden to products with different expected negative externalities creates market distortion, with the relative prices for the goods unproportionally reflecting their costs on society.

If policymakers want to maximize the substitution of cannabis and tobacco with a reduced-risk product such as C-light, the economic tool is differential taxation. Kleiman et al. (2014) suggests basing taxation on cannabis composition, rather than actual sales, in order to incentivize the use of less psychoactive forms[45]. Assuming there is a greater marginal damage that is proportional with the amount of tobacco, product bundling of C-light with tobacco should be subject to a sin tax. The tax rate should be proportional with the amount of tobacco contained in a cigarette to discourage their co-use. The taxation level should be the highest on conventional cigarettes to incentivize switching to a product with both tobacco and C-light, which is less harmful for users. It could be argued taxing C-light should be avoided when is *not sold* in pre-rolled cigarette, due to the lack of side effects, the possibility of vaporizing it, and the potentially therapeutic purpose.

Turning to the supply architecture, offering both cannabis and tobacco in the same retail shop might incentivize the products' complementary use. This calls for a rethinking of the most adequate distribution channels for specific sub-products of C-light. As a harm reduction tool, C-light should be sold in tobacco shops only when it is contained in pre-rolled cigarettes of either only-C-light or in a mixture with tobacco. On the contrary, the distribution channel for hemp flowers and other CBD products should be completely separate to minimize concurrent use, similar to the US framework. This distribution architecture would likely minimize its poly-use with tobacco and effectively perform a useful form of nudging.

1.6.3. Licenses quotas in the markets

Entry barriers should be adapted to the nature of the market. For instance, a licensing system would create distortions if neither the production nor the consumption of the good involve harmful potential. This is the case with industrial hemp, which should be treated as any other plant-based commodity,

[44] Most jurisdictions with a fully legal cannabis market do not treat C-light differently from high-THC cannabis. The European countries applying a specific tax on C-light – Belgium and Switzerland – have imposed the same tax rate imposed on tobacco products. Recently, the Swiss Federal Court has ruled that C-light should not be subject to the tobacco tax, as it is not intended to be smoked in all forms.

[45] Room (2008) demonstrates how differential taxation and retail availability can turn the prevalent form of alcohol consumed from spirits to beer. Chaloupka et al. (2012; 2015) show a similar pattern with tobacco products.

as long as there is traceability on the certified seeds. Higher quality standards may be required for the C-light market because of its human consumption and should be based on the specific product classification (e.g. food, cosmetics, nutraceutical, novel food, herbalist). A different approach should be taken for the medical and recreational markets, which must be regulated through a licensing scheme that considers their intoxication potential. Higher quality requirements and thus market concentration should be imposed in the MC segment to minimize the risk of product contamination and to create avenues to perform the efficacy research.

Looking at the recreational market in the US, the different licensing policies have produced different levels of market concentration, varying from New York with only 10 licensees to Oregon with over 2000. Thomas (2017) studied the entry and regulation of the cannabis market in Washington State. Focusing on the competitive effect of restricted entry on social welfare, she found that both suppliers and consumers would benefit from corrective taxation rather than license quotas across regions[46]. The major advantage of a sin tax would be to discourage consumption through an increased retail cost for consumers. The estimated increase in surplus would be even greater if the tax rate is based on the amount of THC, rather than the amount of cannabis purchased.

In obtaining these estimates, however, Thomas (2017) makes a strong assumption about the total lack of consumer leakage into the black market. Henchman and Scarboro (2016) would consider this hypothesis unrealistic with any level of sales tax superior to 30 percent. Increasing quality standards is not sufficient to eliminate the black market if illicit price is much lower. These lessons come from the tobacco industry, where a physiological level of smuggling exists as a consequence of high taxation (Ben Lakhdar, 2008; Chaloupka et al., 2019). Moreover, in jurisdictions that regulate the cannabis market, users often have another option besides the legal and illegal markets: home cultivation. The issue with this supply channel is the impossibility in tracking the output to prevent use by minors and portions of production being sold to the illicit market.

The supply from individual cannabis cultivators is another market which may require some form of licensing. Individuals who cultivate cannabis domestically are considered a major issue for Colorado police. The Denver police chief declared a seven-fold increase in the number of citizen complaints from individuals worried about the smell and the licit status of operation[47]. A licensing system with information on locations would save significant police resources and would be mostly accepted by

[46] Assuming the same number of stores, she found that a nonlinear Piguvian tax would be Pareto-improving as the most cost efficient firms would enter. While the marginal social benefits from a store might differ across regions, licenses will be distributed equally to avoid allocative inefficiencies.
[47] https://masonlec.org/events/symposium-on-cannabis-legalization/

cultivators, according to the *International Cannabis Cultivation Questionnaire 2.0* (Decorte and Potter, 2022). The monitoring system would help study the evolution of the phenomenon. This license may only be required for those who domestically cultivate above a certain number of plants.

1.6.4. Efficiency versus diversity: the case for heterogeneity for medical and light cannabis

Economists agree that diversity is good when the preferences of consumers are heterogeneous (Hotelling, 1929) and the products are not very good substitutes for each other (Meade, 1974). While recognizing the tension with efficiency when there are scale economies, Chamberlain (1950) considers product diversity desirable when the gain is larger than the efficiency loss. This appears to be the case for the current status of the medical cannabis market, due to the heterogeneity of patient preferences and the market failure on clinical research on herbal cannabis. Starting from the former, the medical cannabis demand is characterized by both types of product diversity with "different consumers using different varieties" and "diversification on the part of each consumer" (Dixit and Stiglitz, 1977, p.298). On the one hand, individual preferences of patients are heterogeneous. On the other hand, patients may need to diversify their purchase to find the variety which works well for their genetics and medical condition, or they may use different varieties for different activities (e.g. during working hours and before sleep).

The other reason behind the preference for diversity relates to the market failure on private research on herbal preparations. While physicians prefer to have a limited number of treatment options for a specific condition - to facilitate the choice of the most suitable medication - the evidence-based paradigm is at a loss with herbal cannabis. First, the private sector does not have economic incentives to prove efficacy (Fortin & Massin, 2020). Second, its multi-compound nature makes it difficult to interpret the evidence base (Schlag et al., 2021). Last, it is challenging (if not impossible) to disprove the existence of the entourage effect (Worth, 2019). As a consequence, a fraction of patients may choose to treat their conditions with cannabis-based medications based on anecdotal evidence - rather than treatments undergoing strict randomized clinical trials - only based on their ideology. This segment of patients is likely to decrease with the number of approved cannabis-based medications as this would increase the availability of treatment with proven efficacy for specific illnesses. Their approval should thus be incentivized as it would facilitate the prescription choice of physicians who are more familiar with this type of treatments for their resemblance to evidence-based medicine. Nevertheless, as long as there is a lack of clinical evidence of efficacy for many conditions, the

number of patients which may prefer to treat their disease through products which did not undergo clinical trials may be substantial[48].

In Europe, despite the potential benefits of increased product diversity, so far only about few dozens of varieties are available in European pharmacies (out of more than 600 available) mostly in Germany. To enter the market, the major requirement relates to their degree of standardization, rather than their evidence of efficacy. Therefore, the availability of varieties in European pharmacies depend more on their consistency (in terms of stability of THC and/or CBD content) than on their potential to treat patients. In addition, there are very few cases of patients allowed to domestically grow their cannabis therapies in Europe. Home cultivation would indeed maximize product diversity in the MC market, as well as increase healthcare efficiency, by reducing the amount of treatments supplied by pharmacies. At the same time, it would increase the risk of diversion to non-medical users and impose additional health risks if the product consumed is different from those medically prescribed.

A similar issue occurs in the market for hemp (or non-intoxicating cannabis). For industrial purposes, hemp is considered a traditional agricultural commodity which requires a further transformation of the raw material to be sold in the marketplace[49]. By adopting the categories of Nelson (1970, 1974) and Darby and Karni (1973), it can be argued that industrial hemp is a "search good", as its quality can be determined before the purchase through its external physical attributes. On the contrary, when hemp flowers and leaves are used for wellness purposes, such as C-light, the consumer preferences are heterogeneous. There are multiple combinations of active principles, which may be preferred based not only on the motivation for which it is consumed, but additionally on the genes and personality characteristics of the users (Atakan, 2012; Zobel et al., 2019)[50]. C-light can thus be considered an experience good with credence qualities when used as a treatment for conditions for which there is no clinical evidence[51]. Consumers are then likely to change their purchasing patterns over time as a result of new signaling information. There will be an increase in consumption of

[48] In the Netherlands, for instance, after more than a decade of medical cannabis programs the number of patients is still stagnant likely for their preference to resort to coffeeshops where they can find higher product diversity compared to pharmacies (Hughes, 2016).

[49] Transformation companies have homogeneous preferences depending on the final industrial use. For example, when hemp is used as an input for building concrete walls, its quality standard depends mostly on the fiber content (Nguyen et al., 2009).

[50] While it is unclear how physical processes can cause subjective feelings, the different architecture of the endocannabinoid system across individuals is the reason why different users obtain different effects from the same variety of cannabis.

[51] McCluskey (2000) demonstrates that credence good markets with probabilistically accurate certification are transformed into experience good markets when consumers engage in repeated purchases. Therefore, in legal settings, a consumer decides between varieties based on the information learned from past consumption and informative advertising (Ackerberg, 2003).
Other researchers found that even the quality of recreational cannabis could be judged prior to consumption, but the accuracy of the assessment would be still considered much lower than for industrial hemp (Belackova, 2020).

varieties which advertise a certain combination of compounds (e.g. cannabinoids, terpenes) from which the users derive greater marginal utility.

In the EU, the registration of a hemp variety is a condition for its commercialization and can be considered as a form of quality signaling. Nevertheless, it appears inefficient to apply the same policy in a market characterized by homogenous preference (industrial hemp) *and* in a market with heterogeneous and dynamically changing taste (C-light). Using the Chamberlin (1950) trade-off, the loss of satisfaction from a more standardized product is lower than the gain from producing more units for industrial hemp[52], whereas the contrary is true in the C-light market for at least three reasons. *First*, contrary to crops used for industrial use, most medicinal and aromatic plants are collected in the wild without using certified seeds (Lubbe and Verpoorte, 2011). *Second*, there is strong innovation in the C-light market, therefore a lengthy registration will deter the entrance into the market of new varieties jeopardizing its ability to satisfy consumer preferences[53]. *Third*, the law enforcement costs for identifying violations of the C-light genetics are substantial.

In conclusion, the EU legislation on industrial hemp can be considered efficient only when the output of the cultivation is fibers, seeds or biomass for extraction. There might be a need to differentiate the regulation for C-light through an approach which prioritize diversity rather than standardization.

1.6.5. Quantity regulation in the hemp market

Most uses of output derived from the Cannabis plant are not related to the intoxicating effect characteristics of the THC molecule. This is related to not only fibre and seed-related products, but also to C-light and its derivatives, or other preparations with only trace-amounts of THC. These products are not likely to be abused as they do not provoke "intoxicating-effects" such as those with high THC.

Despite the lack of excess harms, most countries that allow the cultivation of industrial hemp require a specific license[54]. However, unless it is used for medical and scientific purposes, the conventions allow any use of hemp finalized to the industrial manufacture of goods (Riboulet-Zemouli, 2019) without requiring specialized control. Accordingly, it can be argued that a licensing system for industrial hemp is an unnecessary form of quantity regulation.

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[52] There is indeed large gain in efficiency from a commodity with a supply chain structure that, depending on the final use, requires an intermediate actor to transform a homogenous input that is selected for the enhancement of certain technical characteristics. For example, the thermal and acoustic insulation when it is used as a building material, or the content of Omega-3 and Omega-6 fatty acids when it is used to extract hemp seeds oil.

[53] As of December 2021, 92 varieties where registered at the National Institute of Seeds (INASE) of Uruguay.

[54] To obtain it, farmers must occasionally submit extensive documentation, including background criminal record checks, the GPS coordinates of their fields, and supporting documents regarding their use of low-THC hemp seeds and approved cultivars.

The establishment of a licensing scheme to obtain subsidies for the cultivation of industrial hemp has created an oligopolistic market (Parenty, 2018). To increase competitiveness, variety-licensing regulations would be sufficient, and should be applied only for the production of biomass, which requires standardization (Chamberlin, 1950; Ulrich et al., 1987). The homogeneity would be necessary for the transformation center to function efficiently[55]. Theoretically, to incentivize this production, there would be specific subsidies towards specific certified varieties that are based on the degree of positive externalities derived from the expected final purpose[56]. If a variety is not licensed, it would not receive subsidies, but its output should not have to be thrown away unless it has a potential for intoxication.

Nevertheless, this is not the direction taken by French regulators. In December 2021, a reform of the hemp market prohibited the sale of flowers to consumers, instead restricting their trade only between farmers and transformers[57]. De facto, this creates an oligopsony in the wholesale distribution of CBD-containing products to final consumers. This licensing scheme was already in place for the transformation of hemp fiber and seed, as their cultivation was only possible on the basis of a contract with the transformer. While this may have been justified by the impossibility of selling hemp-based raw material to final consumers without a transformation, for flowers and their derivatives there is already an existing distribution chain that will be shut down by this reform. In practice, it will not only impede the direct sale of flowers from farmers to final retailers, but the contract with the transformer becomes the condition by which the legal status of hemp farmer operations are defined. This shifts of the bargaining power towards the intermediary transformers will increase market concentration and lower the surplus of farmers and consumers. The latter will have to pay a higher price for the same dose of non-intoxicating cannabinoids, due to the transformation costs involved. Moreover, it will become more difficult for those who have found a preferred variety for their medical condition to find a transformed product with the exact characteristics. The likely outcome will be a shift of C-light towards the illicit market, with all the unintended consequences for public health and safety.

Finally, the Swiss experience has shown that even when the final output has a THC content slightly superior to the legal threshold, there is no real danger for public health as the product does not produce significant side effects (Iffland and Grotenhermen, 2017). The EU recently increased the maximum level of THC to the international limit of 0.3%. However, if a country was to adopt the method

[55] For example, textile machines require hemp fibers with precise standards to manufacture clothes.
[56] 0.3% is the THC limit value for industrial hemp has used internationally. Yet, to obtain the Common Agricultural Policy, the EU decided that the limit should have been reduced to 0.2%.
[57] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000044793213

recommended by the UNODC (2009) to distinguish hemp from intoxicating cannabis, the varieties available would likely increase almost tenfold**.** This may substantially increase market efficiency, given that these new varieties would likely be more resistant to diseases, have more robust fibers, and grow more rapidly (Reinders, 2019). This is likely the rationale that led Czech Republic towards an increase of the THC threshold to 1% THC from 1st January 2022[58]. It remains to be seen whether other EU countries will follow this path in the future.

1.7. Research questions and connection between the chapters

This dissertation consists of six chapters that cumulatively complete my doctoral thesis. Both empirically and theoretically, these papers identify ways in which the cannabis markets are interrelated with one another as well as their interconnections with other markets that are influenced by legalization. This thesis utilizes different approaches to examine distortions derived by market interrelations: firstly, an institutional approach, with a cross-comparison of MC models (Ch.2); secondly, an empirical approach, by examining local policy variation through administrative data (Ch.3) and through self-collected survey data (Ch.5); thirdly, a theoretical approach, with a user-controlled discrimination scheme built on two-part tariffs (Ch.4).

The focal point of this thesis relates to the identification of complex MC market boundaries, for which examination is provided in all chapters. We begin by showing how its definition differs between the European and American model and how the modern paradigm of healthcare may not be suitable for herbal preparations (Ch. 2); we then study the evolution of the MC market in Colorado after the creation of the first legal market for adults (Ch. 3); having estimated the interrelation of MC with the recreational demand, we discuss the potential role of the CSC model as an additional supply channel to identify the conditions that would increase segmentation and minimize distortions in the European health system (Ch. 4); we then investigate the substitution patterns which emerged with the creation of the C-light market on MC, but also on other licit substances (Ch. 5). The last chapter provides a summary of the dissertation, with policy recommendations for the optimal design of MC and C-light markets that consider the competition of an illicit market where the demand may shift in the case of inefficient regulations.

Together, each piece contributes to the understanding of cannabis policy and its consequences by comprehensively examining how the legislation in one market can affect other markets. If read as an

[58] https://www.cms-lawnow.com/ealerts/2021/12/increase-in-the-lawful-amount-of-thc-in-hemp-to-1-in-the-czech-republic?cc_lang=en

accumulation of insights, one will emerge with a thorough understanding of the optimal supply architecture for each cannabis market.

1.8. References

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CHAPTER TWO

2. MEDICAL CANNABIS: THINKING OUT OF THE BOX OF THE HEALTHCARE SYSTEM

Abstract

France is experimenting with legal access to medical cannabis. In this short contribution, we propose to analyze the regulation choice made in the light of the intrinsic characteristics of medical cannabis and some lessons learned from foreign experiences. More precisely, we argue that scientific evidence of the efficacy of cannabis is limited, which pleads in favor of restrictive regulation schemes such as those found in Europe. However, since there are strong technical and economic barriers to demonstrating the efficacy of medical cannabis, more accommodative regulatory frameworks such as the North-American ones have advantages, but are also at risk of excessive or diverted use. In order to keep the best of both systems, it might be possible to design innovative regulatory frameworks based on a dual-distribution system for medical cannabis. Cannabis Social Clubs could for instance serve as a distribution structure, complementary to the conventional healthcare system.

Keywords: medical cannabis; regulation scheme; international comparison; clinical trials; patent.

Abbreviations:

CBD	Cannabidiol
CSC	Cannabis Social Clubs
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
THC	Tetrahydrocannabinol
NIDA	National Institute of Drug Abuse
RCT	Randomized Controlled Trials

2.1. Introduction

The National Agency for Medicines and Health Products Safety (ANSM) and the National Assembly allowed a 2-year experimentation to provide legal access to medical cannabis in France[59]. Around 3.000 patients benefit from the experimentation. Cannabis is offered as last-resort treatment for five specific conditions: refractory neuropathic pain, certain severe and drug-resistant forms of epilepsy, supportive care in oncology in palliative situations, painful spasticity of multiple sclerosis and other pathologies of the central nervous system. The proposed medicines will include various dosages of tetrahydrocannabinol (THC) and cannabidiol (CBD) and are offered in different forms: herbal teas, drops, capsules, as well as oils and dried flowers (to be vaporized). The prescription is made by specifically trained physicians and the delivery take place in hospitals. The chosen regulatory framework is of course of great importance in any legalization process. In this short contribution, we propose to analyze the choice made for the French experimentation in the light of the intrinsic characteristics of medical cannabis and some lessons learned from foreign experiences.

2.2. Europe vs North American models

The main dimensions of a given regulation scheme for medical cannabis are: the type of medical cannabis available, the eligibility criteria, the distribution model and the reimbursement scheme. Currently, there exist two main types of regulatory frameworks throughout the world: the accommodative North American one and the restrictive European one. In the US, citizen-initiated referenda have legalized the use of herbal cannabis (i.e. the flowering tops of the plant) through an approach based on dispensaries driven by state-level regulation. Use was initially permitted only for a short list of conditions but the list has been progressively broadened, enabling access to almost any adult (EMCDDA, 2018). Home cultivation, sometimes subject to quantity restriction and/or registration, is also permitted in some states. In Canada, the regulatory framework is similar and allows patients to buy herbal cannabis from a licensed producer. Medical practitioners and registered nurses are responsible for providing a document that allow accessing herbal cannabis. The major difference with the US relates to the lack of a retail distribution for herbal cannabis, which can only be home delivered (Ablin et al., 2016). Patients can also register to produce a limited amount of cannabis for their own medical purposes or designate someone to produce it on their behalf. On the contrary, in European countries (e.g. Belgium, Denmark, Ireland, Spain, Luxembourg, and now

[59] *https://www.ansm.sante.fr/S-informer/Points-d-information-Points-d-information/Cannabis-a-visee-therapeutique-en-France-l-ANSM-souscrit-au-cadre-de-la-phase-experimentale-de-mise-a-disposition-propose-par-le-Comite-d-experts-Point-d-information* and *http://www.assemblee-nationale.fr/dyn/15/amendements/2296/AN/764*. The proposed scheme is described here: *https://ansm.sante.fr/L-ANSM/Comites-scientifiques-specialises-temporaires/Comites-scientifiques-temporaires/Comites-scientifiques-temporaires/CSST-Evaluation-de-la-pertinence-et-de-la-faisabilite-de-la-mise-a-disposition-du-cannabis-therapeutique-en-France*

France), there are significant restrictions both on eligible medical conditions and of the type of products available (EMCDDA, 2018). Medical cannabis is mostly used through special access scheme and as last-resort treatment, meaning that the patient must have tried other commonly used treatment options before. The most common authorized products are standardized drugs containing cannabinoids. Only six countries (Czech Republic, Denmark, Italy, Netherlands, Portugal and Germany) have established programs allowing patients to access herbal preparations (Belackova et al., 2018), with two of them (Italy and Netherlands) permitting only access to irradiated herbal cannabis[60]. Pharmaceutical products containing cannabinoids are usually reimbursed from the health system under specific conditions (Krcevski-Skvarc et al., 2018). Costs for herbal cannabis can be reimbursed if conventional treatments have failed and under specific conditions (upon prior approval in Germany; after visiting a specialist or if the treatment is initiated at a hospital in certain Italian regions) (Novellino et al., 2018).

2.3. The scientific evidence

One way of assessing the respective merits of each framework is to refer to the available scientific evidence. Several reviews have recently summarized the major findings regarding the efficacy of cannabis on humans (EMCDDA, 2018; Hall et al., 2019; Black et al., 2019; Whiting et al., 2015). Most clinical knowledge was found from studies carried out on single cannabinoids (synthetic or plant-based) or extracted standardized preparations, rather than on herbal cannabis. Moderate evidence is found for cannabinoids in relieving the symptoms of multiple sclerosis, chronic pain and intractable childhood epilepsy. Neuropathic pain is the only condition for which there is medical evidence on the effectiveness of herbal cannabis (Caulkins et al., 2016). The effectiveness of cannabinoids as an appetite stimulant and against nausea and vomiting associated with cancer chemotherapy is weak. For other conditions for which some physicians and patients claim cannabis to be effective (e.g., sleep, anxiety disorders, depression, degenerative neurological disorders) the evidence is insufficient.

This limited evidence seems to legitimate to restrict legal medical cannabis to a very limited list of conditions, in the most proven efficient form, i.e. essentially plant-derived and/or synthetic cannabinoids. The point we want to make in this contribution is that this restrictive approach might be misguided because of the strong technical and economic barriers to demonstrate the efficacy of medical cannabis. Our argumentation, developed below, follows the subsequent four points: 1) because of the entourage effect, the herbal form would be much more efficient than single

[60] Irradiation guarantees a predetermined and stable levels of cannabinoids without any contaminants, but reduces the quantity of non-cannabinoid plant components.

cannabinoids; 2) it seems difficult to demonstrate the efficacy of herbal cannabis through randomized controlled trials (RCTs); 3) even if possible, the lack of patentability for the findings would lead to a lack of economic incentives to conduct such research; 4) it seems unlikely that public solutions will solve this problem quickly and inexpensively.

2.3.1. The entourage effect

The entourage effect hypothesis postulates that, due to synergism, there are greater benefits for a patient from using the whole plant (especially in its non-irradiated form) than using single extracts of cannabinoids (Williamson, 2001) for synergic interactions in phytomedicine[61]. For instance, for patients with refractory epilepsy, CBD-rich extracts appear to present a better therapeutic profile than purified CBD. Some scholars consider this concept unprovable considering very challenging to scientifically test the interaction among hundreds of molecules contained in the cannabis plant (Worth, 2019). If valid, this hypothesis could explain the difficulty of demonstrating robust evidence from single cannabinoids and should encourage research on herbal cannabis.

2.4. The technical and economic barrier to research

A first difficulty when trying to demonstrate the efficacy of herbal cannabis is that there exists a wide variety of cannabis plants. Genetic diversity amongst cannabis plants is higher compared to populations of similar plant species (Punja et al., 2017), and as Pertwee (2014 notes "the variability of chemotypical and other characteristics is impressive". Rahn et al. (2016) list 601 different varieties that are currently commercialized via seed sales and reviews[62]. These strains display phenotypically distinct traits, as well as unique chemical composition and can be considered as a heterogeneous array of treatments for patients (Baram et al., 2019). Indeed, besides for the dosage, the effects of cannabis vary depending upon the variety of cannabis (Vergara et al., 2017). A second difficulty stems from the variability in the treatment response of most human subjects tested with cannabis (Atakan, 2012). Genetic predispositions can lead to significantly different reactions and effects among patients for the same cannabis-based product (Yeung et al., 2019). This could lead to a lack of external validity not only when cannabis-based product derived from different varieties are used to treat a certain condition, but even when the preparation is made using the same variety. According to Berman et al. (2018), genetically-identical cannabis strains can express different phytocannabinoid compositions when grown in slightly different environments. Even when choosing a specific variety, a patient may thus receive a cannabis-based treatment whose content will not produce the desired effect as its

[61] See Ben-Shabat (2001), Russo (2011; 2016) and Anand (2021) for details on the entourage (or symbiotic) effect.
[62] This number is likely conservative given that breeding occurs also in response of the demand. For instance, high CBDA plants have only recently become more available in North America (Lynch et al., 2016).

component may differ significantly. A third difficulty, pointed out by Russo (2016), relates to the ability to produce adequate blinding in clinical trials of psychoactive drugs. Indeed, usual placebo effects due to the sole fact of being involved in a clinical trial might be aggravated when the measured outcomes are subjective (i.e. relating to pain reduction or improvement of mood) and when there is social turmoil around the tested drug (as it is the case for cannabis).

However, the most complex issue is getting a patent to make the research investment profitable. Herbal products are quite different from chemical drugs and are difficult to protect by existing patent laws (Kartal, 2007). Whole-plant cannabis extracts cannot be patented on their own even if they are produced from a specific variety. Plant varieties formed from classical breeding and selection are indeed not patentable as novel innovation[63]. Plant breeders can freely cross any varieties of others to produce new varieties, which may then be commercialized (Gambini, 2019). An alternative strategy would be to patent combination therapies made with two or more cannabis compounds having some working combination together. There are however limitations on this strategy. The first is that it does not allow obtaining a product benefitting from the entourage effect. The second is that the cost of the proof is likely to be high since each compound taken separately, as well as the combined final product, must be proved safe and efficacious (Brodie et al., 2015). The third is that since the patent concerns a mere combination, with no chemical reaction, only limited protection is granted. For example, a patent on an equal ratio CBD and THC will not prohibit any one from mixing the two cannabinoids in different proportions and obtaining new patents (Saha and Bhattacharya, 2011).

That fact that only 2 of the 79 trials on medical cannabis reviewed by Whiting et al. (2015) evaluated herbal cannabis provides a tangible sign of the lack of financial incentives to conduct such trials. Considering clinical research on herbal cannabis as a market failure, public research could take the lead. This is certainly the case with regards to *RCTs* looking at therapeutic benefits of herbal cannabis: to date, the only completed trials in phase 3 registered at clinicaltrials.gov were sponsored by European universities or the National Institute of Drug Abuse (NIDA). NIDA is likely the largest single sponsor on cannabis research worldwide. Yet, in 2017 only one quarter of its research on cannabis was directed on studying its therapeutic properties as the agency mostly focuses on the effect of drug use and addiction. Moreover, Schedule I classification of cannabis may have discouraged researchers in public institutions from applying for grant funding or pursing cannabis research efforts (Nutt et al., 2013). This could certainly change with adequate political momentum. Yet, to obtain the

[63] The Chartered Institute of Patent Attorneys (CIPA) considers that for the patentability of biological material, this must be "produced by a technical process which by itself introduced a trait into the plant genome or modified a trait in the genome of the plant produced, so that the introduction or modification of that trait was not the result of the mixing of the genes of the plants chosen for sexual crossing".

required proof-of-principle in RCTs with different cannabis varieties might require extensive resources. Even assuming the red tape on cannabis research will be minimized and several authorized suppliers will have the flexibility to provide customized ready-to-use formulations to be used in RCTs, it will take several decades to be able to study the therapeutic potential on hundreds of different cultivars for the extensive number of conditions for which herbal cannabis might be used therapeutically.

2.5. Cost and benefits of the American model

Considering these arguments, the North-American accommodative models have a clear benefit since they allow access to a large variety of herbal cannabis and hence maximize the potentialities of medical cannabis. They also have demonstrated more general health, social and economic benefits, such as a reduction in opioid-related harms (Powell et al., 2018), cigarette consumption (Choi et al., 2019), sickness absence (Ullman, 2017) and an increase in older adult labor supply (Nicholas and Maclean, 2019), without increasing use prevalence among minors (Sarvet et al., 2018). However, these schemes also increase the risk of accidental poisoning (Wang et al., 2016) as well as diverted recreational use (Pacula et al., 2015) and initiation (Wen et al., 2015). Since diverted use leads to unjustified - and possibly exorbitant - costs in systems that subsidize or reimburse patient expenditures, such accommodative systems generally expect all patients to pay the full price, potentially excluding some patients with genuine indications for medical cannabis, or treating them unfairly compared with patients using conventional medicines.

2.6. A new supply architecture for medical cannabis

As both systems (the restrictive European one and the accommodative North-American one) have their limitations, it might be interesting to develop innovative schemes that keep the best of both approaches while avoiding their limitations. A possible option would be to create a dual distribution system for medical cannabis. The first channel would be similar to the existing restrictive models, i.e. it would be limited to a restrictive list of serious conditions for which there exists scientific evidence of the efficacy of medical cannabis. Patients fulfilling these criteria could benefit from a specified list of cannabis medicines in the same conditions as conventional medicines (i.e. delivery in pharmacies upon medical prescription with total or partial reimbursement from the health insurance system). In parallel, a second channel would be available, as a complementary distribution system. This system would provide non-irradiated herbal cannabis for patients who do not fulfill the criteria for the first channel, or have a preference for the entourage effect or for cannabis strains not supplied in pharmacies. This second system could be considered in two different ways: either as a last-resort, even more restrictive distributive channel, or as an alternative more easily accessible channel. In the

first case, prior to providing prescription for herbal cannabis, a treatment trial with medicinal-grade herbal cannabis or cannabinoids should be undertaken. In the event of a negative response with these pharma-grade products, the opinion of a second physician specialized in herbal cannabis must be obtained. These patients should be monitored periodically rigorously with face-to-face healthcare operators and would benefit from reimbursement from the health insurance system. In the second case, this channel could be used in the first line of action. It would rely less on medical expertise (it won't necessarily require a medical prescription), but more on users' expertise. The counterpart would be that patients would not benefit from reimbursement from the health insurance system. It would also de facto blur the distinction between medical and recreational cannabis. This is not a problem in countries where recreational cannabis has been legalized, but it is one in countries where it has not. Hence, if legalizing non-medical use is not a pursued political goal, the first approach is preferable.

2.7. The Cannabis social clubs

For both configurations, Cannabis Social Clubs (CSC) could serve as a structure for the additional channel (Pardal and Bawin, 2015). CSCs have to date only been formally allowed and regulated in Uruguay. Yet, the model exists in several other countries, being shaped by the self-regulatory efforts of groups of users (Queirolo et al., 2016; Pardal, 2018). Some common core features have been typically (or ideally) ascribed to this model: it should be non-profit driven; it tends to operate in a cooperative fashion – with production generally being a task taken by a group of CSC members; distribution is restricted to members only, who must meet certain requirements (e.g. 18 years or older, residency or nationality in the country where the CSC is based, already have used cannabis, etc.). In at least four European countries, some CSCs exclusively serve medical users: Spain, Belgium, Italy and Switzerland (Decorte and Pardal, 2017). Belgium provides an interesting example, operating for over a decade and with no evidence of significant deviations from the non-profit framework (contrary to Spain for instance) (Pardal, 2018). In Belgium, those using cannabis for medical purposes have been integrated in CSCs under three different schemes: mixed CSCs without distinction between recreational and medical members, CSCs featuring a separate subunit to serve only medical members and CSCs admitting medical members only (Pardal and Bawin, 2015). Candidate medical members must fulfil additional documents from a physician such as a prescription or a letter acknowledging the condition or symptoms for which the patient is using cannabis. Only one CSC featuring a medical subdivision collaborated with a volunteer nurse. Yet, more regular and specific follow-up is offered to medical members. CSCs supply different varieties of herbal cannabis at a lower price compared to the illicit market, and medical members often get a discount (Pardal and Bawin, 2015).

Roth (2018) suggests that economists should help to design new marketplaces to improve social welfare. Our proposed novel architecture would go in this direction by being the first to implement product differentiation across supply channels for patients. If well-monitored, this dual system would shed light on the pattern of use of patients once they can choose between medical paradigms, indirectly providing a real-world example of how plant medicine can be incorporated into a contemporary regulatory framework that is both evidence-based and appropriate for traditional therapies (Evans, 2008).

2.8. References

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CHAPTER THREE

3. LEGALIZING MARIJUANA IN COLORADO: DISPLACEMENT OR MARKET EXPANSION?

Abstract

This paper examines how sales at medical marijuana centers in Colorado were affected by the opening of recreational marijuana stores in 2014, where any adult can purchase without the necessity of a doctor's recommendation. We exploit differences across counties in the availability of medical and recreational marijuana to examine whether the sales growth of recreational marijuana was at the expense of sales of medical marijuana or acted by expanding the overall legal market. Our findings suggest a statistically significant but economically modest amount of displacement (less than 10 percent), demonstrating that the legalization of recreational marijuana primarily expanded the legal market.

Keywords: Marijuana Legalization, Panel Data, Cannibalization effect, Medical cannabis

Abbreviations:

CDPHE:	Colorado Department of Public Health and Environment
MED:	Marijuana Enforcement Division
MMC:	Medical Marijuana Center
MMJ:	Medical Marijuana
RMJ:	Recreational Marijuana
RMS:	Retail Marijuana Center

3.1. Introduction

Over the past 20 years, the United States has been at the forefront of change in marijuana policy with 37 states and the District of Columbia currently having established medical marijuana (MMJ) programs. Among these, 21 have also legalized marijuana for recreational purposes, despite its prohibition under federal law. In Colorado, where licenced medical marijuana centers (MMCs) have operated since 2009 and retail marijuana stores (RMSs) since 2014, there are currently approximately 500 of each type. The expansion of stores and greater availability of marijuana have undoubtedly contributed to the large increase in consumption. This is the first study which not only investigates whether allowing recreational marijuana (RMJ) leads to a reduction in MMJ sales, but also attempts to quantity the displacement effect of full legalization on the medical market. The degree of substitutability between medical and recreational marijuana has implications not only for public

health policy, but also for public finance, as taxation of marijuana has become a major source of tax revenue at both the state and local level.[64]

To be eligible for MMJ in Colorado, a doctor's recommendation is required. A large number of physical and mental conditions may respond to treatments with marijuana such as pain, appetite, insomnia, anxiety, and depression. Some of these are difficult to diagnose and it may therefore be possible for the patient to influence the outcome and obtain a recommendation, even in the absence of a medical reason (i.e. chronic pain, a condition declared by more than 9 out of 10 patients in Colorado, which is not medically verifiable).[65] At the MMC, the patient can choose among many different varieties (or strains) of marijuana and formulations (e.g. flowers, edibles, chemically-extracted concentrates) with different properties in terms of active ingredients. Some of the offerings will have euphoric and uplifting properties similar to illicit marijuana and the RMJ presently sold at the RMCs (Cash et al., 2020). It is conceivable that some of the sales at the MMCs have been for recreational purposes, either for the patient themselves, or for others (Wen et al. 2015).[66] Once the RMSs entered in 2014, the amount of marijuana sold by MMCs but used for recreational purposes would be expected to drop.

The staged legalization of marijuana in Colorado and the local authorities' ability to restrict marijuana within their jurisdiction allow us to examine the extent to which the medical and recreational markets are interrelated at a local level. Across Colorado, a large number of applications to operate a MMC were filed before 2012, but the processing time and general view on marijuana differed across both across counties and local governments. As seen in Figure 2, by Q3:2013 the medical market appears to have stabilized with about 500 MMCs, while in the recreational market the number of RMSs has increased steadily since their inception in Q1:2014.

In this paper, we quantify the effects of the entry by RMSs on the sales at the MMCs with county-level data (Q3:2012 - Q4:2017) on the number of stores, their sales revenue, and the number of registered patients. The overall results suggest that an additional RMS in a county would decrease

[64] In Colorado, for instance, substantial tax revenues are collected both at the state, county and local level through a variety of taxes. As of January 2018, MMJ is subject to a 2.9 percent state sales tax whereas RMJ is subject to a 15 percent special sales tax in addition to a 15 percent excise tax on wholesale transfers; from the two sources the state collected 75 and 558 million USD in tax revenues so far, respectively. For 2016, they represented about 0.8 percent of the state's overall revenues (Rocky Mountain High Intensity Drug Trafficking Area, 2017). In addition, there are revenues collected from local taxes, licensees, and fees.

[65] The opening of MMC and the greater accessibility of MMJ had a dramatic effect on the number of registered patients. Just before the MMCs were allowed in 2009, there were less than 6000 patients with recommendations, which increased rapidly to approximately to 115000 in 2011, before falling to less than 90000 in 2017 (see Figure 1).

[66] Thurstone et al. (2011) show that leaking of MMJ from legal patients or dispensaries might be common. Pacula et. al (2016) found that 76 percent of those who self-identified as having a physician's recommendation reported also RMJ use. For more on classifications and uses of marijuana see Caulkins et al. (2016) and Sznitman (2017).

MMJ sales by $14200 to $57300 per quarter, which is 1.4 to 5.7 percent of the sales in the sample median county ($1.0m). In terms of sales per capita, we estimate that an additional RMS reduces medical sales per capita by between 0.1 to 0.7 percent; the elasticity at the sample means is -0.12. Finally, using the sales per MMC as the dependent variable, we find that an additional RMS is associated with a reduction in MMJ sales of $1100 to $1900 per MMC. Again, this is in the order of 0.6 to 1.1 percent of the average sales per MMC. Overall, our results suggest that the expansion of RMSs has had a statistically significant but economically small effect of the sales of MMJ.

Among the set of controls, we include the outcome of the 2012 ballot regarding legalization of RMJ, a dummy variable for whether the county is bordering another state, unemployment and the importance of the leisure industry. The sentiment towards marijuana, as proxied by the ballot, is found to be positively related to both the existence and prevalence of MMCs and RMSs, as well as sales of MMJ. Counties that border other states tend to have higher sales in the RMCs and higher sales of MMJ, in comparison to the number of MMCs or patients.

A limitation of our approach relates to the potential endogeneity occurring between sales of MMJ and the number of MMCs. Sales of a product are indeed generally driven both by the underlying demand for it and the number of shops selling it. Nevertheless, we provide several arguments to show that the opening of RMSs is most likely exogenous in view of the licensing scheme. Besides for the sentiment towards marijuana and the population of the county, we found no other factors affecting the chance to have dispensaries operating within a county.

The question of whether the marijuana sold as medicine is used recreationally is present in discussions of policy reforms elsewhere, but the paucity of reliable data limited the evaluation of already implemented reforms until recently (Pudney, 2010; Kleiman, 2015). This study is, to our knowledge, the first to quantify the effects of the entry by RMSs on the sales of MMJ, extending and complementing some of the earlier studies using survey-based methods and other indirect measures.

Pacula et. al (2016) found a large degree of overlap between medical and recreational users, and reported that registered patients use marijuana more frequently and intensively. Chu (2015) estimated the effect of the passage of MMJ laws on marijuana arrestees and admissions to treatment concluding that legal protection for patients have increased marijuana consumption. Certain policy dimensions are particularly responsible for the increased consumption, namely the existence of a legal distribution model (Pacula et al., 2015) and the "non-specific pain" provision[67] (Wen et al., 2015) which suggest

[67] It refers to a situation when physicians use generic chronic pain as the eligible condition for MMJ recommendation without specifying which specific medical condition is causing the pain.

MMJ laws may have an impact on the consumption of the non-patient population. Moreover, older programs, such as in Colorado, tend to have higher enrolment rates compared to those which legalized this market recently (Williams et al., 2016). Further, Smart (2015) shows that an increase in the share of adults registered as marijuana patients increased marijuana use. Surprisingly, no evidence has been found on the increase in marijuana use among adolescents (Sarvet et al., 2018)

Through survey-based methods, Jacoby and Sovinsky (2016) investigated how full legalization would expand marijuana use by focusing on both the effect played by dispensaries in increasing accessibility, and the removal of the stigma of illegality. Despite higher price-sensitivity of young individuals, their model predicts that the largest impact would be on the population over 30 years old. Dragone et al. (2018) confirmed the intuition and found that bordering counties in Washington state experienced an increase in the consumption of marijuana after the legalization relative to the bordering counties in Oregon, a state which passed the legalization ballot just two years afterwards.

While the passage of laws allowing suppliers increases the demand for marijuana, the consequent market expansion is not captured by illicit suppliers. A growing body of empirical evidence show that the entry of legal competitors reduces the demand for illegal marijuana, and in turn the size of its black economy (Huber et al., 2016; Gavrilova et al., 2017; Brinkman and Mok-lamme, 2019; Dragone et al. 2018; Xiong, 2018). Contrary to policies which only reduce user sanctions, marijuana legalization for medical or recreational purposes has a substantial supply-side effect by allowing home cultivation, commercial production and distribution (Pacula et al., 2010). This effectively create a new legal competition for the incumbent suppliers, which in turn diminish their risk premium (Huber et al. 2016). Those involved in the illicit marijuana trade end up finding themselves in a worse economic environment characterized by increased competition and lower mark-ups which erodes the available rents (Miron and Zwiebel, 1995).

As there is no direct way to identify the rate of change in illicit cannabis market after legalization, scholars have used indirect measures by examining how the criminal behaviour of marijuana dealers had responded to the natural experiment created by new marijuana regulations. Gavrilova et al. (2017) looked at how counties close to the Mexican border where affected by MMJ laws. They found a strong reduction in systemic crime habitually committed by criminal organization which signals lower financial incentive to use violence consistent with the hypothesis that MMJ laws reduce the demand for illegal marijuana from Mexico[68]. Huber et al. (2016) found a connection between MMJ

[68] Miron & Zweibel (1995) discuss how in illicit drug markets criminal organization resort to violence to enforce contracts and to regulate disputes. Their investment in violent activity depends on the amount of disputed revenues

laws and a reduction of crime related to the illicit marijuana market at the state level[69]. The decline in supplier-related violence – along with reallocation of policing efforts and the substitution away from crime-inducing substances - is considered as a likely cause, indicating changes occurring to the entire marijuana market.

Similar effects were found after the legalization of cannabis for adults. Using census-track data from the city of Denver, Brinkman and Mok-lamme (2019) found that - in the short-term - the density of dispensaries within a neighbourhood is associated with lower crime related to marijuana trade[70]. In parallel, Dragone et al. (2018) consider the disruption of the illegal market as one of the most plausible explanation for the lowering of crime rates after the full legalization in Washington state. The policy change appears to have reduced the role for criminals in local marijuana market as the legal product has substantial competitive advantages in terms of safety and quality. In turn, the risk of being victimized while buying or consuming has declined resulting in a reduction in property crime. Rather than looking at the effect of legalization on crime by location, Xiong (2018) looks at the response of arrested marijuana trader exiting prison. He finds that their behaviour changes after legalization as they become less likely to commit future marijuana offences. They search for better opportunities, both in the legal and illegal sector since legalization have disrupted the profitability of marijuana trade.

Other studies have investigated whether MMCs are targeting recreational users. Through surveys collected outside four California' MMCs, Cooke et al. (2018) found that the characteristics of patients buying at the dispensaries differ significantly from those of individuals living in the area. Most dispensaries have clients who reflect more the population who buys MMJ in California - males with low median age - rather than the local population. This suggest that these dispensaries may be drawing in patients from other areas, and either track specific groups living there (young males) or those coming in the area for other purposes. Similarly, Hsu et al. (2018) argue that existing MMCs have responded to the competition of RMSs in different ways, depending on the socio-political support for legalization. They have emphasized their distinct identity in communities with weak support, whereas they directly compete for recreational consumers in areas with strong support for marijuana reform.

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which appears to decline after legalization. As gangs lower their demand from marijuana, they have a lower incentive to resort to violence.

[69] States with a MMJ regulation experienced a larger reduction in robberies, larcenies and burglaries compared to those states that did not.

[70] An additional dispensary was found to decrease changes in crime by 19 percent relative to the average monthly crime rate in the neighbourhood.

3.2. Institutional Background

In the United States, marijuana was listed in the Pharmacopeia until 1942. The plant was classified as a Schedule I substance by the Controlled Substance Act of 1970, meaning that it has no accepted medical use and high potential for abuse. Nonetheless, in November 2000 Colorado voters approved a ballot permitting marijuana patients and their primary caregivers to possess up to two ounces of marijuana and to grow up to six plants for medical purposes. While the ballot initiative did not address any retail supply channel, in 2007 MMCs came into place as an indirect consequence to the judiciary decision to expand the maximum patient base per caregiver beyond five patients (Kamin, 2012). An informal MMJ market was created, but very few MMCs were operating until 2009, when the Attorney General committed to not prosecuting stakeholders in compliance with state law (Anderson and Rees, 2014). This resulted in the proliferation of hundreds of new MMCs with very limited state regulations in place.[71] In parallel, the number of registered patients climbed twenty-fold between January 2009 and July 2010. The emergence of this industry became a major concern for policymakers who chose to regulate it by allowing MMCs to be active on a for-profit basis under certain operating conditions, such as distance buffers from places associated with children and problem drug users, as well as vertical integration.[72]

In November 2012, Colorado became one of the first two states to vote for marijuana legalization for all adults aged 21 or older in 2014, through a ballot measure. The legislation permits to legally possess no more than one ounce of marijuana, grow up to six plants, and transfer no more than one ounce to another adult without being remunerated. On January 1st 2014, the legislation was implemented and RMSs opened their operations, allowing any adult to legally buy marijuana and grow up to six plants for personal use.

Colorado state defers to local entities the authority to allow or prohibit the operations of MMCs or RMSs through legislative action or popular vote (Allen, 2010). As of June 2017, 26 percent of Colorado's local jurisdictions had adopted both medical and recreational marijuana operations, while 9 percent allow only one of the two segments. The remaining jurisdictions have put a total ban on marijuana sales (Hartman et al., 2017) in some cases to learn lessons from other localities. Although

[71] There was also evidence of misconduct by physicians in relation to patients' recommendations and dosage. For instance, prior to October 2012, the 12 physicians with the most recommendations had recommended MMJ for 50 percent of the patients on the registry (CDPHE, 2013).

[72] Before October 2010, there were no state licencing requirements for selling marijuana and there is no official information on the number of places that offered the product. Those who had applied for a local license by July 2010 were temporarily allowed to continue their activities as long as they also applied for a state license. The mandatory licencing scheme came in to effect on July 1st 2011.

a significant portion of Coloradans lives in communities where the sales of marijuana are not allowed, the great majority can find active dispensaries in their own counties[73].

Under the current regulations, a firm that wishes to open a MMC or RMS needs to first obtain a license from the Marijuana Enforcement Division (MED) which is the specific body tasked with regulating the marijuana industry. These licenses allow retailers to sell products to the final consumer, (other types of licenses are issued for producers and for processors) [74]. Licenses are granted for a two-year period, and local government can set license fees to cover their enforcement costs discretionally. Conditional upon having a license, local jurisdiction approval is required from the municipality where the company wants to operate (or the county if the operation is to be located in unincorporated area). Localities are thus responsible to decide how many dispensaries are allowed to open in their jurisdiction. These restrictions had an impact on the geographical distribution of new marijuana dispensaries across Denver neighbourhoods which appear to be related to poverty rate and employment (Brinkman and Mok-Lamme, 2019). On the contrary, the authors found no significant relationship between demographic factors and change in dispensary density at the county level, suggesting preference are more diluted across this geographic unit.

As noted in the introduction, both MMCs and RMSs sell an array of marijuana strains with different properties in various formulations. Their effectiveness for specific conditions has not been studied in view of a market failure in clinical trials on herbal cannabis (Fortin and Massin, 2020). There is no comprehensive information regarding price differentials at the local level for comparable items. However, the existence of a 10 percent special tax on sales at RMSs would tend to lead to higher prices, compared to a MMC. Although there are similar products at the MMC and RMS, and prices at the former likely lower, being able to purchase without a recommendation is a factor that may direct not only recreational but also some medical users to purchase at a RMS rather than a MMC. (For instance, being a registered marijuana patient may make it difficult to legally purchase firearms, Graham (2017)). For occasional users, the direct and indirect costs associated with being registered

[73] As of December 2017, about 84% and 75% of Coloradans live in counties with active MMCs and RMSs, respectively. County ordinance applies only to the unincorporated part of a county, thus incorporated city may create different laws than the county they are nested in.

[74] Under the current regulations, a MMC must grow at least 70 percent of what it sells, and it may not sell more than 30 percent of what it grows to other MCs or producers of marijuana-infused products (the "70/30 rule"). The federal prohibition indirectly set other regulations. Most dispensaries are required to operate on a cash-only basis, while it is not possible for business owners to deduct expenses from gross profits, nor get a loan from federally licensed banks (Subritzky et al., 2016). As of December 2017, no marijuana delivery service is allowed.

as a patient[75] may well outweigh the lower prices, but for frequent consumers, these costs may be small relative to the savings.[76]

3.3. Data

We examine the development of the medical market and the recreational market along several dimensions, where the segmentation is based on point-of-sale rather than purpose of use. For each county, we have information at a quarterly frequency on sales revenues (if any) and the number of outlets.[77] This data is from the MED. For each of the 64 counties in Colorado we also have information on the number of patients from the Colorado Department for Public Health and Environment (CDPHE) and several different demographic variables collected from US Census and US Bureau of Labor Statistics for the 22 quarters Q3:2012-Q4:2017. Table 1 provides descriptive statistics for the non-zero observations of each variable. Table 2 lists the key variables by county as of Q4:2017.

TABLE 1
Descriptive statistics

Variable	mean	SD	min	p25	Median	p75	max	N
REV_MED	4.95e+06	1.09e+07	20492	391718	1.0e+06	3.78e+06	5.89e+07	432
REV_RECR	7.22e+06	1.41e+07	113511	1155562	2.54e+06	6783840	1.04e+08	369
REV_TOT	1.03e+07	2.26e+07	98236	879882	3.13e+06	9026416	1.57e+08	421
#MMC	13.34	34.65	0.33	2	3	7.5	207	767
#RMS	11.72	25.8101	0.33	3	5	10.16	176	516
POP	64952.5	130320	587	4799	11636	35540	552422	1408
ln*(POP)*	9.535	1.725	6.375	8.476	9.361	10.47	13.22	1408
REV_MED/POP	24.18	19.14	2.878	11.35	19.31	30.62	106.6	432
REV_REC/POP	11.56	124.1	5.624	46.54	87.00	144.5	1178	369
REV_TOT/POP	91.87	114.4	5.855	25.11	55.76	128.6	1189	421
REV_MED/#MMC	172983	105429	13658.2	83562	167599	238150	570348	432
REV_REC/#RMS	446091	330194	46162	206237	370122	570781	2.02e+06	369
PATIENTS	1657.3	3657.3	3	76	257.5	940.5	19909	1408
PATIENTS/POP	0.025	0.013	0.004	0.016	0.022	0.034	0.084	1408

[75] Potential patients need to acquire a written diagnosis from a physician, registered with CDPHE and pay an administrative fee of $15.

[76] The amounts spent on marijuana by registered patients are substantial. At last quarter in in our sample (Q4:2017), there are 90112 registered patients in Colorado and total sales at the MMCs is approximately $97m, which means that the average purchase per registered patient is just above $1000 per quarter or about $80 per week. Even accounting for the possibility that some sales at the MMCs are diverted to out-of-state users or to friends (Belackova and Vaccaro, 2013), the sums involved are significant. There is no corresponding information on the average amount spent per customer at the RMSs, but it is likely to be substantially lower.

[77] During the first year, MED operated with a lack of resources (Room, 2014). Identification procedures gradually improved from 2012 with the licensing of MMJ businesses. However, the first monthly report which distinguishes active MMC from those with a pending application is from August 2012. In parallel, quarterly MMJ sales data are also available from the same quarter.

REV_MED/PATIENT	752.2	600.9	130.5	431.5	624.3	850.5	4568	432
PATIENTS/#MMC	341.5	426.6	18	113.7	192.5	334.5	3365	767
BALLOT	51.32	10.40	31.9	43.75	49.35	58.25	79.1	1408
LEISURE	0.101	0.14	0.004	0.037	0.056	0.092	1.004	1408
UNEMPL	4.440	2.302	1.23	2.7	3.87	5.63	16.07	1408
BORDER	0.406	0.491	0	0	0	1	1	1408

Sales revenue in the medical segment, *REV_MED*, is available from Q3:2012, when state marijuana taxes began to be collected. For counties with less than three MMCs, or where one MMC has a revenue share exceeding 80 percent, *REV_MED* is not disclosed. Sales revenue in the recreational segment, *REV_REC*, starts in Q1:2014. As with the previous variable, the value is not reported if there are fewer than three RMSs, or if one has a revenue share exceeding 80 percent[78]. We observe quarterly MMJ sales in 24 counties with 23 of them experiencing a RMS opening within their jurisdiction. MMJ sales in about 63% of the counties are observed every quarter, and in 79% of the counties are observed in at least 16 quarters. As seen in Table 1 and Table 2, sales in the two segments differ greatly across counties which is, to a large extent, due to differences in population and the number of MMCs and RMSs. The total sales in the county is denoted *REV_TOT* and is the sum of *REV_MED* and *REV_REC*.

The share of adults registered as medical marijuana patients per county ranges between 0,4% and 8,4% during the study period. We perform a preliminary analysis to examine whether the presence of a competitive legal market has affected the patient growth post-legalization. We look at the difference in the share of adults who had obtain a prescription for MMJ between the month with the minimum number of patient post-legalization (June 2017), and the month with the maximum number pre-legalization (June 2011). Appendix table 1 show that the magnitude of the drop in the registration rate differs substantially between the counties in the sample and the remaining counties, namely those with either no MMC or without a competitive MMJ market (less than three active MMCs). The reason lies on the initial registration rate of counties with a competitive MMJ market which was almost doubled compared with the remaining counties. Among the counties in the sample, those with both competitive MMJ and RMJ markets experienced a larger drop in the registration rate of about 2,7%,

[78] This reporting standard implies that the data employed here is not adequately reflecting the sales pattern in the counties with few outlets, but enables us to distinguish between true zeros and missing data. Sales at MMCs and RMSs are missing for a month in a quarter in 9 and 19 counties, respectively. We have imputed the sales for the missing months to obtain the quarterly sales, using average monthly sales in the county in the same calendar month for the adjacent years.
Appendix table 1 shows simple averages of selected characteristics for the sample and the remaining counties. Except for higher tourism, there appear to be no major differences in terms of socio-economic characteristics, preferences for legal drugs and pre-MMCs prevalence rate of marijuana patients between our sample and the group of counties which are not included in the sample.

whereas the two counties in the sample with only a competitive MMJ market experienced an average drop of 0,15%. It thus appears that the existence of a RMJ market affects the decision of users to leave the MMJ program by providing an alternative to a portion of the patient base.

The number of MMCs is denoted *#MMC* and the number of RMS is *#RMS*. Both variables refer to the average number of dispensaries that are active in the quarter. Again, the number of dispensaries displays a great deal of variation across counties, which reflects not only the population but also county and local licencing policies.

We use two variables to measure the overall demand level in a county. First, the adult population size (over 18), *POP*, should be a good proxy for the potential demand. Second, the number of registered patients, *PATIENT*, would be a reasonable predictor for demand in the medical market, as only they can buy at the MMCs.

To control for possible differences in per capita demand, we use the fraction of the population working in the leisure sector (defined as Arts, Entertainment and Recreation, as well as Accommodation and Food Services), *LEISURE*, a dummy variable for whether the county is bordering another state, *BORDER*, and the fraction of the county population that voted in favour of the ballot on Amendment in 2012, *BALLOT* (see below for details). The motivation for including *LEISURE* is that some counties are heavily reliant on tourism, and some tourists might purchase marijuana while visiting. If a county is on the state border, there may likewise be some purchases from out-of-state citizens (Hansen et al., 2017; Hao and Cowan, 2020). *BALLOT* gives an indication of the underlying sentiment of the population in the county regarding the use of marijuana.[79] Finally, we control for the level of unemployment in the county, *UNEMPL*.

We use several alternative dependent variables to capture multiple aspects of the two segments. First, we normalize sales with the county's population to get the variables *REV_MED/POP*, *REV_REC/POP*, and *REV_TOT/POP*. Variation in these variables may be driven by differences in per capita demand and are expected to be positively related to *LEISURE*, *BORDER*, and *BALLOT*. Second, we use *REV_MED/PATIENT* and *PATIENT/#MMC* to examine whether the composition of

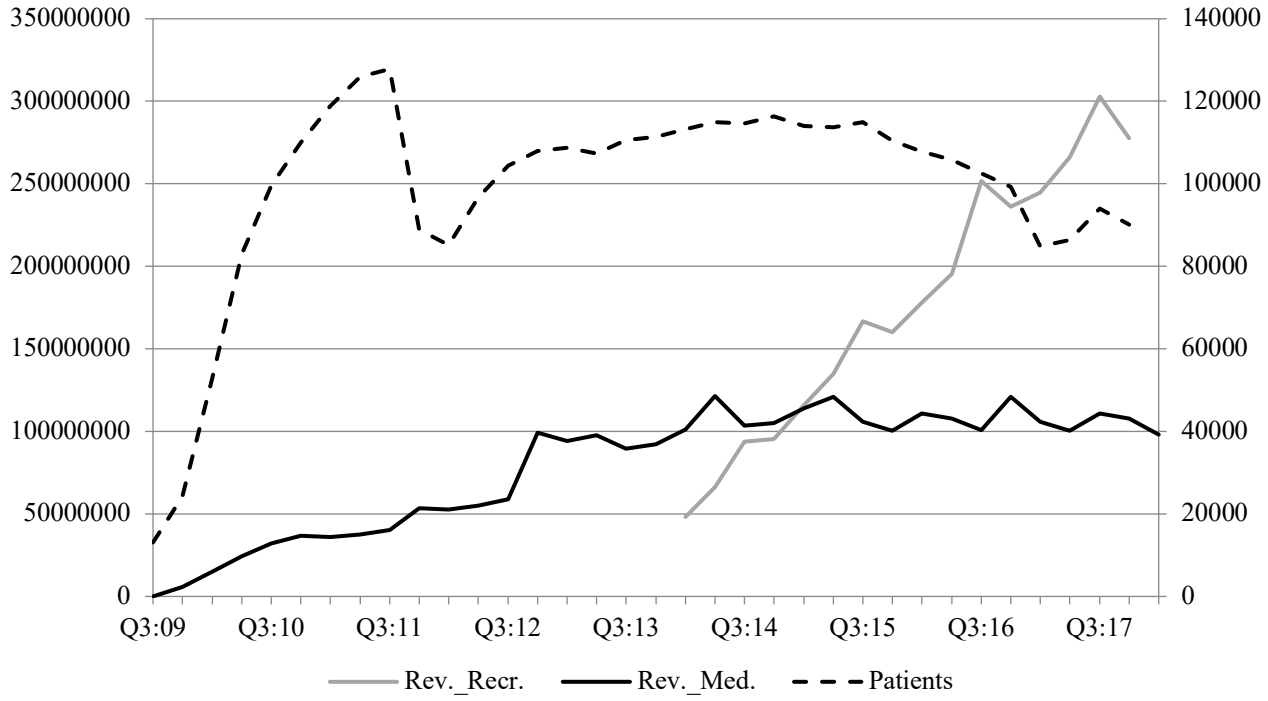
[79] In addition to the included variables, we have experimented with a number of other variables that might capture differences in per capita demand such as the fraction of university students to population, unemployment rate, average income, and the fraction of the population with a Bachelor degree. However, neither of them had any significant or consistent effect on the dependent variables we are interested in. The one exception is the election result (from the 2012 and 2016 presidential election) where the fraction voting for the Democrats candidate is highly correlated (0.85) with the variable *BALLOT*. We prefer the variable *BALLOT* since this more directly measures the sentiment regarding marijuana rather than the relative attractiveness of two different political platforms. Data collected from http://data.denverpost.com/election/results/amendment/2012/64-legalize-marijuana/ accessed Jan 27, 2017.

the patients can be explained. Finally, we examine the sales revenue per store *REV_MED/#MMC*, and *REV_REC/#RMS*.

Figures 1-4 illustrate the main variables over the period, aggregated to the state level. Figure 1 shows the sharp increase in sales of RMJ and the relatively stable sales of MMJ, and the decrease in the number of registered patients towards the end of the sample period. Figure 2 suggests that the number of MMCs reached a broadly stable level within one year from inception, but that the number of recreational stores has continued to grow since they began to open in 2014. Figure 3 illustrates the general decline in sales per medical store, and shows that RMSs have higher sales that are increasing over time. Finally, Figure 4 shows that medical sales per patient are slowly increasing and that total sales of marijuana per capita are sharply increasing.

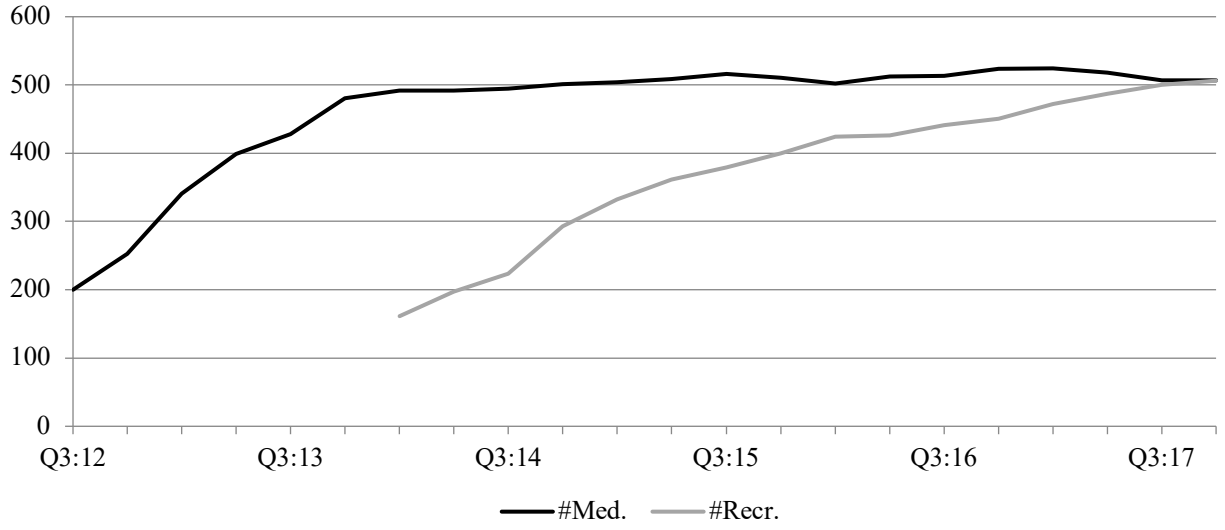
FIGURE 1

Sales and Marijuana Patients, Q3:2009 – Q4:2017



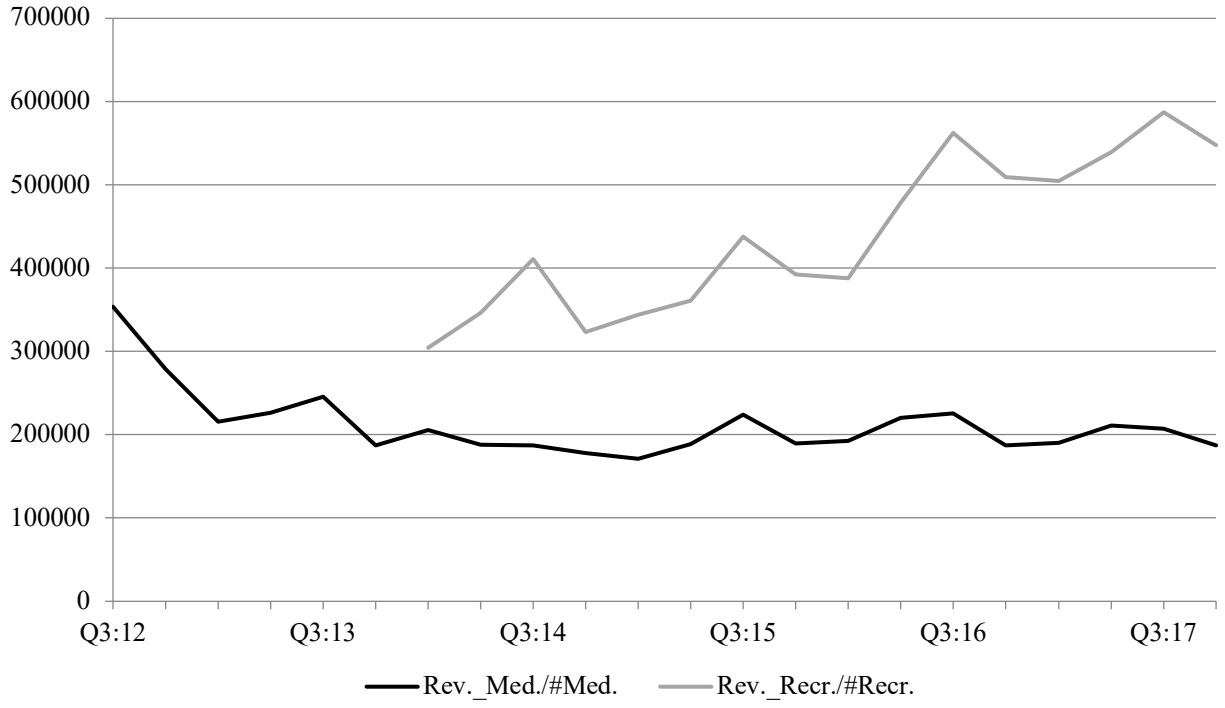
Note: State-wide sales data for the period before Q3:2012 is less reliable, as explained in the main text.
Source: MED; CDPHE.

FIGURE 2
Number of Marijuana Dispensaries, Q3:2012 – Q4:2017



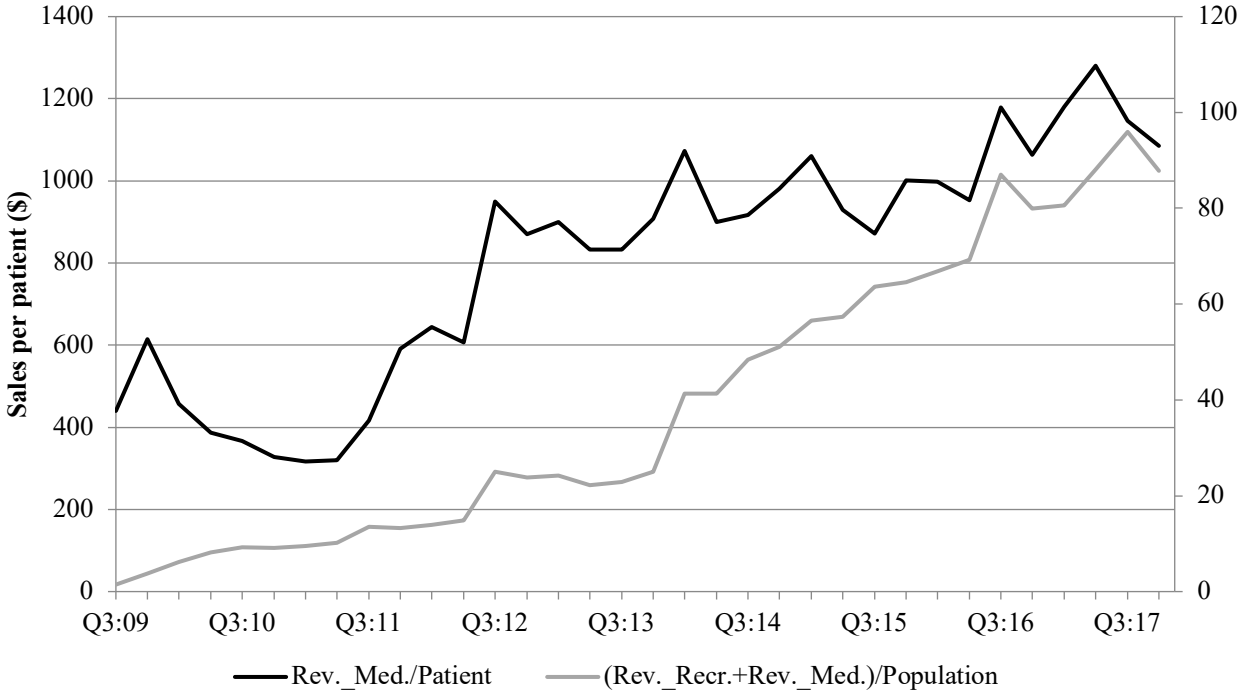
Source: MED.

FIGURE 3
Sales per Dispensary, Q3:2012 - Q4:2017



Source: MED.

FIGURE 4
Sales per Patient and Sales per Capita, Q3:2009 - Q4:2017



Note: State-wide sales data for the period before Q3:2012 is less reliable, as explained in the main text.
Source: MED; CDPHE; U.S. Census Bureau, Population Division.

3.4. Econometric model and results

Before turning to the econometric specifications, it is useful to discuss the economics of the problem. Differences across counties in sales of medical and RMJ in Colorado will be driven both by the underlying demand for the products and the number of outlets. The underlying demand will depend on county population and the per capita demand, both of which can be proxied by demographic variables. In the absence of a licencing requirement, a zero-profit condition in a free-entry model would determine the number of outlets as a (possibly concave) function of market size (see e.g. Bresnahan and Reiss 1991; Asplund and Sandin 1999; Mazzeo 2002; Seim 2006). However, given that local authorities can and do restrict the number of outlets, the accessibility of marijuana will vary across counties, and the free-entry equilibrium number of firms would be an upper bound.[80] In this paper, we do not explicitly model the details of competition within and between segments. Instead, we use a parsimonious specification to examine how revenue within a segment responds to changes in the number of both types of outlets.[81]

We proceed in two steps. First, we examine the probability that a county has at least one MMC or at least one RMS at different points in time. In addition, we estimate the number of firms and the number of firms per capita. The conclusion from this is that even though market size is important, there is considerable unexplained variance, which indicates that local regulations play an important role for the number of stores. Second, we estimate the effect of MMC and RMS on the key outcome variables *PATIENT, REV_* , *REV_/POP*, *PATIENT/POP*, *REV_/#_*, *REV_MED/PATIENT*, *PATIENT/#MED*.

3.1.1. Probit and Tobit

If the free entry model is applicable, there should be a close (possibly concave) connection between market size and the number of firms. Markets that are very small will not have any firms, as the level of market demand is insufficient to cover entry costs. We test this prediction using a probit model for *#MMC*>0 in Q4:2013 (the last quarter when only MMCs were allowed) and *#MMC*>0 and *#RMS*>0 in Q4:2017 (the last quarter in our sample). The results are illustrated in Table 3.

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[80] A number of studies have used extensions of the framework of Bresnahan and Reiss (1991) in settings where there are entry restrictions (e.g. Schaumans and Verboven 2008; Ferrari and Verboven 2010; and Abraham et al 2007). Given the limited number of counties and the fact that licensing is decided at a lower (municipality or local) level make it impossible to apply these methods on our sample.

[81] The exact details of the market competition (e.g. whether firms are setting prices or quantities, the amount of product differentiation within and between segments) are difficult to gauge from the information at hand. However, a simple model that would capture the essence of the revenue effects is a Cournot model where the demands in the two markets i and j with N^i and N^j firms, respectively, are interrelated $P^i = a^i - b_1^i Q^i - b_2^j Q^j$ where $Q^i = \sum_{k=1}^{N^i} q_k^i$, $b_1^i > b_2^j > 0$ and that all firms are symmetric with constant marginal costs c^i. The Nash equilibrium q^{i*} and the resulting Nash equilibrium price $P^i(q^{i*}, q^{j*})$ are decreasing in N^i and N^j. Moreover it can also be shown that the market revenue $P^i(q^{i*}, q^{j*})Q^{i*}$ is increasing in N^i and decreasing in N^j and that the revenue per firm $P^i(q^{i*}, q^{j*})Q^{i*}/N^i$ is decreasing in both in N^i and N^j.

Not surprisingly, the size of the market is a primary determinant for whether there is an MMC or RMS, and the number of these within a county. The underlying sentiment towards marijuana, as expressed by the results of the 2012 ballot, has a statistically significant effect on both the existence of at least one MMC or RMS and on the number of these outlets. In addition, the number of outlets in per capita terms is higher in the counties where the sentiment is more favourable. Of course, this could be due to more favourable treatment in the applications for licenses and/or higher underlying demand that makes it more profitable to operate. Counties that border another state tend to be more likely to have at least one MMC or one RMS, but the effect is only statistically significant in Q4: 2017 for medical centers.

TABLE 2

Data as of Q4:2017 listed by county in order of descending population.

County	*POP*	*#MMC*	*#RMS*	*REV_MED*	*REV_REC*	*PATIENT*	*BALLOT*
Denver	552422	200	176	4.71e+07	9.70e+07	12450	65.9
El Paso	519254	136	2	2.43e+07	N.D.	18816	49.3
Arapahoe	483960	11	28	2564502	2.80e+07	7299	52.8
Jefferson	455902	22	13	4200039	1.21e+07	9289	53.7
Adams	362131	10	27	2729659	1.71e+07	5897	56.0
Larimer	271968	14	14	3384746	1.59e+07	4876	54.6
Boulder	258999	22	35	5456849	1.99e+07	6433	66.1
Douglas	239132	0	0	0	0	2769	45.4
Weld	216615	4	4	1093926	7559947	2998	50.2
Pueblo	127116	19	33	1554058	1.06e+07	3276	54.9
Mesa	116961	1	5	N.D.	3034117	1547	46.4
Broomfield	50704	0	0	0	0	940	52.8
La Plata	44895	4	12	878514	5734578	1327	61.7
Garfield	43886	8	20	743469	5036638	740	56.8
Eagle	41728	6	8	372670	3495018	703	66.5
Fremont	39731	4	0	423317	0	1163	48.6
Montrose	32332	2	0	N.D.	0	534	42.9
Summit	25502	3	10	362241	5240838	523	69.2
Delta	24262	0	0	0	0	482	44.1
Morgan	20810	2	3	N.D.	2745415	214	42.3
Montezuma	20773	3	7.5	183616	5104946	568	48.9
Routt	20075	3	4	458474	2389708	781	62.9
Elbert	19860	0	0	0	0	252	45.7
Teller	19766	1	0	N.D.	0	850	51.5
Logan	17837	0	0	0	0	169	43.4
Chaffee	16110	1	3	N.D.	1198151	332	54.7
Pitkin	15047	3	7	171779	2546982	277	75.2
Park	14358	1	6	N.D.	1035955	427	58.1
Otero	13950	1	0	N.D.	0	295	45.7
Gunnison	13583	1	11	N.D.	1393046	125	67.3
Alamosa	12691	2	0	N.D.	0	220	56.3
Grand	12326	2	6	N.D.	1003348	274	58.4
Las Animas	11448	6	24	121598	1.22e+07	345	52.4
Archuleta	10533	1	5	N.D.	1816118	339	55.6
Moffat	9746	1	0	N.D.	0	198	47.1
Prowers	8876	0	0	0	0	139	40.7
Rio Grande	8800	0	0	0	0	158	49.1
Clear Creek	7963	5	7	103749	1513305	256	64.0
Yuma	7454	0	0	0	0	74	37.3
San Miguel	6498	1	5	20492	842543	157	79.1
Kit Carson	6354	0	0	0	0	42	37.5
Conejos	5948	0	3	0	1327431	60	45.0

Lake	5947	0	3	0	587156	147	40.2
Huerfano	5625	0	1	0	N.D.	225	43.2
Rio Blanco	4990	0	0	0	0	56	40.7
Bent	4987	0	0	0	0	71	49.4
Gilpin	4966	2	7	N.D.	565685	187	64.7
Saguache	4962	0	4	0	312354	165	64.8
Crowley	4960	0	0	0	0	90	44.3
Lincoln	4532	0	0	0	0	43	38.1
Ouray	4084	1	3	N.D.	1362628	80	61.5
Custer	3950	0	0	0	0	109	45.6
Washington	3800	0	0	0	0	45	38.5
Phillips	3263	0	0	0	0	15	37.1
Costilla	2986	0	4	0	878469	126	60.4
Baca	2824	0	0	0	0	30	36.7
Sedgwick	1925	1	1	N.D.	N.D.	49	39.5
Dolores	1625	0	0	0	0	39	45.0
Cheyenne	1360	0	0	0	0	25	35.3
Jackson	1133	0	0	0	0	17	45.7
Kiowa	1081	0	0	0	0	10	31.9
Hinsdale	629	0	0	0	0	3	48.4
Mineral	626	0	0	0	0	14	52.5
San Juan	612	0	2	0	N.D.	12	65.3

The explanatory power of the regressions (measured by the pseudo R-square) with the number of outlets is low (below 0.1) This suggests that, even after controlling for population and other observable factors, there is a great deal of variation in the accessibility of marijuana across counties. This is also evident from an examination of Table 2, which contains an overview of the key variables by county as of Q4:2017. Colorado is very diverse with counties that differ in economic, political and demographic characteristics. While there is a positive correlation between the population and the number of outlets (Denver is the largest and has the most MMCs and RMSs); among the smallest counties there are almost no outlets at all. Despite being the smallest, with a population of only 600, San Juan has two outlets. However, a number of large counties have none at all (i.e. Douglas with population of 239000) or many MMCs but few RMSs (i.e. El Paso with population of 519000 has 136 MMCs and 2 RMSs), and for many of the other counties the population size appears to be a poor predictor of the number of outlets. Overall, this suggests that differences in unobservable licencing policies play an important role for the number of outlets within a county. This also suggests that treating the number of MMCs and RMSs as exogenous in the regressions below is a reasonable approximation.

3.1.2. Panel Data Regressions

Turning next to the estimations with *PATIENTS*, *REV_*, *REV_/POP*, *REV_/#_*, *PATIENTS/POP*, *REV_MED/PATIENT*, and *PATIENT/#MED* as dependent variables with *#MMC*, *#RMS*, *#MMC/POP*, *#RMS/POP*, ln(*POP*), *BALLOT*, *LEISURE*, *BORDER*, *UNEMPL* and a linear time trend, *TIME*, as independent variables. We report random effects, fixed effects, and difference estimators in Tables 4-9. The results from the different specifications are complementary, but we

wish to emphasize those from the difference specifications, which removes unobservable differences between counties and possibly different seasonal sales patterns.

For the *REV_* and *PATIENT* regressions we include ln(*POP*) in addition to *#MMC* and *#RMS* in the random effects estimator but exclude it in the fixed effects estimations, as it displays little within-county variation. The other explanatory variables are excluded as they relate to per capita sales and not to the overall market. For the regressions where we employ normalization with the population, number of outlets or the number of patients (*REV_/POP*, *REV_/#_*, *REV_MED/PATIENT*, *PATIENT/MMC*) we include *#MMC*, *#RMS*, ln(*POP*), *BALLOT*, *LEISURE*, *UNEMPL*, *BORDER*, and *TIME* in the random effects estimations but only *#MMC*, *#RMS*, *UNEMPL,* and *TIME* in the fixed effects estimations. Finally, in the difference estimations, $\Delta Y_{q,q-4}$, we include $\Delta_{q,q-4}\#MMC$ and $\Delta_{q,q-4}\#RMS$ and as an alternative include differences in the density measures $\Delta_{q,q-4}\#MMC/POP$ and $\Delta_{q,q-4}\#RMS/POP$.

TABLE 3

Medical and Recreational outlets as of Q4:2013 and Q4:2017.

	Medical segment Q4:2013			**Medical segment Q4:2017**			**Recreational segment Q4:2017**		
VARIABLE	Probit #MMC>0	Tobit #MMC	Tobit (per capita) #MMC/POP	Probit #MMC>0	Tobit #MMC	Tobit (per capita) #MMC/POP	Probit #RMS>0	Tobit #RMS	Tobit (per capita) #RMS/POP
Constant	-10.85***	-209.1***	-1.220***	-10.72***	-239***	-0.835***	-8.782***	-179.8***	-2.066***
	[2.277]	[38.75]	[0.379]	[2.435]	[46.48]	[0.234]	[1.908]	[33.52]	[0.754]
ln(POP)	0.340**	11.87***	-0.031	0.630***	16.85***	0.036**	0.239*	8.825***	-0.087
	[0.151]	[2.582]	[0.027]	[0.172]	[3.338]	[0.017]	[0.134]	[2.304]	[0.055]
BALLOT	0.150***	1.686***	0.029***	0.085***	1.219*	0.008**	0.128***	1.729***	0.055***
	[0.038]	[0.517]	[0.005]	[0.031]	[0.641]	[0.003]	[0.034]	[0.479]	[0.012]
LEISURE	0.672	-10.05	0.126	4.053	15.63	0.350	-0.026	-21.14	-0.248
	[3.139]	[33.07]	[0.355]	[3.635]	[45.10]	[0.245]	[2.385]	[33.92]	[0.825]
BORDER	0.777	-0.896	0.061	0.858*	0.243	0.064	0.690	1.758	0.166
	[0.500]	[9.125]	[0.096]	[0.517]	[10.75]	[0.058]	[0.457]	[8.216]	[0.198]
Sigma		28.17***	0.310***		32.69***	0.186***		25.70***	0.644***
		[3.282]	[0.039]		[3.839]	[0.024]		[3.067]	[0.082]
Marg. Effect POP	0.121			0.189			0.090		
Marg.Effect BALLOT	0.053			0.036			0.048		
Observations	64	64	64	64	64	64	64	64	64
Pseudo-R^2	0.550	0.098	0.465	0.514	0.098	0.718	0.449	0.093	0.235
Log-likelihood	-19.74	-179.3	-21.84	-21.41	-179.6	-4.710	-24.31	-173.2	-48.65

Notes: Standard errors are in brackets below estimated coefficients. All estimates for marginal effects were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

TABLE 4

Number of Patients and Medical Marijuana Sales, 3Q:2012- 4Q:2017

	Patients			**Medical Sales**		
VARIABLE	RE Patients	FE Patients	Diff Patients	RE *REV_MED*	FE *REV_MED*	Diff Δ*REV_MED*
Constant	-2.03e+04***	6458***	-650.2***	-5.53e+06***	1.65e+06**	1.01e+06*
	[2476]	[404.8]	[81.65]	[1.58e+06]	[7.58e+05]	[5.29e+05]
#MMC[1]	47.69***	43.561***	28.59***	2.20e+05***	1.57e+05***	1.69e+05***
	[3.840]	[3.976]	[3.879]	[5572]	[7447]	[8056]
#RMS[1]	-41.02***	-39.539***	3.350	-1.42e+04**	-2.13e+04***	-5.73e+04***
	[2.811]	[2.798]	[3.159]	[6095]	[5240]	[6109]
ln*(POP)*	2415.2***			5.52e+05***		
	[227.2]			[1.34e+05]		
TIME	-102.1***	-93.23***		-3.15e+04	12.061	-2.70e+04
	[14.43]	[14.31]		[29566]	[26803]	[21218]
UNEMPL	-291.1***	-295.3***	-380.7***	-1.27e+04	-2.22e+04	-1.22e+05*
	[50.682]	[50.559]	[62.15]	[1.02e+05]	[94703]	[71292]
$\mathcal{E}_{\#MMC}$	0.230	0.214		0.996	0.710	
$\mathcal{E}_{\#RMS}$	-0.106	-0.104		-0.034	-0.051	
Observations	432	432	352	432	432	352
Groups	24	24	23	24	24	23
R^2 *within*	0.443	0.447	0.350	0.590	0.600	0.528
R^2 *between*	0.870	0.584	0.012	0.972	0.969	0.835
R^2 *overall*	0.868	0.569	0.181	0.951	0.946	0.579

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1]In the difference specification the variable is defined as the year-on-year change, Δ#_.

TABLE 5

Recreational and Total Marijuana Sales, 3Q:2012- 4Q:2017

	Recreational Sales			**Total Sales**		
VARIABLE	RE *REV_REC*	FE *REV_REC*	Diff *ΔREV_REC*	RE *REV_TOT*	FE *REV_TOT*	Diff *ΔREV_TOT*
Constant	-1.63e+07***	-7.44e+06***	2.16e+06*	-1.81e+07***	-3.90e+06*	3.72e+06***
	[2.91e+06]	[2.40e+06]	[1.31e+06]	[2.64e+06]	[2.12e+06]	[1.26e+06]
#MMC[1]	-2.49e+05***	-6.47e+04	-1.55e+05***	1.95e+05***	54257**	49487***
	[24467]	[78415]	[36464]	[13005]	[27512]	[15180]
#RMS[1]	7.51e+05***	8.07e+05***	2.80e+05***	4.63e+05***	4.93e+05***	1.93e+05***
	[31085]	[32673]	[15511]	[15806]	[17332]	[11679]
ln*(POP)*	1.35e+06***			1.52e+06***		
	[2.29e+05]			[2.10e+05]		
TIME	86.576	1.16e+05*	1.818.518	1.36e+05**	2.75e+05***	-4.16e+04
	[58963]	[67196]	[44869]	[59972]	[74977]	[44567]
UNEMPL	43.207	3.90e+05	-2.33e+05	1.56e+05	7.45e+05***	-3.87e+05**
	[2.45e+05]	[2.96e+05]	[1.98e+05]	[2.04e+05]	[2.69e+05]	[1.70e+05]
$\mathcal{E}_{\#MMC}$	-0.552	-0.137		0.351	0.098	
$\mathcal{E}_{\#RMS}$	1.598	1.738		0.580	0.617	
Observations	369	369	318	469	469	351
Groups	31	31	28	27	27	25
R^2 *within*	0.748	0.755	0.585	0.829	0.840	0.447
R^2 *between*	0.971	0.950	0.933	0.989	0.958	0.919
R^2 *overall*	0.942	0.911	0.707	0.960	0.922	0.633

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1]In the difference specification the variable is defined as the year-on-year change, Δ#_.

TABLE 6

Patients and Medical Sales per capita, 3Q:2012 - 4Q:2017

VARIABLE	**Patients per capita**				**Medical Sales per capita**			
	RE PAT/POP	FE PAT/POP	Diff PAT/POP	Diff PAT/POP	RE *MED/POP*	FE *MED/POP*	Diff *MED/POP*	Diff *MED/POP*
Constant	0.115***	0.053***	-0.005***	-0.005***	-83.65**	32.82***	-1.145	-1.939*
	[0.021]	[0.002]	[0.000]	[0.001]	[42.56]	[3.760]	[0.948]	[1.032]
#MMC[1]	0.016***	0.013***	-0.000		49.52***	47.46***	27.47***	
	[0.003]	[0.003]	[0.002]		[5.052]	[5.214]	[3.510]	
#RMS[1]	-0.009***	-0.010***	0.002		-16.03***	-16.88***	-7.840***	
	[0.001]	[0.001]	[0.001]		[2.201]	[2.266]	[2.892]	
#MMC/POP[1]				0.000***				0.387***
				[0.000]				[0.042]
#RMS/POP[1]				0.000				-0.150***
				[0.000]				[0.035]
ln*(POP)*	-0.005***				6.587***			
	[0.001]				[2.247]			
TIME	-0.001***	-0.001***			-0.555***	-0.589***		
	[0.000]	[0.000]			[0.137]	[0.123]		
UNEMPL	-0.002***	-0.002***	-0.002***	-0.002***	-1.713***	-1.944***	0.257	0.863
	[0.000]	[0.000]	[0.000]	[0.000]	[0.460]	[0.428]	[0.698]	[0.669]
BALLOT	-0.000				0.638			
	[0.000]				[0.410]			
LEISURE	0.000				3.768			
	[0.003]				[5.793]			
BORDER	-0.002				6.196			
	[0.003]				[6.549]			
$\varepsilon_{\#MMC}$	0.106	0.086			0.437	0.410		
$\varepsilon_{\#RMS}$	-0.05	-0.054			-0.12	-0.123		
Observations	432	432	352	352	432	432	352	352
Groups	24	24	23	23	24	24	23	23
R^2 *within*	0.602	0.603	0.200	0.202	0.398	0.395	0.154	0.210
R^2 *between*	0.559	0.147	0.000	0.117	0.340	0.136	0.559	0.379
R^2 *overall*	0.622	0.289	0.145	0.191	0.391	0.231	0.225	0.234

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1]In the difference specification the variable is defined as the year-on-year change, $\Delta\#\_$.

TABLE 7

Recreational and Total Sales per capita, 3Q:2012 - 4Q:2017

VARIABLE	**Recreational Sales per capita**				**Total Sales per capita**			
	RE *REC/POP*	FE *REC/POP*	Diff *REC/POP*	Diff *REC/POP*	RE *TOT/POP*	FE *TOT/POP*	Diff *TOT/POP*	Diff *TOT/POP*
Constant	-124.1	-7.784	35.58***	33.83***	71.16	25.83	13.97***	11.58**
	[145.7]	[33.39]	[8.962]	[12.34]	[164.5]	[19.25]	[3.542]	[4.627]
#MMC[1]	169.9***	187.6***	14.94		109.4***	89.881***	20.96*	
	[27.98]	[28.84]	[20.21]		[18.94]	[18.613]	[12.08]	
#RMS[1]	338.4***	364.4***	139.4***		134.8***	115.134***	112.6***	
	[19.98]	[21.24]	[13.59]		[11.26]	[11.377]	[8.802]	
#MMC/POP[1]				-1.360*				-0.186
				[0.716]				[0.182]
#RMS/POP[1]				0.856***				0.425***
				[0.315]				[0.149]
ln*(POP)*	30.85***				-0.386			
	[9.035]				[9.830]			
TIME	0.340	0.633			3.609***	3.017***		
	[1.218]	[1.090]			[0.742]	[0.666]		
UNEMPL	-22.46***	-21.26***	1.840	-11.84***	-1.058	-3.892	-1.663	-10.92***
	[5.234]	[5.055]	[3.993]	[4.313]	[2.591]	[2.389]	[2.469]	[2.897]
BALLOT	-3.262**				-1.536			
	[1.542]				[1.730]			
LEISURE	-22.32				40.91*			
	[33.05]				[23.443]			
BORDER	38.46				86.66***			
	[27.69]				[32.791]			
$\mathcal{E}_{\#MMC}$	0.273	0.305			0.197	0.180		
$\mathcal{E}_{\#RMS}$	1.179	1.281			0.333	0.317		
Observations	369	369	318	318	469	469	351	351
Groups	31	31	28	28	27	27	25	25
R^2 *within*	0.611	0.613	0.267	0.063	0.601	0.600	0.363	0.083
R^2 *between*	0.560	0.522	0.539	0.015	0.692	0.705	0.294	0.006
R^2 *overall*	0.544	0.492	0.382	0.029	0.481	0.540	0.333	0.058

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1] In the difference specification the variable is defined as the year-on-year change, Δ#_ and Δ#_*/POP*, respectively.

TABLE 8

Medical and Recreational Sales per dispensary, 3Q:2012 - 4Q:2017

	MMJ Sales per Medical center			**RMJ Sales per recreational stores**		
VARIABLE	RE REV_MED/ #MMC	FE REV_MED/ #MMC	Diff ΔREV_MED/ #MMC	RE REV_REC/ #RMS	FE REV_REC/ #RMS	Diff ΔREV_REC/ #RMS
Constant	-8.74e+05***	2.19e+05***	668.0	-1.27e+06***	3.42e+05***	1.08e+05***
	[1.51e+05]	[28774]	[6614]	[3.88e+05]	[1.19e+05]	[24266]
#MMC[1]	-1079***	-1432***	-1849***	2926*	2.478	-3.622
	[223.5]	[282.6]	[340.3]	[1519]	[3873.498]	[2769]
#RMS[1]	220.3	284.903	540.4**	-6615***	-5639***	-1.72e+04***
	[191.3]	[198.9]	[265.3]	[1565]	[1613]	[2342]
ln(POP)	79128***			1.62e+05***		
	[8038]			[23681]		
TIME	-2539**	-2432**		22562***	17755***	
	[1077]	[1017]		[3523]	[3319]	
UNEMPL	3.172	2.197	16898***	-2.66e+04*	-3.85e+04***	-3.96e+04**
	[3676]	[3593]	[5690]	[14189]	[14640]	[15937]
BALLOT	3064**			-5.200		
	[1382]			[3886]		
LEISURE	30.199			3.14e+05***		
	[41275]			[90099]		
BORDER	43305**			1.65e+05**		
	[21694]			[68975]		
$\varepsilon_{\#MMC}$	-0.141	-0.185		0.102	0.085	
$\varepsilon_{\#RMS}$	0.015	0.020		-0.234	-0.197	
Observations	432	432	336	369	369	251
Groups	24	24	22	31	31	28
R^2 *within*	0.199	0.200	0.155	0.320	0.292	0.222
R^2 *between*	0.791	0.154	0.001	0.655	0.002	0.033
R^2 *overall*	0.600	0.035	0.116	0.612	0.032	0.067

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1]In the difference specification the variable is defined as the year-on-year change, Δ#_.

TABLE 9

Medical Sales per Patient and Patients per Medical Center, 3Q:2012 - 4Q:2017

	MMJ sales per patient			**Patients per medical center**		
VARIABLE	RE REV_MED/ PATIENT	FE REV_MED/ PATIENT	Diff ΔREV_MED/ PATIENT	RE PATIENT/ #MMC	FE PATIENT/ #MMC	Diff ΔPATIENT/ #MMC
Constant	-1.022	594.2***	61.32**	-717.0	340.134***	-20.988
	[670.5]	[112.7]	[29.50]	[569.7]	[79.757]	[17.724]
#MMC[1]	7.808***	6.484***	5.759***	-2.896***	-2.165**	-4.155***
	[0.918]	[1.107]	[1.207]	[0.953]	[1.045]	[1.110]
#RMS[1]	4.847***	5.078***	-6.168***	0.598	0.375	1.557*
	[0.754]	[0.779]	[1.003]	[0.720]	[0.730]	[0.884]
ln(POP)	46.917			141.9***		
	[35.71]			[35.31]		
TIME	-1.159	-4.476		-6.513**	-4.839	
	[4.287]	[3.984]		[3.291]	[2.965]	
UNEMPL	13.524	0.644	58.77***	19.03*	22.251**	25.170**
	[14.613]	[14.07]	[19.01]	[9.904]	[9.283]	[11.611]
BALLOT	14.23**			-7.136		
	[6.225]			[6.202]		
LEISURE	258.9			-117.1		
	[169.3]			[160.9]		
BORDER	180.9*			60.89		
	[98.08]			[113.6]		
$\varepsilon_{\#MMC}$	0.24	0.193		-0.122	-0.09	
$\varepsilon_{\#RMS}$	0.80	0.081		0.014	0.009	
Observations	432	432	352	671	671	524
Groups	24	24	23	36	36	35
R^2 *within*	0.325	0.319	0.214	0.137	0.139	0.046
R^2 *between*	0.859	0.836	0.063	0.445	0.009	0.015
R^2 *overall*	0.792	0.769	0.077	0.384	0.043	0.032

Notes: Standard errors are in brackets below estimated coefficients. Constant in fixed effects estimator is average of individual fixed effects. All estimates for elasticity were calculated using the mean values for the independent variables. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively.

[1] In the difference specification the variable is defined as the year-on-year change, Δ#_.

Regressions with patients (*PATIENTS*) and revenue (*REV_*). Before proceeding on the effect of the number of outlets on the number of patients, note that being registered as a patient can be influenced by the person in question, and thus there is an inherent endogeneity/causality problem in interpreting the coefficients: an increase in accessibility of MMC might result in people to registering as patients or, alternatively, that more patients increase the number of MMCs. Bearing this in mind, the positive coefficient on *#MMC* in table 4 demonstrates an association between the number of MMCs and the number of patients. Each quarter on average, there are between 28 and 47 additional patients per additional MMC operating. On the contrary, RMS has a negative association with the number of patients. Each RMS is associated with an average reduction of about 40 patients. Among the controls, the negative and significant time trend shows that the number of patients tend to decline over time, and that there is also a negative association with *UNEMPL*.

For the MMJ (quarterly) revenue in a county, an additional MMC is associated with between $157000 and $222000 in additional sales (depending on the estimator) and the coefficient in each case is statistically significant. At the same time, an additional RMS reduces the medical sales revenue between $14200 and $57000, and again the coefficient is statistically significant. Compared to the sample median of *REV_MED* ($1.0m), this amounts to 1.4 to 5.7 percent, and 4.5 to 14 percent for the 25th percentile ($0.4m). At the sample means, the elasticity is -0.04 (i.e. a 10 percent increase in the number of RMSs would lower the medical sales by 0.4 percent). As an alternative measure – the ratio of the coefficient on *#RMS* to *#MMC* is for the different estimators approximately 0.1 and 0.3, suggesting that between three and 10 RMSs would reduce the MMJ sales as much as one MMC would increase it.

Turning on table 5, the coefficients on *#MMC* in the *REV_REC* regressions are negative and statistically significant, and again suggest that there is some limited degree of substitutability between the two segments. At the sample median, adding one MMC would reduce the sales of RMJ by 3 to 10 percent; at the sample means the elasticity is -0.14 and -0.55 for the two estimators, respectively. Alternatively, looking at the ratios of the coefficients, adding two to ten MMCs would decrease the RMJ sales as much as adding one RMS would increase it.

The overall sales is increasing in both *#MMC* and *#RMS*, and the point estimates indicate that sales at the latter is three to nine times higher compared to the former. Although the previous regressions showed some degree of displacement, this is evidence that the increase in the number of outlets has expanded the overall market. For instance, the difference estimator

indicates that another MMC would add $49000 and one more RMS $193000 of marijuana sales, or 1.6 and 6.0 percent at the sample median ($3.1m).[82]

Regressions with per capita patients *(PAT/POP)* and revenue in segment (*REV_/POP*). We now normalize *both* the number of patients *and* the sales in a segment with the population in the county, which allows us to relate the per capita demands to factors that are *a priori* plausible. Table 6 and 7 give the results.

For *PAT/POP*, the effects of *#MMC* and *#RMS* have the same direction of the regression which was not normalized, whereas the density of MMCs, *#MMC/POP* has a positive effect on the number of patients per capita. TIME and UNEMPL are also negatively associated as before.

With *REV_MED/POP* as the dependent variable, the coefficient on *#RMS* is negative and statistically significant in all specifications. However, the economic significance of the effect is limited – at the sample median ($19.3) an additional RMS would be associated with a reduction in the sales of MMJ per capita by 0.1 to 0.7 percent; at the sample means the elasticity is -0.12 for both specifications. The positive and significant coefficient on *#MMC* can be interpreted as showing that greater accessibility of medical outlets tend to increase sales; at the sample median an additional MMC would increase sales by about 2 percent. Supporting this notion, using a change in the density measures *#MMC/POP* and *#RMS/POP* indicates that an increase in the density of MMCs has a positive effect on sales per capita, and that the reverse is true for an increase in the density of RMSs.[83]

Among the controls, the negative and significant time trend shows that the medical sales tend to decline over time, and that *UNEMPL* is negatively associated with higher sales per capita in both. The other controls are not statistically significant.

Turning to the regression with *REV_REC/POP* as dependent variable, we find a statistically negative significant effect only from *#MMC/POP* in the difference specification. Unemployment is still negative associated with higher recreational sales per capita.

Finally, the overall sales of marijuana, *REV_TOT/POP* is increasing in both *#MMC* and *#RMS and #RMS/POP*. Both counties bordering other states and those with large leisure industries

[82] As a robustness check, we have excluded the five largest counties and the results are similar to those that reported above. Results are available upon request.
[83] Replacing *#MMC* and *#RMS* with *#MMC/POP* and *#RMS/POP* in the random effects and fixed effects estimation gives coefficients that have the same signs and largely the same significance as those reported. Results are available upon request.

have consistently significantly higher sales per capita, supporting the idea that seasonality and out-of-state demand are affecting sales of marijuana.

Regressions related to the number of outlets (*REV_ /#_*). The results in Table 8 with *REV_MED/#MMC* and *REV_REC/#RMS* as dependent variables, reveal that there is significant within segment substitutability. More outlets within the segment lowers the sales per dispensary for both RMSs and MMCs, which is inconsistent with a free entry model but in line with the predictions from a model of restricted entry. Moreover, the negative time trend in the sales per MMC is not consistent with a free-entry model but might be related to excessive entry once the RMS entered – an MMC that has already entered and sunk some costs might remain, even though its demand is declining.

That ln(*POP*) is positive and significant for both random effects regressions could either be interpreted as the combined effect of higher operating costs in more populous counties, or that per capita demand is higher in these areas. The positive and significant coefficients on *BORDER* and *LEISURE* (only in the *REV_REC/#RMS* estimation) support the above assertion about the importance of out-of-state demand.

Regressions related to sales per patients and patients per MMC (*REV_MED/PATIENT*, *PATIENT/#MMC*). The final results relate to normalizations with the number of patients, and can be found in Table 9. The positive coefficient on *#MMC* is consistent with larger number of outlets spurring sales. However, the fact that *#RMS* is also positive and significant in the random and fixed effects specifications appears to be at odds with the former. Here, an interpretation of the negative coefficient in the difference specification is that the number of patients shows a slow response to market structure – increasing *#RMS* would not immediately influence the number of registered patients but will result in some of these to turning to RMSs. Thus, an increase in *#RMS* will reduce the sales per registered patient. Note also that the constant term in this specification suggests that medical sales per patient are increasing over time.

The controls are in line with the interpretations above – the in-county registered patient underestimates the true demand, given that some sales are to out-of-state buyers.

The final part of the results suggests that the number of MMCs relative to the number of patients is declining over time. To make this consistent with the results reported above, the sale

per patient is increasing but their numbers are decreasing. In other words, there are fewer patients but those that remain tend to be buyers of larger amounts.

3.1.3. Summary of Econometric Results

The evidence presented thus far is consistent with a statistically significant but economically limited displacement effect. The evidence suggests that the emergence of RMJ had a modest effect on sales in the medical segment and that the marijuana sales tend to fragment, such that customers with large demands continue to purchase from the MMCs but other, marginal users switch to the RMSs when available.

The estimation is subject to heterogenous treatment effects. For instance, the effect of the opening of RMSs on MMJ sales may have been stronger in counties that were more geographically distant from counties where RMSs were operating. Other differences relates to the timing as it is possible that the effect was stronger during the first quarters of operations of RMSs. Future estimation looking at the effect on a longer time period are needed to confirm the magnitude of displacement effect.

3.5. Conclusion

In this paper, we have examined how sales at licenced medical marijuana centers (MMCs) in Colorado were affected by the opening of retail marijuana stores (RMSs) in 2014. Our results suggest that although the two types of outlets may cater partially to the same marijuana demand, allowing RMSs has had only a modest negative effect on sales at the MMCs. Using a variety of estimates, our conclusion is that medical sales decreased by about 10 percent at most, and likely only in the low single digits. The fact that the sales of recreational marijuana have increased dramatically since 2014 indicates that the main effect of legalization has been market expansion, rather than displacement of medical sales. The number of registered patients has been decreasing since the inception, but sales per patient increasing. This implies that some occasional users who may have previously purchased at an MMC have now shifted to RMSs. It is plausible that some of these occasional users had a recommendation for marijuana, although the main use was for recreational purposes, and that the introduction of RMSs has discouraged this abuse.

Our findings indicate that medical and recreational marijuana outlets can co-exist, but it seems likely that the lower taxation of the medical variety is an important reason behind this. There is overlap in the product offerings at the two, but as recreational marijuana stores can sell to any adult, it is difficult to see other reasons for sales in the medical centers, other than the lower

price that comes from lighter taxation. This differential in taxation have lead some (see e.g. Caulkins et al., 2016) to consider MMCs as "tax-evasion machines" and the whole medical program as friction, limiting the ability of the state to collect the maximum possible revenues (e.g. Washington state collected 25 percent more tax revenues per resident in its third year of legalization by integrating the medical and recreational market). However, if one argues that use of marijuana for medical reasons should be treated differently from non-medical use, the evidence presented here reveals that even relatively small tax differentials will separate the user segments. Those requiring large amounts of the product for medical reasons will tend to use the MMCs, while less regular users will purchase from RMSs.

Our finding of a sharp and sustained increase in sales of recreational marijuana coupled with the very limited displacement of the medical marijuana sales begs the question: if sales were displacing illicit marijuana, has this had any effects on the use of alcohol and other substances?[84] Using the same methodology as here - exploiting the county differences in the accessibility of legal marijuana –available data on alcohol sales could be used to estimate the effect on sales in that market from legalizing medical and recreational marijuana.[85] In the absence of county level data on sales of illicit marijuana, any attempt to judge the extent that introducing RMSs replaced the illicit trade would have to rely on indirect measures, such as demand-based or expenditure-based surveys.[86] If the legalization of recreational marijuana completely replaces the illicit trade, the prediction is that changes in observable use measures would be less dependent on changes in legal access; the lower the replacement, the more responsive the observable use is for increasing the accessibility of legal sales. Finding observable measures of marijuana use and other outcome variables – at a county or other local

[84] There is a consensus that legalizing MMJ has reduced the number of prescriptions drugs (Bradford and Bradford, 2016), opioids (McMichael et al., 2020; Wen et al., 2021) and individuals abusing painkillers (Bachhuber et al., 2014; Powell et al., 2018).

[85] Baggio et al (2020) use county level data on alcohol sales and found a 12% decline in alcohol consumption in states where MMJ has been legalized, but does not consider that the accessibility of MMJ may well differ within a state as Colorado. Moreover, it is likely that the effect would be stronger for RMJ than for MMJ.

[86] There is reason to believe that the RMSs has significantly reduced the illicit trade. Light et al. (2014) estimated that during the first year with both MMCs and RMS, the total use of marijuana (legal and illicit) would be 130.3 metric tonnes, out of which 54.8 and 22.2 metric tonnes sold at MMCs and RMSs, respectively, implying a nonregulated use of 58.3 metric tonnes, out of which between 5.0 and 20.6 metric tonnes could be accounted for by home grown marijuana. This implies that the illicit (black market) marijuana trade was between 33 and 48 metric tonnes. Since then the medical sales (in revenue terms) have remained roughly at the same level but recreational sales has increased by 120 percent (in revenue terms) which, assuming constant prices, would imply that the equivalent of an additional 26 metric tonnes or between 55 and 80 percent of the illicit quantity as of 2014.

level – and relating these to legal and medical outlet access is a promising future direction for future research on the effects of marijuana legalization.

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3.7. Appendices

APPENDIX TABLE 1.
Summary statistics for selected characteristics

	Characteristics	Sample counties	Other counties
Patients	Patients (2009)	0,16%	0,16%
	Patients (Jun-2011)	4,74%	2,69%
	Patients (Jun-2017)	2,29%	1,69%
	Six years drop in patient	2,46%	0,99%
Out-of-state demand	border	33%	45%
	Ski Resort	58%	18%
	Tourism (2017)	15,1%	10,7%
Addiction	Smoking	17,5%	17,9%
	Excess Drink	20%	16,1%
	Alcohol-driving	29,8%	28,3%
Political View	Competitive RMJ market	92%	23%
	Dem2016	49,0%	29,6%
	Ballot2012	59,7%	46,3%
Socio-economic	Student	8,02%	5,21%
	Bachelor	37,9%	24,5%
	Median income ('000)	58,22	46,88
	Mean income ('000)	77.41	60.54
	2015 Unemployment	4,07%	4,26%
	Adult Population (Million)	3,574	0,704
	#counties	24	40

CHAPTER FOUR

4. PRICE DISCRIMINATION AND CONSUMER DISTORTIONS IN THE LEGAL CANNABIS MARKET: THE ROLE OF CANNABIS SOCIAL CLUBS

Abstract

This chapter presents a theoretical exercise with the goal of analysing the potential role of Cannabis Social Clubs (CSCs) in a hypothetical post-prohibition regime which would include both commercial outlets for adult users and pharmacies for patients with a physician's prescription. It will discuss whether and how the presence of CSCs could improve market segmentation by appealing to daily users and therapeutic patients, de facto reducing market distortions in a regulatory context allowing other supply options. The proposed scheme would exploit the heterogeneity of cannabis users in three dimensions: price per unit, transaction costs, and quantity consumed. Under specific regulatory conditions, CSCs can minimize the harms deriving from chronic consumption by nudging this riskier group of consumers through a rationing system which would reduce the risks of use escalating to problematic levels. In parallel, this supply architecture is shown to increase market efficiency by reducing the waste of public resources occurring when non-medical users resort to the medical market to buy cannabis, particularly in countries with extensive social welfare systems.

Keywords: legalization, cannabis social clubs, segmentation, distortions, EU.

Abbreviations:

CSC	Cannabis Social Clubs
MC	Medical Cannabis

4.1. Introduction

After the legalization of cannabis in the Americas, its regulation has become a topic of discussion in most Western countries. One of the fundamental elements of the debate around cannabis institutionalization is to determine what type of organizations will be allowed to supply the substance (Caulkins et al., 2015; Kilmer, 2019). Most US states permit for-profit companies to produce and sell cannabis to anyone with a physician's recommendation. In

addition, 21 US states have regulated the supply of cannabis for any adult mostly through a standard commercial model similar to alcohol. There is however more policy space between prohibition and the full commercial model. For instance, Caulkins et al. (2015) list twelve supply alternatives (including non-profit and government monopoly models), with combinations already adopted in some American jurisdictions and elsewhere. Uruguay adopted a more state-centred form of cannabis regulation which allows three middle-ground supply channels including Cannabis Social Clubs (CSCs) (Cerdá and Kilmer, 2017). The latter is a non-commercial supply model which exists in different forms in at least 13 countries (Blickman, 2014; Pardal et al., 2020). Nevertheless, Uruguay remains the only national jurisdiction to have introduced a regulatory framework for CSCs (Decorte and Pardal, 2017; Decorte et al., 2017; Queirolo et al., 2016).

Elsewhere, the CSC model has been shaped by the self-regulatory efforts of groups of users (Queirolo et al., 2016; Pardal, 2018a). The common core features of this model are its non-profit nature, production performed by members, and distribution restricted to consumers meeting certain requirements. Medical users may by served under three different schemes: mixed CSCs without distinction between recreational and medical members, CSCs featuring a separate subunit to serve only medical members and CSCs admitting medical members only. In schemes with specific medical use access, candidates must fulfil documents from a physician such as a prescription or a letter acknowledging the condition or symptoms for which the patient is using cannabis (Pardal and Bawin, 2018).

Scholars have discussed a number of advantages associated with the CSC model such as the potential to curb the illicit market and to play a harm reduction role (Belackova et al., 2016; Belackova and Wilkins, 2018; Decorte, 2015; Pardal, 2018a). Yet, its positioning when competing with other supply alternatives has not been investigated yet (Queirolo et al., 2016). Accordingly, the goal of this theoretical exercise is to analyse the potential role of CSCs in a hypothetical post-prohibition regime which would include both commercial outlets for adult users and pharmacies for patients with physician's prescription. Overall, the chapter investigates under which conditions the presence of CSCs could improve market segmentation by appealing to those users who either use cannabis for medical purposes, but do not have a physician's prescription, or recreational consumers who would benefit from a sin license scheme. This form of personalized regulation would enable those with self-control problems

to commit to a future consumption through the voluntarily choice of a maximum amount to be purchased at a lower price (Haavio and Kotakorpi, 2016).

The model introduced in this chapter uses the two-parts tariffs framework to screen customers based on the quantity consumed as well as on the price and transaction costs involved with the specific supply channels. The model generates a number of testable predictions concerning demand characteristics and preferred supply channel. While we could not fully test this model in real-life settings, we draw on data gathered by Pardal and colleagues to explore and reflect on the validity of the hypotheses put forward (Pardal, 2018a, 2018b; Pardal and Bawin, 2018). In particular, in the context of that study, the author carried out field observations and interviews with CSC directors, cannabis growers operating within CSCs and other stakeholders; ran an online survey among Belgian CSC members (n=190) (Pardal and Decorte, 2018); and gathered other private and public documentary sources concerning the development of the model in that country (Pardal and Tieberghien, 2017). Further below, we introduce the Belgian context and the presence of CSC model in the country, and discuss their features in light of the proposed theoretical framework.

The chapter proceeds as follows. It starts with the literature review of CSCs and compare the model with other distribution channels for cannabis. Then we move to the conceptual framework by providing a taxonomy of cannabis users. We then describe the potential dimensions of attractiveness of the various supply channels to four archetypes of cannabis users. The two-parts tariffs model is then introduced based on the adoption of sin licences to access CSCs. We then discuss how its inclusion among the supply options can increase efficiency and reduce harms. We conclude looking at the evidence from a real-world experiment in Belgium and analyze whether the conditions to improve welfare are satisfied[87].

4.2. CSC as a legal supply channel

The first CSCs emerged as a result of grassroots initiatives during the 1990s in Spain, but the model has been experimented with in many other countries worldwide (Decorte and Pardal, 2017; Pardal et al., 2020). In Uruguay, they constitute one of the three mutually exclusive options in which adults can legally obtain cannabis. To operate, a non-profit organization with between 15 to 45 members must be constituted, and receive an authorization from the Institute for the Regulation and Control of Cannabis (IRCCA) and from the Ministry of Education after

[87] A reduced version of this chapter was published as Fortin (2022).

an inspection of their premises and crop plan. In general, their operation is heavily regulated and cannot be located within 150 meters from education or addiction treatment centers, and keep a distance between one another of at least 1000 meters. Most CSCs charge a fixed monthly membership (between 26 and 92 US dollars) which allows individuals to access to up to 40 grams per month, but in few cases members may be only charged for the grams purchased. To avoid the registration in more than one CSC, the IRCCA keeps a centralized record of all CSC members. In most CSCs, existing members need to introduce candidate members. The consumption of cannabis and other legal substances is allowed in the CSCs. The size of cultivation areas is chosen based on the number of members, and the production operations are generally taken by CSCs members who may receive a salary. CSCs are only allowed to produce and distribute flowers and leaves and not their derivatives, but they may have more than 20 different varieties available. Testing for contaminants is not mandatory (Decorte et al., 2017).

With exception of Uruguay, no other national jurisdiction has introduced legislation regulating the activities and functioning of CSCs (Queirolo et al., 2016)[88], and thus the model continues to be shaped by the self-regulatory efforts of groups of users (Belackova and Wilkins, 2018; Pardal, 2018a). A European organization which advocates for a change in current drug laws has issued a Code of Conduct for the affiliated CSCs, but this remains non-compulsory, and may not be adhered to in practice (Pardal, 2018b). In fact, a study of Belgian CSCs' supply practices in Belgium has highlighted the diversity of practices and shifts in the way CSCs organize the cultivation and distribution of cannabis for their members (Pardal, 2018a). Some common core features have, nevertheless, been typically (or ideally) ascribed to this model: it should be non-profit driven; it tends to operate in a cooperative fashion – with production generally being a task taken by a group of CSC members; distribution is restricted to members only, who must meet certain requirements (e.g., 18 years or older, residency or nationality in the country where the CSC is based, already have used cannabis, etc.).

In Belgium, CSCs have been present since 2006 (Pardal, 2018b). Nevertheless, the CSCs active in that country have been doing so in a context of legal uncertainty (at best), exploiting a (contested) interpretation of a 2005 Ministerial Guideline which attributed some prosecutorial discretion to cases of possession of cannabis involving one plant or 3 grams of that substance, in the absence of aggravating circumstances or public nuisance. However, as cannabis

[88] Despite many attempts to introduce such legislation, in particular in Spain (Franquero et al., 2015).

cultivation and distribution remain prohibited, and no particular framework for CSCs has been introduced in the country, many of these organizations have faced criminal charges. The volume of CSCs active in Belgium has remained relatively small, but the model has had a continuous presence in the country for over a decade now (Pardal, 2018b). Scholars have in fact called for a legislative change that would also encompass the regulation of CSCs in the country (Paoli et al., 2018).

Recently, a new bill to regulate CSCs has been approved by Maltese Parliament (Pardal, 2022). The reform allows adult members to buy up to 7 grams per day or 50 grams per month of flowers or derivatives. In parallel, CSCs are allowed to sell up to 20 seeds per month to each member. One adult cannot be member of more than one CSC at the same time. CSCs operate as NGOs without promotion of the products. Each CSC would be authorised to have up to 500 members and must be situated more than 250 metres away from schools, youth centres and clubs visited by youths.[89]

4.2.1. Retail stores vs CSC

Thus far, most jurisdictions have chosen a for-profit model to distribute cannabis, perhaps – at least in part, for the fear of losing consensus by introducing hybrid or other lesser known models which may be more difficult to explain to voters (Caulkins et al., 2016). Nevertheless, scholars have become concerned that the commercial interests driving this supply model will promote daily use. This consideration stems from three assumptions: (1) daily users account for the largest proportion of the cannabis consumed in a given market and may abuse it (Caulkins, 2017); (2) an industry prioritizes profits over consumer protection, eventually targeting the minority of users "whose consumption is, on balance and at the margin, damaging rather than beneficial to themselves" (Kleiman et al., 2014, p. 79); and (3) the influence of the industry on politicians might eventually also favour producers' interests over consumers' interests (Caulkins and Kilmer, 2016).

The adoption of a third supply channel whose access require a sin license may improve the status quo (Haavio and Kotakorpi, 2011). This personalized regulation enables those with self-control problems to commit to a future consumption (O'Donoghue and Rabin, 2003), and may function through a pricing scheme where consumers can voluntarily opt for a maximum quota in order to purchase it at a lower price (Haavio and Kotakorpi, 2016). Through a system of sin

[89] Act LXVI of 2021 (Chapter 628 of the Laws of Malta).

licenses, CSCs have the potential to reduce the perverse relation between daily users and the profit-oriented recreational industry (Caulkins, 2016) without the need to ban retail outlets. Indeed, the commercial model could serve the vast *majority of users* since they buy small amount of cannabis occasionally.[90] The retail stores could become the preferred option for those who do *not* want to commit towards a certain level of consumption by becoming CSC members.

Additionally, the 'supply-follows-demand' philosophy of CSCs would be a form of nudging which may improve the decision-making of cannabis users and lower their risk of abuse (Thaler and Sunstein, 2008). Scholars argue that policymakers should design the choice architecture of consumers so their decision is more in line with their goals and less with their instinct by establishing a personal quota to limit their consumption (Kleiman et al., 2014).[91] While these control mechanisms do not guarantee a lower absolute consumption level among members, they are likely to deter escalation by monitoring user consumption.

Whereas there are clear advantages in term of harm reduction for regular users, even occasional users would benefit from this additional non-profit channel, if it changes the behaviour of commercial suppliers. Overall, there are two conditions which must be satisfied for a cannabis shop owner to counsel customers when they buy a much larger quota than usual: either, when there is a non-profit incentive for the supplier (i.e. CSCs); or when the for-profit supplier fears that the escalation of consumption may incentivize the client towards a CSC in the future. The current evidence from CSC experiences is mixed though (Parés-Franquero et al., 2019). In Belgium and Spain, the portion of members declaring to have lowered the intensity of consumption after joining the CSC is greater than the fraction who declare to have increased it.[92] Conversely, the contrary is true in Uruguay, perhaps in view of the different institutional

[90] Other advantages stemming from the existence of the commercial model include the provision of a constant stream of revenues, the reduction of the illicit market, the implementation of quality control (MacCoun, 2013) and an incentive to product innovation with positive externalities for consumers. This can in turn raise the health burden on the increase of sales of high THC products and other relatively more dangerous products (Smart et al., 2017; Carlini, 2017).

[91] Behavioural economics have demonstrated that individual decision-making deviates from rationality in certain circumstances (Laibsen, 1997). Problematic drug us can then be considered a problem of impaired will. A change in the conditions under which choices are made – for instance by respecting the consumption quota of CSCs - can help to reduce its consumption.

[92] Note that in Spain other three key patterns of use after joining a CSC were identified: those who have stopped and started using cannabis again many times; those whose consumption has changed over the years; and those whose consumption gradually increased until it reached a peak and then decreased (Parés-Franquero et al., 2019).

framework. All in all, however, the majority of members reported using about the same amount of cannabis than before joining the CSC.

Finally, an indirectly positive effect of the co-existence of different supply channels is that it is likely to limit the empowerment of a cannabis industry. The special interest of CSCs could counterbalance the industry power, permitting greater regulatory controls.

4.2.2. Pharmacies vs CSC

The supply of cannabis for medical use is the most complex and controversial policy issue. Overall, the jurisdictions that regulated the access for patients to MC have introduced different models in term of (1) conditions under which its provision is allowed, (2) products supplied, (3) distribution mechanisms, and (4) extent of domestic supply (Kilmer and Pacula, 2017). The regulatory scheme significantly affects the extent to which MC is purchased via that legal channel, but accessibility has to also be balanced with another policy objective, such as the minimization of diversion of cannabis (meant for medical use) to recreational users. In fact, cannabis products can be consumed for both medical and recreational purposes and this complicates - and likely delays - a wide(r) provision of cannabis for medical reasons. Indeed, most European countries impose significant restrictions both on eligible medical conditions and on the type of cannabis products available for those (EMCDDA, 2018). Currently, only these EU member states allow herbal preparations: Denmark (within a pilot program), Czech Republic, Italy, Netherlands, Portugal and Germany. Furthermore, Italy and the Netherlands only permit access to irradiated herbal cannabis.[93] At the same time, in a growing number of European countries, treatment costs are covered by the health system for certain patients (Fortin et al., 2022).[94]

Thus far, a regulatory model that maximizes access to cannabis for medical use has been primarily implemented in North America. In Canada and in several American states, cannabis (for medical use) is distributed through dispensaries without restrictions on specific types of

[93] Gamma irradiation minimizes the content of potentially harmful microbes by exposing the herbal material to packets of light that damage their DNA strands.

[94] There is great heterogeneity across European countries in term of reimbursement regulation (Zaami et al., 2018): in Germany, health insurers reportedly accept two-third of requests for reimbursement (The Economist, 2018); in Italy, MC policy differs across regions. It is generally prescribed at the expense of the National Health Service if the prescription is based on a treatment plan drawn up by the medical specialist for patients with specific diseases who have not previously responded to recommended treatment; in the Netherlands, most Dutch health insurance companies provide some form of reimbursement (Hazekamp & Pappas, 2014); in Canada, the reimbursement policy is limited to three grams per day to Veterans (Veterans Affairs Canada, 2017).

cannabis products. Patients with a valid recommendation from a medical professional can buy cannabis from these specialized outlets, which provide a range of (cannabis) products, therefore virtually addressing any segment of patients' demand. The problem with this distribution approach is that it is relatively easy for a recreational user to obtain a medical card/recommendation. This phenomenon is common to other psychotropic prescription drugs (Fischer et al., 2010) especially among young adults (Bawin et al., 2021) and is exacerbated in countries allowing direct-to-consumer advertising where physicians adopt a for-profit orientation (Fischer et al., 2014). An additional problem for MC is the lack of formal education of physicians on the endocannabinoid system in medical school (Takakuwa et al., 2021).

In general, there seems to be a blurred line between medical and recreational use. Sznitman (2017) examined the differences by distinguishing between people who use cannabis for recreational purposes, unlicensed and licensed medical users in Israel. She found more variables distinguishing unlicensed from licensed medical users than there were distinguishing features between unlicensed medical users and recreational users. Mode and patterns of use represented the most meaningful differences: recreational users were more likely to be male, to use cannabis frequently and less likely to eat it than unlicensed medical users. Other research has found an interrelation between medical and recreational users not only within jurisdictions allowing only MC sales (i.e. California), but also in supply architectures which separate the medical and recreational markets (MacCoun, 2013; Pacula et al., 2016).

The problem is that medical and recreational use pursue very different objectives and have very different social costs, which justifies that they should be priced differently. Recreational use may indeed generate two kinds of harms which are not considered by the users: harms that affect the others (externalities) such as impaired driving, and harms that affect users (internalities) - but that they do not take into account - such as lower educational achievement (Rogeberg, 2018). Corrective taxation is thus aimed to increase the price for cannabis in an effort to lower its problematic use. Accordingly, this regulatory tool is appropriate only for non-medical users whose consumption may involve excess harms. Conversely, patients using cannabis according to the prescription indication are not expected to incur social costs and should thus not be subject to a corrective tax. This favourable treatment occurs in some North American jurisdictions where advocates have succeeded in having MC exempt from cannabis specific taxes, and for specific cases to even obtain the reimbursement from the insurance (Howard et al., 2021).

Together, the differential monetary cost for individuals using cannabis medically and recreationally may interfere with the behaviour of some consumers. In practice, it leads to a deviation between the market price of cannabis and its marginal social costs in two scenarios: first, when a non-medical consumer purchases cannabis at a price that was set only for individuals using it for medical purposes and; second, when a medical user pays a corrective tax on its purchase.

In Colorado, for instance, the direct consequence of the first distortion is that the state collects tax revenues below the social optimum due to the lower taxation for MC; to a degree, the recreational market serves out of state tourists, while in-state residents can generally obtain a medical card regardless of their actual state of health. Nevertheless, such a distortion could become a major issue in a welfare state framework. Indeed, when considering countries that cover patient costs, there would be a real risk that public funding would be subsidizing recreational use of cannabis - if recipients were to acquire and use the substance outside of its intended medical scope. However, if there is a distinct group of patients who use it exclusively for medical reasons, governments may want to guarantee that this group can obtain cannabis products at a reasonable price. Another approach was taken in Canada to reduce the economic incentive for recreational users to purchase their cannabis in medical outlets. There, policymakers have set the same tax rate on medical and recreational cannabis, de facto applying (after the regulation of non-medical use) a corrective tax on its medical use.[95] Despite each Canadian jurisdiction has developed different reimbursement policies for the treatment of work-related health conditions, MC is generally not considered an approved treatment and the insurance coverage depends on the qualifying condition as well as a full risk assessment of its impact on the work environment (Howard et al., 2021).

All in all, the inclusion of the CSC as an additional supply option would lower the distortions created by the interrelations between medical and recreational users in two ways. First, if a part of non-medical users decides to become a CSC member rather than resort to the medical market in view of the lower transaction costs as well as price per unit involved. Second, if a part of patients who do not want to register as a patient decides to become a member of the CSCs instead of resorting to the commercial stores.

[95] Available at: https://www.ctvnews.ca/health/there-is-a-difference-between-medical-and-recreational-marijuana-patients-say-1.3798663

4.2.3. Illicit market vs CSC

The replacement of the illicit cannabis market with legal supply appears to be a longer process than previously thought. Three years after retail stores opened in Washington, it was estimated that almost half of the cannabis consumed was still being supplied by the illicit market (Caulkins et al., 2019). As a solution, the authors suggest that, during the transition period, law enforcement ought to chase out the residual illicit market more aggressively.

There are a number of reasons why the illicit markets persists in places where cannabis has been fully legalized (Robertson and Thyne, 2021). The major barrier is the high price per unit for legal cannabis, but the limited inclusion of illicit suppliers in the legal market might play an important role as well. Excessive taxation is thus one of the factors contributing to the survival of the illicit market. Unlike Colorado, Washington State implemented a uniform taxation scheme which in practice demands that medical users pay a corrective tax for cannabis products. As a result, those consumers who are more sensitive to price (or less willing to pay more for the product) may be deterred from switching to the legal market.

The second issue limiting the ability to reduce the presence of an illicit market relates to the relational embeddedness between consumers and their illicit cannabis dealers. This plays a significant role in enhancing loyalty to current suppliers, especially when both sides are part of the same social network and altruistic values are involved (Sandberg, 2012; Robertson and Thyne, 2021). Buyers' preference for small-scale dealers with whom they also have non-commercial ties suggests the existence of some degree of monopoly (Kennally, 2001) which may be also due to the preferences for a specific cannabis variety or preparation. Accordingly, illicit suppliers will continue to operate in the illicit business so long as they can make profits through their existing network of clients or are embedded in social supply networks.

A seemingly simple yet controversial solution would be to try to engage these individuals in the legal market - together with their existing customers. The critique to this view points out that participation in a newly regulated industry will depend on a high degree of voluntary cooperation and adherence to rules. Accordingly, those who have previously engaged in illicit activities and are not accustomed to comply with business regulations, may not be ideal candidates to enter this new industry. From a social equity perspective, the entrance of individuals previously involved in the illicit market in the new legal market remains de facto

limited by a number of legal and economic barriers. [96] For instance, in many jurisdictions, legal market operators are not allowed to employ those individuals with a criminal record. In other places, there are high entry barriers to obtain a commercial license which deters most cannabis dealers who are not able to ensure proper compliance.

A lower monetary cost per unit of cannabis for CSC members compared to retail stores would keep a larger fraction of users in the legal sphere, therefore improving the average quality consumed by them. Without this intermediate supply option, those users who are neither willing to buy in retail stores, nor able to obtain a prescription/recommendation from a medical professional would resort to the illicit market to satisfy their demand. This would be highly problematic from a public health standpoint as they would be acquiring a product which they have no control of in terms of its quality, purity and potency. While most CSCs are not testing their production (Belackova et al., 2016; Pardal and Bawin, 2018), members often contribute to the cultivation process as CSCs tend to rely on in-house members/growers, which de facto reduces the asymmetric information exchange between consumers and producers. In fact, there is a natural incentive towards quality when growers will consume the output themselves.

4.3. The theoretical framework

The theoretical model we put forward is conceptualized to maximize segmentation between medical and recreational cannabis markets by reducing consumption distortions. It integrates the commercial model adopted in the US for the recreational market with the European approach of integration of MC within the healthcare system (Fortin and Massin, 2020). These two supply models have been chosen not only because they have been the most adopted so far, but as they appear to be the most politically feasible to policymakers in Western societies given their resemblance to existing models for alcohol and prescription drugs respectively.

The CSC model is included as a complementary supply channel to enhance a user-controlled discrimination scheme, i.e. a scheme where cannabis users would select themselves into one of the three supply channels: pharmacies (i.e. through the healthcare system), specialized commercial outlets (i.e. retail stores) and CSCs. This self-selection approach would exploit the heterogeneity of cannabis market participants in three dimensions: price, transaction costs and volume purchased. The assumed supply/demand relation will be explained in the following paragraph and is shown in Table 1.

[96] See Kilmer (2019) for details on the relationship between cannabis regulation and social equity.

TABLE 1
Supply and Demand assumed relationship

TYPE OF CONSUMERS	LEGAL SUPPLIER
MEDICAL PATIENTS	Pharmacies
THERAPEUTIC PATIENTS	Pharmacies or CSCs
RECREATIONAL REGULAR USERS	Retail Stores or CSCs
TOURISTS AND OCCASIONAL USERS	Retail Stores

4.3.1. The access for patients to cannabis: a cost-benefit approach

Cannabis remains a contested substance. As such, those who have never used it before may find it difficult to ask for advice on its use from physicians - even though they might be suffering from a condition for which it might be effective (Pardal and Bawin, 2018). This is particularly problematic in the chronic pain field where training for physicians (on pain management) tends to be limited and where those with high level of 'perceived knowledge' were found to have a lower intention to prescribe cannabis (Zolotov et al., 2019). In spite of this, as regulation evolves and more doctors are aware of the potential therapeutic properties of cannabis products, it is likely that a growing number of individuals is able to initiate its use for strictly medical reasons.

Apart from this segment of users, being able to accurately distinguishing whether someone is using cannabis for medical vs. recreational reasons is challenging. In a regulated system allowing different legal supply models for recreational and medical users, users' choice on which market to resort to would likely depend on:

- the decision to use cannabis in a medical context. This will mainly depend on the user's belief on the effectiveness of self-medication, the perception that medical-grade cannabis is of higher quality and the health benefits of cannabis. Another factor involved in the choice of the cannabis user is an intuitive cost-benefit analysis depending on the trade-off between the monetary cost of the product and the patients' entry barriers (i.e. privacy concerns, stigmatization and ethical concerns: for instance, if this user does not have a medical condition);

- the willingness/capacity of health care professionals to prescribe or recommend a less conventional type of therapy for a certain condition (which in turn may depend on the medical evidence supporting the utility of cannabis for a given condition, and on the availability of effective, evidence-based therapeutic alternatives);
- the physician's ability to distinguish medical users from recreational ones, which in turn stems from their knowledge of MC, their monetary incentives and beliefs about the harms of cannabis use, as well as the penalties for an incorrect prescription.

4.3.2. Taxonomy of cannabis users and their supply channels

We contextualize our model within an European welfare state. In doing so, we will adopt the simplifying assumption that the market for MC is in equilibrium and is fully integrated within the healthcare system. In other words, there is full (or partial) coverage of the treatment based on the severity of the disease. Accordingly, the price per unit of product in a pharmacy is assumed to be always cheaper than at any other supply alternative, regardless of their cost-structure. In this scenario, it is reasonable to believe that there will be cases of users who attempt to obtain cannabis from pharmacies to save money. The aim of the model we put forward is to encourage users to self-select their supply channel in a way that minimizes this consumption distortion, while incentivizing risky users towards a supply channel which may offer more opportunities for harm reduction support.

Overall, we distinguish four consumer segments, which we argue will be attracted to particular supply models. The first two user segments represent non-medical consumers which differ only on their intensity of use and on their demand elasticity. Indeed, given their higher price-sensitivity, daily non-medical users are assumed to be majorly responsible for the *over-consumption* of MC when the substance is cheaper than if purchased in retail stores (Collins et al., 2014; Pacula and Lundberg, 2013). Therefore, the introduction of the CSC model in our hypothesized scenario is aimed at attracting this segment and lower their incentive to participate in the medical market. Accordingly, from the perspective of this type of user, CSCs must be more competitive not only with regards to the retail outlets, but also vis-a-vis with pharmacies.

The other user segments represent those suffering from a medical condition for which cannabis appears to be effective. They differ on two aspects: the accuracy of the signal they reveal to physicians and inclusion of their medical condition in a pre-defined list of pathologies where there is evidence around the effects of cannabis. Members of the first group (*medical patients)*

suffer from a condition which is medically verifiable, and where clinical trials on humans have been performed proving the efficacy of cannabis such as multiple sclerosis and certain types of epilepsy. Conversely, the second group (*therapeutic patients*) includes all other patients who seek to use cannabis for a variety of other conditions or complaints but for which the evidence on cannabis benefits is lacking, making it challenging to verify its real medical purpose by physicians (which, incidentally, account for the great majority of conditions cited by medical card applicants in some jurisdictions). Appendix table 1 shows a list of conditions with the estimated prevalence and portion of treatment-resistant patients. Our framework would generally benefit patients suffering from a medical condition for which there is a lack of effective pharmacological treatments, or where the existing treatments have significant side effects and contraindications.

Both medical and therapeutic patients would likely obtain a recommendation from a medical professional in the North-American context and would therefore end up effectively paying the same price, with no or reduced cannabis specific excise *tax*. Nevertheless, the price would be quite different within a welfare state framework as (1) it would likely be more difficult to obtain a valid prescription/recommendation for the *therapeutic patients*; (2) some established systems discriminate (in an economic sense) against *therapeutic patients* in terms of both access and treatment costs.

While *medical patients* would have access to the healthcare system, *therapeutic patients* could benefit from the existence of CSCs when they are unable to obtain a valid prescription/recommendation from a medical professional. Indeed, while the CSC model has primarily attracted non-medical users consuming the product on a daily or near daily basis (Parés-Franquero et al., 2019; Pardal and Decorte, 2018), we argue that some medical users could join a CSC to accommodate their needs. That could happen in at least four scenarios. Firstly, if access to the legal supply of cannabis for medical purposes is restricted to verifiable conditions. Secondly, if the costs for the pharmaceutical-grade product is considered too high for non-subsidized patients. Thirdly, if a segment of individuals using cannabis for medical purposes is concerned about privacy and lacks trust in the confidentiality of a government-controlled database. Fourth, if medical users believe in the entourage effect[97] and thus in the

[97] The concept of herbal synergy assumes a combinatorial activity of endocannabinoids via "the entourage effect" of active and inactive metabolites: i.e. the entourage hypothesis postulates a symbiotic effect in the interaction of multiple compounds resulting in greater benefits for a patient when the whole plant is used compared to using

efficacy of a specific product (or cannabis variety) and cannot find such product within the supply system for medical use.[98]

In this context, we assume that occasional users (and tourists) would acquire cannabis through retail stores. The low quantity consumed makes their demand more inelastic than that of regular users (Pacula and Lundberg, 2013), and an entry cost– such as a membership fee – would counterbalance the lower cost per unit associated with CSC membership. Overall, it appears unlikely that this group of users would give away their private information without an economic gain. Any additional commitment mechanism, such as a minimum consumption quota (i.e. some CSCs in Uruguay have set a minimum quantity threshold of 10-25 grams that members must acquire monthly – see Pardal et al., 2019) would be a strong deterrent for them, and could be a strong incentive for these users to satisfy their needs in retail stores.

The goal of the model is to limit the arbitrage between medical and recreational cannabis markets by creating a buffer for those consumers who would not fit within the supply channel designed for their use. According to this self-selection discrimination scheme, CSCs would attract primarily: 1) daily non-medical consumers who would be willing to spend time being enlisted into these clubs, or whose reservation price is below the price per unit of retail stores; as well as 2) therapeutic patients whose request for a prescription/recommendation was refused by their medical professional, or that have a preference on purchasing through CSCs due to their product offerings and/or their privacy policy.

4.3.3. The model

In the model, there are two types of consumers (medical and recreational) for three supply channels. The choice for non-medical cannabis users will depend on q_1. If they consume *more*, they may decide to buy cannabis through the *CSCs*. If they consume *less than* q_1, they will buy through *stores*. In parallel, the choice for those using cannabis for medical purposes will depend on q_2. If they consume *more* than q_2, they will decide to buy cannabis *through the healthcare system*. If they buy *below* q_2, they are more likely to buy *through CSCs* (and those with high privacy costs and very low quantity consumed may even buy cannabis in stores).

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single extracts of cannabinoids (such as in the cannabis-based pharmaceuticals who have received marketing approval thus far). See Russo (2019) for a review of cannabis synergy.

[98] Except for Germany - where is possible to find dozens of varieties across different pharmacies - European countries with a MC program allow up to fourteen varieties (Schlag, 2020) compared to over 350 sold in Canada (Grootendorst and Ranjithan, 2019).

In other words, occasional consumers would prefer to buy in stores rather than in CSCs. In parallel, regular users will purchase at CSCs or through pharmacies to minimize their total expenditure. Note that not all those with a demand above q_2 will purchase in pharmacies. Many regular users may not be able to obtain the prescription/recommendation from their medical professional, or they may perceive that the privacy costs of enlisting in a government-run database may overcome their economic benefits.

This model taps into the heterogeneity of consumers in terms of intensity of consumption (or volume purchased). Regardless of the purpose of use for cannabis, two major factors would influence the consumer's choice in term of supply: the actual price of the product, and the transaction costs needed to access the product (e.g. annual membership fee, costs of obtaining a prescription, privacy costs associated with registration in a state-controlled database). For simplicity, income is not included in the model.

We assume M is a composite good whose price is set to 1, and cannabis is a homogenous good with q being the quantity purchased by a consumer. $\overline{U}$ is the initial and minimum level of utility which must be guarantee to each consumer. There are three schemes available to purchase cannabis depending on the chosen supply channel: E_{LP} which is the linear pricing with per-unit price p_{RET} (applied at retail stores); E_{2PT} menu is a two-parts tariffs where p_{CSC} is the per-unit price and T_{CSC} is the fixed fee (applied at CSCs); E_{FT} is a menu with a fixed tariff T_{PHA} and is not dependent on the quantity consumed (applied within the healthcare system with full reimbursement of medication costs). The illicit market is omitted from the model as it is assumed that the legal market would attract the most skilled labour outcompeting the illicit market on price in the long term, assuming reasonable taxation levels.

Consumer program with linear pricing:

$$\min_q E_{LP} = M + p_{RET}q$$

$$s.t. \overline{U} = M + U(q)$$

which can be rewritten:

$$\min_q E_{LP} = \overline{U} - U(q) + p_{RET}q$$

Consumer program with two-parts tariffs:

$$\min_q E_{2PT} = M + p_{CSC}q + T_{CSC}$$

$$s.t.\ \overline{U} = M + U(q)$$

which can be rewritten:

$$\min_q E_{2PT} = \overline{U} - U(q) + p_{CSC}q + T_{CSC}$$

Consumer program with fixed tariff:

$$\min_q E_{FT} = M + T_{PHA}$$

$$s.t.\ \overline{U} = M + U(q)$$

which can be rewritten:

$$\min_q E_{FT} = \overline{U} - U(q) + T_{PHA}$$

For a given $\overline{U}$, the consumer will choose the two-parts tariff if:

$$E_{2PT} < E_{LP} \text{ and } E_{2PT} < E_{FT} \quad \text{i.e. if}$$

$$\overline{U} - U(q) + p_{CSC}q + T_{CSC} < \overline{U} - U(q) + p_{RET}q \quad \text{and}$$

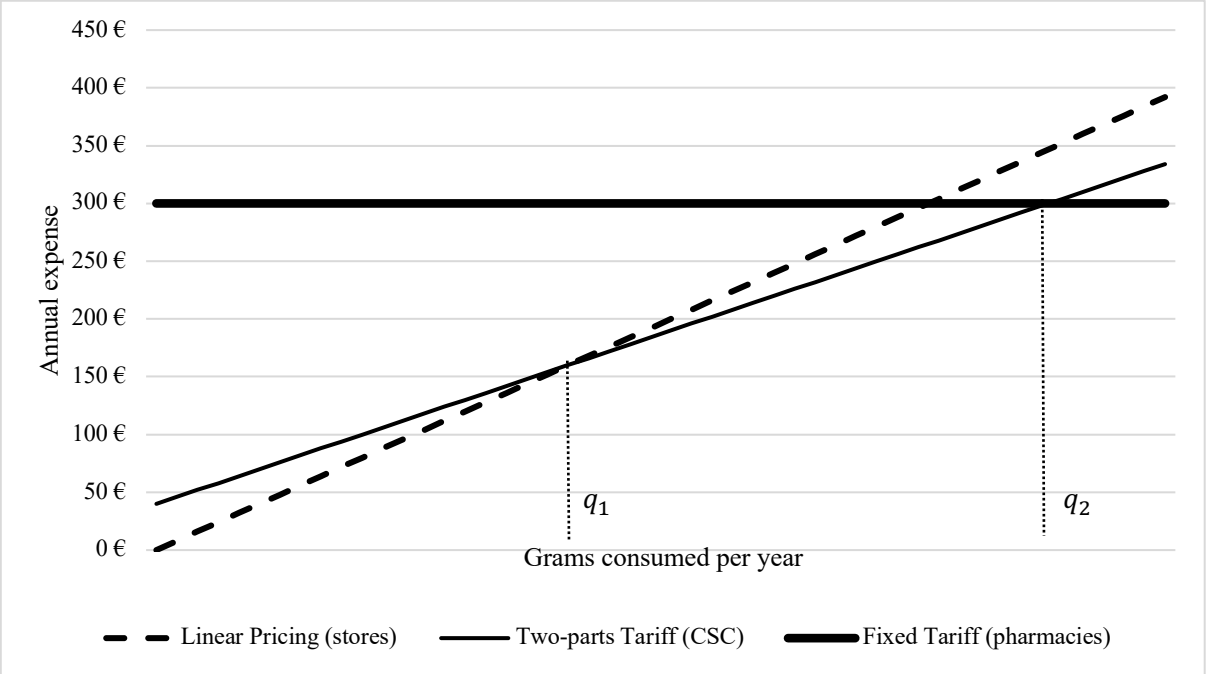
$$\overline{U} - U(q) + p_{CSC}q + T_{CSC} < \overline{U} - U(q) + T_{PHA}$$

which can be rewritten:

$$q_1 = \frac{T_{CSC}}{p_{RET} - p_{CSC}} < q < \frac{T_{PHA} - T_{CSC}}{p_{CSC}} = q_2$$

These quantities are also denoted as q_1 and q_2 in Figure 1. Accordingly, the chosen scheme will depend on the quantity consumed, the price per unit and the access fees across the different supply channels. To show how the choice would change across consumer types, we assume the following schemes: the per-gram price in retail stores and CSCs is 8€ ($p_{RET} = 8$) and €6 ($p_{CSC} = 6$) respectively. The annual membership of the CSC is set at €40 ($T_{CSC} = 40$), so q1 = 20 grams per year, or less than one joint per week, whereas the transaction cost to obtain a prescription for a patient is set at to €300 ($T_{PHA} = 300$) which makes q2 = 43 grams per year.

FIGURE 1.
Pricing across supply channels



4.3.4. Transaction costs and price

We consider the access fee to be the sum of the transaction costs necessary to have access to the specific supply market. For instance, T_{PHA} differs across type of cannabis consumers based on the purpose of use and the effort necessary to obtain a prescription/recommendation. To put it simply, at the two extremes lie individuals suffering from a verifiable condition for which there is strong evidence of efficacy for cannabis (e.g. epileptics) and those whose only purpose of use is to alter their state of consciousness. For the former group of users, it is possible that their own medical professional prescribes the cannabis product – i.e. given its approval from major health agencies worldwide for this condition, *de facto* minimizing the transaction costs. Conversely, it may be more challenging for users with non-verified conditions to convince a medical professional to get a prescription and sometime incur an ethical cost in reducing the budget available to patients (when treatment costs are reimbursed). There is also a privacy cost linked with being registered in a centralized database which varies on the employment of the consumer and the stigmatization of the substance within a given community. This privacy cost would occur also for CSC member to ensure compliance with quota system.

For the model to be able to increase the segmentation within the cannabis market, the transaction costs of CSCs would need to be perceived to be lower compared to those requested

by pharmacies. At the same time, the retail stores would need to have the lowest level of transaction costs to purchase cannabis among the available supply channels. In this setting, the model would satisfy the following condition:

$$T_{RET} < T_{CSC} < T_{PHA}$$

In the US, the CSC model has not been implemented, but this condition has been validated in the medical and recreational market. Indeed, patients need to undergo an annual physical examination to obtain a prescription/recommendation, pay a fixed annual cost to the authorities, as well as being registered in a centralized database, whereas any adult can buy at retail stores without any preliminary obligation.[99]

In relation to the final price paid by consumers, in this scenario, the CSC model would need to satisfy a second condition:

$$p_{PHA} < p_{CSC} < p_{RET}$$

Ideally, in a CSC the price for a unit of cannabis (i.e. for one gram of herbal material or oil) would need to lie between the price paid by patients through a healthcare model and the cost for consumers who would buy it in retail outlets. These conditions behind the functioning of the model are motivated by political economy reasons as well as to minimize market distortions. Even assuming similar production costs in the three settings, the higher price in CSCs and retail stores could be achieved through taxation, as a form of corrective tax is considered appropriate for the non-medical use of harmful goods.

The higher price in retail stores compared to CSCs is motivated by the adoption of a form of sin license *a la* Haavio and Kotakorpi (2016). This personalized regulation was first considered as a way to enable those with self-control problems to commit to a future consumption (O'Donoghue and Rabin, 2003). Haavio and Kotakorpi (2016) extended it through a system where individuals can voluntarily opt for a maximum quota of sin goods in order to purchase it at a lower price. Any purchase of cannabis above this quota would incur a higher tax. By supplementing sin licenses to sin taxes, the authors show that social welfare would be increased if consumers differ significantly in their degree of self control problem *and* tax revenues are not reduced compared to the scenario with sin taxes only. As a form of quantity regulation, sin licenses have the advantage to combine market mechanisms such as the personalization of the

[99] Available at: https://www.colorado.gov/pacific/cdphe/laws-and-policies-medical-marijuana-registry

quota, with government intervention such as the commitment device which allow the discount. The price difference between those purchasing with or without license should be balanced to avoid trades in the secondary market and thus profitable transactions between individuals hoarding sin licenses and consumers who either exceed the quota, or are not CSC members.

For simplicity, we do not incorporate the functioning of sin licensees in the model, although we consider them as a form of transaction costs. However, this is the intuition behind the lower pricing paid by CSC members compared with what customers would pay at retail stores. The choice of abandoning the purely sin tax approach for a model which combines Pigouvian taxes and sin licenses can be explained by other characteristics of the cannabis market: firstly, high prices are unlikely the best way to target problematic users (Williams, 2016); secondly, cannabis can be cultivated domestically for a relatively low cost (Potter, 2008). [100] As a consequence, above a certain threshold of price per unit, daily consumers' choice in term of quantity consumed may remain virtually unaffected by price increase: some of them may respond by beginning a home cultivation, or increasing the size of their crop, to supplement or replace their reliance on the illicit market (Potter et al., 2015). Accordingly, a corrective tax is unlikely to neither distort nor correct their consumption behaviour.

Retail outlets would mostly attract occasional users and out-of-state visitors/tourists who are unwilling (or incapable) to incur in the transaction costs demanded to a CSC member given their occasional consumption behaviour. With regards to the medical market, patients would obtain a cheaper product either without paying any tax, or by obtaining coverage through private insurance or by the national health system.

4.4. Discussion

4.4.1. The Belgian experience

Having clarified the model, it is important to discuss how realistic its assumptions are. The closest real-world examples to our theoretical model can be found in Belgium and Uruguay (Pardal, 2018a; Queirolo et al., 2016). In Uruguay, consumers can (legally) opt between joining CSCs, acquiring cannabis in pharmacies (not necessarily for medical reasons) or produce it themselves. In Belgium, although no legal regime for the supply of cannabis has been introduced to date, users have resorted to the existing CSCs in the country and, given the

[100] Small-scale home cultivation for personal use or 'social supply' has some minimal requirements of space, time and skill, although growers can (and often do) use specialist equipment, and more advanced growing techniques are easily learnt from online sources (Potter, 2010).

proximity with the Netherlands, may also purchase cannabis through Dutch coffee shops.[101] Although neither the case of Uruguay nor Belgium fully matches our hypothetical scenario, we discuss it in light of the Belgian experience, seeing as Dutch coffee shops are considered more commercial than pharmacies in Uruguay.[102]

We turn to the exploratory validation of the two conditions in our hypothetical regulatory framework. The first is the existence of an entry cost for consumers to access CSCs, in order to deter occasional users. In Belgium, the model only partially fits with this condition, as the possibility of obtaining cannabis through a CSC is limited by a number of entry barriers. At the same time, it can be argued that, for most users, the transaction costs are still lower than visiting a medical professional to obtain a prescription[103]. This is assuming that, in terms of privacy costs, the list of patients is available at the national level in a centralized government-controlled database, while the list of members may be kept by the clubs individually. However, this scheme was not chosen in Uruguay where also CSC members have to register in a centralized government-controlled database.[104] Nevertheless, it must be recognized that the physical distance of coffee shops from Belgian consumers increases the transaction costs involved with their access, and some may perceive it to be of the same magnitude (or even greater) than those involved with becoming members of CSC or obtaining a prescription.

The second condition relates to the per-unit price of cannabis in the CSCs – which, according to our framework, should be lower than in the retail stores. This would depend both on the production efficiency of cultivators and on the taxation applied at the various channels. In the current CSC framework in Belgium, the amount of cannabis cultivated is based on the number of members as well as their predicted level of consumption. Given its unregulated nature, it appears to be difficult to implement a large-scale system of production (Pardal, 2018c). At the

[101] The Dutch government's decision to introduce a 'weed pass' to deter foreigners to buy cannabis in the coffeeshops of cities at the border may have decreased this purchase behaviour. Yet, the great majority of observations on CSCs are collected from Flanders, a region at the border with the Netherlands only few hours away from Amsterdam where any adult can purchase cannabis at coffeeshops.

[102] In Uruguay, aside from CSCs, cannabis can also be purchased through licensed pharmacies at a price set by the government, which in turn acquire the product through at least two producers. The limitation of both Uruguayan and Belgian models is that they lack a medical distributor, although in practice it is possible for Belgian medical users to obtain their medical cannabis from Dutch pharmacies.

[103] For instance, the majority of CSC members declaring to use cannabis for medical reasons did not have a written recommendation from a health care professional (Pardal and Decorte, 2018).

[104] While the registration of this information would be likely privacy-protected, Boidi et al. (2016) show that 40 percent of frequent users in Uruguay would not register mostly for lack of trust in the registry or as they reject the idea of being registered as cannabis users.

time of that research, the Belgian CSCs applied a price per gram ranging between 6.5-9EUR, and did not apply quantity discounts (Pardal, 2018a). That value is lower than the average price per gram at a Dutch coffee shop, which was estimated at 11.82EUR based on 2016-17 data (Rigter and Niesink, 2017). While this would appear to show that the condition related to the per-unit price between CSC and retail stores is currently validated, it must also be recognized that cannabis production has not been legalized neither in the Netherlands, nor in Belgium.

It is fair to note that our analysis can say little about the details of how a CSC would compete with the commercial model in practice. We discuss the Belgian experience which is likely to be most similar, but perhaps we would need to examine this model in other contexts for further validation. Still, it is difficult to conceptualize other supply model formulations with the same potential to increase market segmentation. Home cultivation could be considered as another potential buffer to reduce the participation of non-medical users in the medical market. Nevertheless, the transaction costs involved with this model are arguably larger than those involved with getting a prescription in the medical market, and would make its adoption more limited than with CSCs. It would also incentivize a grey market when regular users do not have the resources (i.e. space, skills) to grow it themselves as they would have to obtain it from other domestic growers. Moreover, home growing cannot be considered a harm reduction model as there would be no nudging to avoid an increase in consumption patterns.

4.4.2. Economic efficiency and harm reduction

Having explained this theoretical scenario, we should remember that the main objective of drug policy is to find the equilibrium between economic efficiency and harm minimization (Kopp, 2004). In term of economic efficiency, the goal of CSCs as an additional supply channel is to improve market segmentation between medical and recreational users in order to minimize three major distortions. First, when non-medical users purchase MC without incurring the corrective tax, or worse at a subsidized price. This is particularly important in jurisdictions where the National Health System supports the costs of MC as it would imply not only a loss of tax revenues, but also a waste of public funding. Second, the shift of *therapeutic patients* towards CSCs would increase efficiency in two ways: on one hand, by reducing the corrective tax paid by individuals who must rely on commercial dispensaries as they are unable to obtain a physicians' prescription; on the other hand by saving medical resources, such as doctor's time, which would be spent in visiting these medical professionals. Unless the medical effectiveness of cannabis is demonstrated for the majority of these conditions for which it is

used, the efficiency gain for the health system would be substantial. Third, if the entry barriers necessary to be employed within CSCs is lower than the commercial enterprises, the existence of a non-profit supply model is expected to move a larger fraction of illicit suppliers within the legal sphere. This in turn will shift a larger share total demand in the legal market and increase tax revenues.

In terms of harm minimization, scholars (Belackova et al., 2016) argue that CSCs can simultaneously promote a number of public health objectives and that its non-profit nature could help prevent the most problematic uncertainties of legalization (Kleiman et al., 2014). First, a sin licenses scheme would be a cheap way to obtain commitment from users as a form of nudging which could lower their risk of abuse. Second, CSCs would attract heavier users and thus reduce their relationship with the for-profit industry. Third, the competition from CSCs may provide incentives to retail stores towards the maximization of consumer health. The industry may have an interest in avoiding their clients' escalation in consumption as they would become more price-sensitive, and eventually shift towards CSCs for a lower cost per intoxication. Fourth, CSCs would attract a portion of the demand from the illicit market thus reducing the risk of contaminated products and other health risks related to the uncertainty in their content.

4.4.3. Limitations

The major limitation of the model presented here relates to the assumed homogenous nature of cannabis-derived products which may be considered overly simplistic. The plant can indeed be cultivated and processed to generate a wide range of products with very different combinations of active principles. In certain MC markets, regulators restrict the type of products available allowing standardized drugs containing a mix of isolated cannabinoids.[105] This type of medication would provide a consistent dose of active ingredients for patients. Individuals with compromised immune systems would clearly have a preference to receive such products, if available. If we consider these products separable from what is used in the recreational market, the market dynamics of our model would change compared to the scenario of homogenous good. Regardless on the quantity consumed, any patient who do not believe in the entourage effect will perceive them as of superior quality. This is due to their greater resemblance to modern pharmaceutical products in terms of standardization, lack of contaminants and

[105] Whereas it may be difficult to standardize the content of an herbal product, it is an easier task to use formulated pharmaceuticals based on phytocannabinoids and/or synthetic cannabinoids.

evidence of efficacy. In parallel, physicians who do not believe in the entourage effect would always prescribe these type of products to medical patients. In this scenario, CSCs would be used as a supply channel from therapeutic patients unable to obtain a prescription, medical patients who believe in the entourage effect and users who perceive that the privacy costs of enlisting in a government-run database may overcome the benefits.

Nevertheless, access to the market of these cannabis-based pharmaceuticals depends on the interest of companies to apply for their marketing authorization through clinical trials on safety, quality and efficacy which are currently very costly (DiMasi et al., 2003). The limited number of conditions for which there is evidence of effectiveness for cannabinoid-based products along with the high cost of these medications have persuaded regulators to allow herbal cannabis, mostly through special-access schemes and even reimburse its costs in certain cases. One may speculate that there will be cannabis-based drugs authorized for most conditions where it may be beneficial. However, the technical and economic barriers for demonstrating its efficacy and in protecting patents may extend their approval times by decades (Fortin and Massin, 2020)[106]. Even with a significant expansion of cannabinoid-based pharmaceuticals, it is unlikely that patients using herbal cannabis will switch to these standardized medicines, if they believe in the superiority of the entourage effect (Russo, 2019). Unless it will be proven that botanical drugs are less efficacious than their isolated components, there will thus still a share of patients using herbal cannabis[107]. As this is the most common form of cannabis used recreationally, we consider our assumption of homogenous product to be reasonable for the time being.

Another significant limitation relates to the very limited applicability of the model in the US context in view of the specific nature of its MC market. The transaction costs to become a patient is much lower there as its historical use has lowered the stigma and prescription practices for narcotics seem to be looser than in other countries (i.e. opioid crisis). Compared to a prescription, physicians' responsibility deriving from the misuses of the recommended treatment is much lower and there are clear economic incentives for medical professionals to

[106] The multi-compounds nature of cannabis lowers the incentive to perform clinical trials (in particular on its herbal form) as pharmaceutical companies need to secure a patent to make the research investment profitable. These patents rely on the ability to identify an active principle to be effective in a specific condition. Accordingly, there is little financial incentive for the pharmaceutical industry to explore a medication whose most common form (i.e. herbal preparation) is characterized by multiple active ingredients. Even patent combination therapies containing two or more isolated cannabis compounds would be difficult to protect in term of intellectual property as (1) they would lack the entourage effect; (2) the cost for efficacy testing is very high; and (3) limited protection is granted on patent concerning a combination without chemical reaction.

[107] This is however very unlikely in view of the herbal nature of cannabis and its diversity (Worth, 2019).

close an eye on non-medical users 'faking an ache'. While the model may provide good insights to European countries and other jurisdictions with a welfare system having the characteristics presumed in the framing, it may not adequately fit other markets with health approaches similar to the US.

Other limitations stem from the risk of over-regulating CSCs and the potential unsustainability of the model (Belackova and Wilkins, 2018). Setting for instance extremely low thresholds to the number of members, the number of plants per CSC or the member's quantity supplied might in turn cause other distortions such as an increased diversion of the product outside the closed-circle or even deter cannabis users from CSC membership. Yet, unless the CSCs are regulated through an unreasonable layer of bureaucracy, their introduction will likely encourage economic efficiency in a harm reduction context.

Finally, one may argue that if daily or near daily users indeed join CSCs, then the size of the private industry would become much smaller. While this is likely, the great majority of cannabis users are occasional and could potentially be interested in purchasing in retail stores (Caulkins et al., 2016). Besides for occasional users, in certain countries, tourists may represent another group of users who could source their product through the private industry. Among regular users, some may be interested in buying it in recreational stores for privacy reason or because the CSC is located to far from where they are located. Even CSC members may purchase something in stores if it will not be available in CSCs. Together, the level of the corrective tax of retail stores is likely to be a major factor behind the size of the private industry and its ability to reduce the illicit trade.

4.5. Conclusion

The first commercial markets for cannabis have demonstrated that commercialization conflicts with public health oriented policy goals (Pacula, 2017; Subritzky et al., 2016) and market segmentation between medical and recreational users (Pacula et al., 2016). Canadian regulators have decided to apply the same taxation level to cannabis regardless on the purpose of use of the product. Government officials declared having taken this decision in view of the shortcomings of Amendment 64 in Colorado which is argued to have allowed significant market distortions of non-medical users using the medical channel to save money by avoiding taxes. It also recognizes the reality that there is in fact little difference between the "medical" product and the "recreational" product (Cash et al., 2020).

This chapter suggests that there are design options that can represent an improvement vis-à-vis the sole implementation of a commercial model especially within the European model. Kilmer (2019) identified 14 choices concerning the introduction of cannabis legalization – the 14 Ps. Among the different design choices, Kilmer includes a consideration of the profit motive and the price - which are aspects that are critical for the correct functioning of our proposed model as well. Our analysis suggests an additional important (P) choice: plurality, in the sense that jurisdictions may want to consider the introduction of multiple supply models in light of the different segments of users in a given jurisdiction.

In particular, we argue that the CSC model has the potential to complement the commercial and medical models. If a jurisdiction has an established reimbursement policy for medication, the co-existence of the CSC model could help reducing the number of cannabis users procuring cannabis from the national health system. If the CSC charges lower prices than the private industry, it would also be an attractive model for daily or near daily users, who would thus be supplied by a non-commercial model through a system of sin licenses in a harm reduction setting.

In practice, supply models can potentially compete with each other when they are designed to supply different demand segments. The difference should not be limited to the effective price paid, but should consider the overall transaction costs in order to limit as much as possible eventual market distortions. These transaction costs in turn should not be limited to an annual fee, but should reflect other aspects, such as an ideological choice to avoid being registered on a centralized government-control database.

In conclusion, current research suggests that plant-based psychedelic substances might have a significant therapeutic potential for the treatment of addictions and other mental illnesses for which there is limited effectiveness of pharmacological treatments (Carhart-Harris and Goodwin, 2017). As their nature is comparable to cannabis, a similar market design should be considered (Belackova et al., 2022).

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4.7. Appendices

APPENDIX TABLE 1

Prevalence of 'therapeutic patients' and untreated population

Medical Condition	Prevalence (in million)	10 years growth	Untreated population	Reference	Treatment Issues
Anxiety Disorders	267 (28.8% globally)	14.9 %	40%	Bystritsky (2006); Vos et al. (2016);	Tolerance and dependence
Depressive Disorders	311 (6.7% globally)	18.4 %	6.6-35%	Bosco-Lévy et al., (2021); Vos et al. (2016);	Patients fail to achieve meaningful recovery
Sleep disturbances	9 – 22%;	Increasing	40-85%	Vallante et al. (2013); Riemann et al., (2017); Krakov et al. (2010); Dopheide (2020);	Ceases to be effective in treating insomnia after the first few nights; side effects and contraindications
Arthritis	24	23.8%	6-17%	Vos et al. (2016);	
PTSD	3.6 - 9.7%		35%	Gradus (2007); Ot'alora et al. (2018); Hoskins et al., (2021)	Evidence of a small positive effect for existing pharmacotherapies
Dementia	45	37.7%	100%	Vos et al. (2016); Davis et al. (2021)	No treatments to date can reverse or halt the progression of dementia
Fibromyalgia	0.2–6.6 %		98%	Martins et al. (2021); Bazzichi et al., (2020)	Majority turn to complementary therapies
Substance use disorders	109	11.1 - 16.3 %	46 – 65%	Fleury et al., (2016); Vos et al. (2016);	
Migraine	958	15.3%	5%	Vos et al. (2016); Schulman et al. (2009); Negro and Martelletti (2021)	Incomplete pain relief, headache recurrence, and cardiovascular contraindications in some patients
Skin and subcutaneous diseases	2'239	12.5%		Vos et al. (2016);	

Glaucoma	5.9	39.1%		Vos et al. (2016); Shalaby et al. (2020)	Patient compliance and adherence to eye drops. Lack of long-term placebo-controlled trials due to ethical considerations
Attention-deficit or hyperactivity disorder	51	00.3%	30%	Vos et al. (2016); Demirkaya (2019); Mechler et al. (2021)	
Autistic spectrum disorders	62	12.3%	100%	Vos et al. (2016); Lord et al. (2018)	
Tourette's	1%		100%	Roessner et al., (2011)	
Parkinson's	6.2	31.6	100%	Vos et al. (2016); Schneider and Alcalay (2020)	
Schizophrenia	23	19.5	10-60%	Vos et al. (2016); Lindenmayer (2000)	

Note: The table includes only conditions where the strength of evidence for cannabis is considered low and we order them based on the frequency among prescription/recommendation registries for MC, according to Schlag et al. (2021) estimation.

CHAPTER FIVE

5. LIGHT CANNABIS AS A SUBSTITUTE FOR ADDICTIVE SUBSTANCES: THE FRENCH AND ITALIAN EXPERIENCES

Abstract

Cannabidiol-based products are attractive to consumers because of their wide range of potential health effects. Despite the hype of this market, there is a substantial lack of information on consumers' attitudes and motivations toward light cannabis products. We thus conducted an ad-hoc online survey to investigate the characteristics of French and Italian users, focusing on smoking as the main mode of consumption. Logistic regressions are performed to explain the factors associated to light cannabis use as a substitution for any drug or for a specific substance. Our results indicate that one out of five current light cannabis users use it as a substitute (self-replacement therapy) for other substances. The reduction in substance use is more prevalent for regular cannabis, tobacco and medications than for alcohol use. However, the use of light cannabis seems to facilitate alcohol consumption reduction, mostly among males with low income. Whereas sublingual oils are more likely to be used to substitute medications, smoking is the favourite means of substitution for tobacco and regular cannabis. Overall, the motivations behind consumption determine differential preferences across light cannabis users. This calls for a rethinking of the most adequate distribution channels for specific products based on the purpose of use. The goal should be to maximize the substitution with other addictive substances by providing a differential degree of quality and taxation across supply channels based on the expected harm.

Keywords: cannabis survey, light cannabis, substance substitution, logistic regression, EU

Abbreviations:

CBD	Cannabidiol
C-light	Light Cannabis
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
FDA	Food and Drug Administration
THC	Tetrahydrocannabinol
WHO	World Health Organization

5.1. Introduction

The *Cannabis sativa L.* plant contains over 400 chemical compounds. In view of its widespread recreational use, plant breeding has for decades been aimed at production of variety with high tetrahydrocannabinol (THC) content which we call 'regular cannabis'. Cannabidiol (CBD) is the second most prevalent cannabinoid after THC. Contrary to THC, CBD is neither a narcotic nor an intoxicating substance, and has no risk of abuse or dependence according to the World Health Organization (WHO, 2017). It does not produce anxiety, panic, or psychotic symptoms – even at high doses. While CBD was discovered in 1940, scientific interest in this molecule has expanded in recent times (Leas at al., 2019) given its anxiolytic, antiepileptic, anti-inflammatory and antipsychotic properties as well as its potential therapeutic effects in neuropsychiatric and substance use disorders (Crippa et al., 2018; Sholler et al., 2020). Products with high CBD and low THC, which in Europe is often called light cannabis (C-light), have thus become a global consumer phenomenon, resulting in a tenfold increase of sales for certain items between 2017 and 2019 (Gammon et al., 2021).

Despite its medical potential and its apparent lack of side effects (Chesney et al., 2020), policymakers appear to be concerned about the market for C-light and the impact of its liberalisation[108]. De facto, each EU country has responded to its emergence through differential approaches. Given the lack of evidence-based policies around C-light, the EMCDDA (2020) have recommended performing cross-national studies to develop standard monitoring tools and collect information on C-light consumers. To better understand the reasons behind its widespread use, we conducted an anonymous survey among C-light users in France and Italy during the first lockdown and one year forward to determine if there was a change in the patterns of consumption. The survey aimed at collecting self-reported socio-demographic characteristics and behaviors, preferred means of use and reasons for using C-light. Given the large amount of free time, this period represented a unique opportunity to collect detailed information on light cannabis users.

Overall, this study had five goals: (1) to understand which factors can predict the initiation of C-light to substitute other substances; (2) to elicit which profiles and patterns of use increase the likelihood to substitute addictive substances with C-light; (3) to evaluate the behavioral

[108] The WHO recommendation to remove CBD preparations (with less than 0.2% THC) from the international drug control was rejected at the 63rd session of the UN Commission on Narcotic Drugs (2020).

mechanisms behind the substitution effect; (4) to identify which type of product and supply channels maximize the substitution potential of C-light for specific substances and; (5) to understand how institutional differences affect consumption dynamics. While this is the first study on substitution patterns driven by C-light, some of these objectives have been partly addressed from the prior literature outside the EU through online surveys. In Switzerland, Zobel et al. (2019) found that more than one out of ten C-light users use it to substitute regular cannabis or tobacco. In the US, Wheeler et al. (2020) found that three out of ten young C-light users consume it as a substitute of regular cannabis. This chapter contributes to this growing literature on C-light by being the first to (1) study its use in Mediterranean countries; (2) report the proportion who use C-light as substitutes for five different types of substances; (3) investigate which mechanisms influence the substitution; and (4) which factors increase the likelihood to initiate and currently substitute addictive substances with C-light. Moreover, this is the first study to identify specific patterns of consumption linked with smoking C-light to substitute other substances and what increases the likelihood of this behavior.

In spite of the existence of multiple forms of C-light (e.g. e-cigarettes, tinctures, gel capsule), the most common C-light products across EU countries are sublingual oils and herbal products. The latter can indeed be smoked or vaporised in the same way as regular cannabis. Currently, however, its combustion represents the favourite mean of consumption for three quarters of Swiss consumers (Zobel et al., 2019). Given the similarity in consumption method with more dangerous substances and highest prevalence among our surveys, a specific analysis was performed on the respondents who smoke C-light products to substitute tobacco and regular cannabis. Among this sub-sample, the aim was to understand how the intensity of consumption, joint mixture, diversification of varieties and specific sub-products used affect the likelihood to stop these addictive substances.

The results document a significant attitude to use C-light as a substitution product to replace (or reduce) the use of regular cannabis, tobacco, alcohol and medications. One out of ten respondents initiate C-light for substituting at least one of these substances. Among those who initiate use for health and wellness reasons, two thirds have the intention to reduce at least one of these harmful substances. Initiation for substance substitution is greater among employed females or individuals with low income. Being older, overweight or a daily tobacco smoker is also positively associated with C-light initiation for substance substitution as well as domestic cultivation. The proportion of those substituting other substances with C-light is greater among

those who have used it in the last month (so-called current users): one out of five did so, and about half among those are using C-light for health and wellness reasons. Smoking tobacco and frequent C-light use are also positively associated with substitution patterns. Age, income and expenditure on C-light are associated with the substitution of specific substances, whereas other factors have the opposite association, depending on the specific substance which is substituted, namely gender, employment, being a heavy tobacco smoker and using C-light orally through sublingual oils.

Overall, this chapter will attempt to clarify the many unknowns in the C-light market to facilitate the discussion on what could be a reasonable and proportionate response from policymakers. The results suggest that this emerging market has not only helped to satisfy the needs of some patients to relieve their symptoms through self-medication, but also to stop or reduce the use of other more harmful and addictive substances. These findings should be taken into consideration when setting the level of taxation for C-light. While its oral or inhaled consumption does not imply harm, the same cannot be said for its combustion, especially when combined with tobacco or regular cannabis. However, taxing harmful substances has different effects depending on substitution patterns and whether healthier substitution products are available. For instance, if smoking C-light is an effective way to substitute tobacco or regular cannabis, its taxation should be lower compared to more harmful substances. Moreover, the mandatory presence of C-light products in tobacco, alcohol or regular cannabis shops may be an effective way to nudge consumers towards healthier choices (Bucher et al., 2016). Together, differential taxation across C-light products based on their substitution potential across supply channels should be considered to maximize the incentive to switch from the most harmful substances to healthier ones.

The chapter begins with an overview of the literature related to the properties of CBD as a substitute for addictive substances. Then, we move to the institutional framework of the C-light market in Europe and North America. Next, we provide a cross-comparison of descriptive statistics between respondents in the whole sample and the French sample only. Afterwards, we perform a logistic regression on the factors related to initiating C-light to substitute other substances; then, we do a similar investigation to determine which factors affect the likelihood to reduce the consumption of these substances for C-light in the last month for the whole sample and only for smokers. We conclude with a discussion of the results.

5.2. Literature review on the substitution potential of light cannabis

"When everyone is convinced that they're right with no data, I call that religion — and CBD is currently religion for the average person" (Eisenstein, 2019).

CBD is the major compound contained in cannabis, and the WHO recommends that it should not be listed under the drug conventions. Along with other non-intoxicating compounds contained in C-light, it exerts a plethora of pharmacological effects that make it a highly attractive therapeutic entity in pain, inflammation, diabetes, cancer, autoimmune diseases as well as psychiatric and neurological disorders (Britch et al., 2021). By regulating emotions and emotional memory processing, it has potential for treating many anxiety-related and substance abuse disorders (Lee et al., 2017). It can support the reduction in the use and dependency of tobacco (Morgan et al., 2013), nicotine (Smith et al., 2021), alcohol (Turna et al., 2015), cocaine (Alegre-Zurano et al., 2022), opioids and psychostimulants (Calpe-López et al., 2019; Paulus et al., 2022). Fantozzi (2018) considers C-light as a potential instrument for harm reduction for a population of smokers willing to lower their cigarette consumption, but are not (yet) ready for full cessation, and are not interested in more conventional substitutes (vaporizers or nicotine-based drugs).

While there is a wide therapeutic potential for CBD, its effectiveness remains to be demonstrated for the low-doses found in the non-prescription products sold in the C-light market. Looking at popular websites in seven countries, McGregor et al. (2020) found that almost all of the "maximum dose" products yielded daily doses significantly below those which demonstrated efficacy in clinical trials. In other words, there is no evidence that C-light delivers therapeutic doses. Despite this, the opening of specialized C-light shops has proven to reduce the sales of prescription drugs, especially sedatives (Carrieri et al., 2020). Even the Italian market of illicit cannabis was affected. Based on law enforcement data, Carrieri et al. (2019) found a reduction in the number of seizures of regular cannabis in the provinces where specialized C-light retailers operated. The illicit market is estimated to have suffered a reduction in sales of cannabis and hashish of at least € 160 million annually.

Despite the hype of this market, there is very little published literature on consumers' attitudes and motivations toward C-light consumption. In the US, C-light is more common among individuals using cannabis medically, particularly for pain, anxiety, depression and insomnia. Psychological conditions are more likely to be reported as the leading motivation from younger

users, whereas pain is the most common reason within older C-light consumers (Corroon and Philips, 2018; Wheeler et al., 2020). Through interviews, Fedorova et al. (2021) studied patterns of C-light use among young adults in California using cannabis by dividing the sample based on their relative consumption of CBD and THC products. Compared to THC-dominant users, those using mostly C-light were more likely to report (1) using cannabis medically and having at least one medical condition in the past year; (2) fewer cannabis days and hits per day; (3) more instances per day using non-inhaled cannabis products; (4) microdosing cannabis; (5) using cannabis to relieve pain; and (6) using other licit and illicit drugs, in particular e-cigarettes and psilocybin. The authors consider the consumption of cannabis for CBD-dominant users to be more "responsible, functional, and medicinally oriented" (p.6).

Other scholars have different views and are concerned that C-light users may not be consuming the product responsibly (Wheeler et al., 2020). In their survey, most respondents have experienced at least one unexpected side effect using C-light and reported neither an accurate framework for determining their dosage, nor to be knowledgeable about its legality. The lack of precise dosage is considered extremely problematic in view of the bell-shaped dose-response curve of CBD[109] and the fact that the optimal dosage depends on the specific condition which is treated. The use of other substances – even if not concurrent – is another source of concern given their potential interaction with CBD. Given the widespread use of C-light without prescription, the authors recommend healthcare providers educate their patients on the risk of using it as a replacement for other medications.

Other researchers have observed the introduction of C-light products with modes of administration mimicking tobacco products (Gammon et al., 2021). They are concerned these products could be consumed simultaneously, and may appeal to tobacco users or youth given their candy-like flavors. Indeed, adult cannabis users have significantly higher prevalence of tobacco use than non-users (Hall et al., 2019). Nevertheless, the mechanisms linking cannabis and tobacco use appear to be distinct from those contributing to co-occurring use of the substances (Agrawal et al., 2012; Ramo et al., 2012; Ramo et al., 2013). Schauer et al. (2016) found three major mechanisms for their co-usage of these products: sequential use, substitution and co-administration. Accordingly, tobacco use might increase with cannabis legalization if both cannabis and tobacco are consumed together as a 'spliff', or if cannabis acts as a gateway

[109] For instance, only intermediate doses help lower perceived anxiety (Linares et al., 2019).

for cigarette smoking. On the contrary, the mere experience of smoking may link both cannabis and tobacco as substitutes. All-in all, no evidence of product complementarity was found after the legalization reforms which provide a legal supply alternative. On the contrary, Choi et al. (2018) found a small reduction in tobacco cigarette smoking as a result of the enactment of a medical cannabis reforms in the US. The reduced cost of obtaining cannabis for both medical and recreational use is considered as the major substitution mechanism. Accordingly, cannabis legalization does not appear to generate high rates of cessation, but simply reduces days of smoking or number of cigarettes consumed per day among smokers.

The substitution between cannabis and tobacco may, however, be an outcome of US-specific regulation. In this context, not only cannabis retail channels are separated from those used to purchase tobacco, but 'bundling' of cannabis with nicotine products is also forbidden. On the contrary, tobacco and newspaper shops sell C-light and tobacco products in both Italy and Switzerland and most Swiss users have bought it in tobacco shops (Zobel et al., 2019). In Swiss shops, consumers can even find cigarettes containing a mixture of C-light and tobacco. The majority of C-light consumers declare that they are buying it for smoking. Whether this occurs with or without being mixed with tobacco, C-light is conceivable as a new tool for tobacco cessation strategies.

In Europe, there are currently two published articles which study the consumption pattern of C-light through online surveys. The first was conducted in Switzerland with approximately 1500 users (Zobel et al., 2019). In this study, the major reason for C-light use was related to wellness (e.g. stress, insomnia) and health (e.g. pain, depression, anxiety), despite only 1 out of 6 reporting being diagnosed with a medical condition by a physician. Consumers with health motivations had an older age profile and included respondents who do not trust 'big pharma' and prefer to self-medicate with non-synthetic products. The majority of users reported using regular cannabis, and lowering its consumption was the third major reason behind the decision of consuming light cannabis (between 15 and 22 percent users in the previous month). In parallel, only one out of ten C-light users reported the reduction of tobacco consumption as a main motivation. The second published study was conducted in the UK where C-light can only be purchased in oral form. Moltke and Hindocha (2021) found anxiety, stress, wellbeing and general health, pain and sleep as main indications for its use. While less than 5 percent of respondents used it to counteract the effect of THC, more than 5 percent reported a consequent lower the use of other medications.

5.3. Institutional Framework

In feudal times, fibre hemp[110] production was widespread across Europe, reaching a peak in the seventeenth century due to the demands of the naval industry (Robinson, 1996). Hemp was an easy crop to grow and, exhibiting extremely vigorous growth, rapidly smothered weeds. Following the Single Convention on Narcotic Drugs of 1971, however, cannabis cultivation, possession, and sale became illegal except for its industrial and medical use. In spite of this, hemp production in many European countries has never been prohibited.

To diversify its agricultural base and encourage the production of alternative crops, the EU has been subsidizing its domestic hemp industry since the early 1970s. Hemp is covered by the Common Organization of Agricultural Markets in order to prevent that the market for hemp fibre becomes disturbed by regular cannabis crops. This regulation establishes import and export conditions for hemp and allows hemp to be grown from certificateds seed that offer assurance regarding the content of intoxicating substances in the harvested product (Vantrees, 2002). The genetic diversity within the hemp germplasm available for breeding purposes is therefore limited. Cultivating non-certified hemp seeds or growing hemp without the required national authorization is often illegal and prosecuted. Furthermore, crossing the THC limit makes the cultivated crop illegal[111]. When law enforcement authorities find the output of hemp cultivation exceeding the THC limit, the judicial authority intervenes. Some states, however, support farmers by allowing a greater limit of THC in the raw material compared to what is accepted to be at the retail level, considering the inevitable instability of THC content even in certified seeds (Fortin et al., 2020).

Whereas the boundaries of the legality of the market for hemp fibre and seeds are well-defined, the legal status of the nonstem aerial parts, i.e. leaves and inflorescences, is more controversial. Until recently, this component was regarded to as crop residues. The only exploitable by-product that has been legally accepted is as an additive (i.e. taste enhancing substance) for beers or teas (Lachenmeier and Walch, 2006). Up until few years ago, its high CBD content was not considered by the market as valuable.

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[110] The terms ‘industrial cannabis’, ‘industrial hemp’, and ‘hemp’ are employed as synonyms. In general, whenever the purposes of use for derivatives of cannabis are not related to psychoactivity, it can be called ‘hemp’ (Riboulet-Zemouli, 2020).

[111] The first threshold of THC equivalent to 0.5% was established in 1971; then reduced to 0.3% as from the year 1987/1988; and ultimately decreased at 0.2% from 2001/2002, by CE regulation 1251/1999, art 5 bis. From 1 January 2023, the minimum authorised level of THC in the EU will be 0.3%.

5.3.1. Light cannabis in North America

In the United States, CBD is available in three forms: hemp-derived, cannabis-derived, and pharmaceutical-grade products, but this article will mostly focus on hemp-derived CBD products, as they are no longer considered controlled substances and are the only available product in jurisdictions where cannabis is still illegal. Any food or dietary supplement containing hemp-derived CBD is considered illegal for the Food and Drug Administration (FDA); however, non-prescription CBD products are available in drug stores, through online vendors and in cannabis dispensaries. Given this, the FDA is currently considering the possibility of creating a specific regulatory pathway for such products (Mead, 2019). In contrast, the rules around the trade of C-light are rather clear in Canada, where all cannabis-based products require a federal license for production, distribution and sale. They may be categorized both as "Cannabis for Medical Purposes" and "Non-medical", with producers requiring separate licensing based on the final purpose. Nevertheless, a parallel market also exists for illicit C-light sold by non-licensed firms to consumers who are likely unaware of the lack of compliance of these CBD products (McGregor et al., 2020).

5.3.2. Light cannabis in Europe

Despite the potential of CBD for a range of clinical applications, *Epidiolex*™ is the only prescription medication approved by the European Medicine Agency (EMA) which contains CBD and is used for the treatment of rare forms of epilepsies. Evidence of benefits from other ailments is limited, inconclusive and solely considers treatment using CBD as an isolated compound, rather than in its herbal form (Fedorova et al., 2021). With the exception of its pharmaceutical form, CBD is available in most countries without a prescription. Indeed, the regulation of C-light has been in flux, resulting in a variety of approaches to manage the access to CBD-containing products.

In Europe, the institutional change de facto opening the sales of C-light occurred in Switzerland, when the legal limit separating industrial hemp from regular cannabis was increased[112]. A few years later, Swiss producers started marketing C-light flowers as a tobacco substitute (Zobel et al., 2019). Today, C-light products are offered for open sale in tobacco

[112] The new threshold of 1% is substantially higher than the 0.3% allowed in the EU and in North America. Another European country followed this step: through Act No. 366/2021, Czech Republic became the first EU member to raise the maximum THC limit to 1% following Colombia, Costa Rica, Mexico, Peru and Uruguay (Lachman et al., 2022).

shops, pharmacies, kiosks, specialized retail outlets and online vendors in the majority of EU countries. Sales have taken place based on the claim that these products are derived from industrial hemp varieties that been registered in the EU list and their output has no intoxicating effects. Thus far, Austria, Belgium and Luxembourg are the only EU country who has regulated the C-light market for inhalation as tobacco substitute, while other countries simply down-schedule *Epidiolex*™ without clarifying the classification of C-light products[113]. This change comes as EU member states are in the process of adjusting national regulations to align themselves with conflicting decisions taken from different EU agencies. On one hand, the EU has classified CBD as a novel food, which implies that it was not consumed significantly before 1997. The European Court of Justice has also declared that it is inconsistent to ban only organic CBD, de facto liberalizing the market for C-light (EMCDDA, 2020a). Other EU directives and regulations may apply to C-light products based on their specific nature, such as medicine, food (novel food, food supplements) cosmetics or non-food consumer products[114] (EMCDDA, 2020a). Finally, there may be an intersection of different regulations imposed on C-light, and the confusion around is legal status may lead to repression in some jurisdictions, but not others[115].

5.3.3. Light cannabis in Italy

Italy has a long historical tradition of the cultivation of industrial hemp, and was the second-largest producer in 1940 (Capasso, 2001). The prohibition of hemp cultivation for industrial purposes was banned in 1975. Only 23 years later, its cultivation was re-regulated and eventually supported with EU subsidies for fiber production. In 2017, a new reform increased the legal limit of THC in the field from the EU level of 0.2% to a threshold of 0.6%, de facto opening the Italian market for C-light. While the legislation was effective in removing a substantial layer of red tape[116], it failed to regulate the production and commercialization of the most profitable part of the plant: flowers (Fortin et al., 2020). While not forbidden, C-light products have been sold in specialized shops and across different types of retailers

[113] For instance, Slovakia was the last European country to remove CBD from the country's schedule of controlled substance (HempToday, 2021).
[114] The assessment of the legislation applicable to specific products is a complex process and is carried out on a case by case basis.
[115] For example, CBD products were banned in Cologne, and specialized shops were closed in Reims and Macerata provinces (Bisiou, 2019: McGregor et al.; 2020; Repubblica, 2019).
[116] For instance, when the content of THC overcomes this threshold, the product is subject only to confiscation and destruction as long as the starting material are seeds from certified EU varieties.

inconsistently, through these products use labelling aimed at minimizing the risk of law enforcement rather than ensuring consumer awareness on content and dosage. For instance, flowers are not intended for consumption or inhalation, but just as home fragrance use, products for "collection" or "technical purposes", and thus do not contain any health claims. These disclaimers are considered an attempt to shift responsibility for consumption to the user (EMCDDA, 2020a), as long as a specific regulation is put in place.

5.3.4. Light cannabis in France

Contrary to Italy, France has never completely stopped the cultivation of hemp. It was the first country – along with the Soviet Union - where breeding of hemp plants started in the 1970s (Lachenmeier and Walch, 2006) and French farmers cultivate the largest number of hectares in Europe. The cultivation of hemp is allowed only to use its fibers and seeds and is authorized on the basis of a contract with an authorized transformer through a Common Agricultural Policy file.

Nevertheless, the legal framework related to hemp flower has been extremely ambiguous (Bisiou 2021). Although there is no legislation which explicitly prohibits the commercialization of C-light, the government in its interpretation has excluded any commercialization of CBD extracted from the cannabis plant. In 2018, an inter-ministerial agency introduced strict rules against CBD oil in France and banned any traces of THC. As a result, only synthetic CBD was allowed. In some provinces, public prosecutors were ordering the closure of C-light shops, while in other areas the trade has been operating unhindered. This very restrictive interpretation was contested by several jurisdictions and justified the referral to the EU Court of Justice. The Court stated that CBD is "not a drug within the meaning of the 1961 Convention" (EMCDDA, 2020a, p.14) and should be thus freely traded across the EU, provided it is manufactured legally in the country of origin. As a response, the French government published a decree which prohibits the sale of flowers or raw leaves to consumers alone or in mixture with other ingredients, de facto putting in place a prohibition of C-light that is not transformed[117]. This decision was justified by the inter-ministerial agency only by reasons of public order as it is impossible to distinguish illicit cannabis from C-light for law enforcement without testing the seized flowers[118]. The ban was suspended and then lifted in

[117] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000044793213
[118] https://www.drogues.gouv.fr/actualites/cbd-nouvel-arrete-paru

2022 by the Council of State in view of its disproportionateness to the product's harm and the possibility for law enforcement's to identify C-light using rapid tests (Casanova et al., 2022).

5.3.5. Differences between France and Italian light cannabis market

All in all, there are three major institutional differences which identify the French C-light market compared to the Italian at the time of the study: firstly, the legal THC threshold is lower (0.2% rather than 0.5%) which in turn determines lower levels of CBD in the resulting herbal products (Jikomes and Zoorob; 2018); secondly, the domestic production of C-light flowers has not been liberalized; and thirdly, there is no medical market for CBD products. On one hand, Italians suffering from a medical condition for which CBD may be effective can obtain a physician's prescription and purchase pharmaceutical-grade CBD products in pharmacies, sometimes even with reimbursement. On the other hand, French patients who may benefit from CBD could only obtain this active principle either through the C-light market (which does not manufacture according to pharmaceutical standards) by paying its full price or by purchasing it in pharmacies abroad (e.g. Germany, Italy).

5.4. Material and methods

An anonymous online survey based on a design close to Zobel et al. (2019) was conducted using Google Forms between April 1, 2020 and March 30, 2021 in France and Italy. Ethical approval was given by INSERM Ethics Committee (approval #20-677). A link to the survey was distributed online via media outlets specialized in cannabis-based products, emails of retail shops selling CBD as well as to an online community for people with chronic health conditions (only in France). It was also shared with CBD user groups on Facebook and other social networks. The survey had two inclusion criteria: to be above 18 years old and to have used C-light in the lifetime. The acronym "CBD" or "Cannabis CBD" was used to include all legal products marketed as containing CBD, irrespective of actual CBD content.

The survey collected self-reported characteristics, demographics, frequency of tobacco and cannabis use and pattern of C-light acquisition and use. Questions related to pattern of use included, among other information, delay since first C-light use, number of times using C-light in the last 30 days and principal type of C-light product.

Users answered a question about their primary reason for C-light use in the previous 30 days. Only one answer was allowed from a list of several options. Besides "to substitute other substances", other answers included those related to well-being, treatment of a medical condition, difficulty of finding regular cannabis and curiosity. Those who indicated "to

substitute other substances" were asked four separate follow-up questions to declare which substance they were reducing the consumption of between regular cannabis, tobacco, alcohol and medication. If they declared the substitution of one or more of these substances, they were then asked to report the perceived degree of reduction and the reasons for the substitution (multiple responses allowed). Additionally, those declaring to substitute medicines were also asked to identify which substances they were substituting (multiple responses allowed). People who ticked "for wellness" or "to treat a medical condition" as motivations for CBD use in the last month were then asked which effects were expected (multiple responses allowed). In each investigation on the substitution of C-light on regular cannabis, we excluded respondents who reported to have never used regular cannabis. See appendix 1 for additional details.

The study sample was constituted of respondents who declared using C-light in the previous 30 days and answered the question related to the primary reasons for using C-light. Descriptive statistics are provided for the entire sample. A total of 7646 and 1509 participants in Italy and France, respectively, completed the survey, of which 2608 and 1166 reported to use C-light in the previous 30 days.

5.5. Descriptive Statistics

Table 1 shows the main characteristics for those who have used C-light and for 'current users' who have used C-light within the previous 30 days. Almost all respondents lived in France (98%) and Italy (99%). The sample was predominantly male (76%) who graduated or are currently enrolled in universities or post-secondary degrees. The samples over-represent young adults, compared to the average population in these countries, with a median age of 23 (interquartile range 20-32) years. Given the young age of the sample, most respondents are not employed. Only one-fifth of the sample have prolonged experience with C-light (more than 100 instances of use).

Table 2 shows information related to the consumption of other substances. With the exception of alcohol use – which was only collected systematically for the French sample – the prevalence of use for these substances is higher than among the general population. Less than one out of twenty respondents uses e-cigarettes. Almost every respondent has used regular cannabis, and approximately three quarters have used it in the previous month. Finally, less than one-third of the sample used regular cannabis on a daily basis.

Table 3 illustrates the supply channel for accessing C-light the first time and within the previous month. In the first experience of use, the most common purchase locations were in specialized

shops (45%), from acquaintances (25%), in tobacco shops (12%) or on the Internet (11%). The proportion buying C-light through the Internet increases substantially for current users (39%) which is likely partly due to the difficulty of physically visiting shops due to COVID-19 restrictions. In the previous 30 days, specialized and tobacco shops were used for purchasing C-light for approximately one third (32%) and one out of ten respondents (10%), respectively. In parallel, a significant share of current users decided to cultivate C-light domestically (4%). Other channels identified by respondents were pharmacies, para-pharmacies, herbalists, vending machines and grocery shops.

TABLE 1

Socio-characteristics and life-time use of light cannabis among survey respondents

	Full Sample		Current Users	
	TOT	**FR**	**TOT**	**FR**
Gender				
Male	7034 (76.8)	1045 (69.3)	2839 (76.1)	799 (69.5)
Female	2121 (23.2)	464 (30.7)	890 (23.9)	351 (30.5)
Age (years)				
18-29	6661 (72)	500 (32.6)	2134 (56.5)	340 (29.2)
30-39	1504 (16.3)	497 (32.4)	907 (24)	399 (34.2)
40-49	687 (7.43)	339 (22.1)	478 (12.7)	273 (23.4)
50+	395 (4.27)	197 (12.9)	255 (6.76)	154 (13.2)
Higher education[H]				
No	1488 (16.6)	506 (33.9)	984 (27.2)	370 (33.1)
Yes	7497 (83.4)	986 (66.1)	2630 (72.8)	748 (66.9)
Employment Status				
Without employment	4673 (51.2)	544 (35.1)	1239 (33.4)	339 (29.3)
Employed	4459 (48.8)	1004 (64.8)	2473 (66.6)	819 (70.7)
Life-time CBD use				
Once	996 (11.2)	74 (5)	65 (1.80)	24 (2.1)
2-10 times	3705 (41.6)	348 (23.6)	805 (22.3)	174 (15.5)
11-50 times	1801 (20.3)	312 (21.2)	990 (27.4)	258 (23)
51-100 times	591 (6.64)	151 (10.3)	398 (11)	125 (11.2)
More than 100 times	1803 (20.3)	588 (39.9)	1351 (37.4)	539 (48.1)

Note: Frequencies and percentages (in parenthesis) were used for all categorical data. Current users refer to individuals who declared to have used light cannabis in the previous month.

[H] Higher education was defined as attending third-level education.

TABLE 2

Consumption of other substances in the previous 30 days

	Full sample		***Current users***	
	TOT	**FR**	**TOT**	**FR**
Tobacco use currently	*65.9*	56.6	64.1	54.8
> 5 cigarettes daily	*45.5*	33.8	34.1	31.5
E-Cigarette use currently	*4.6*	6.7	4.4	6.9
Cannabis use ever	*97.3*	87.1	95.5	88.9
Cannabis use currently	*76.4*	54	73.6	51.6
Cannabis use daily	*29.2*	21.9	24.6	18.3
Alcohol use currently		69.3		69.8

Alcohol daily	5.9	5.8

Note: Percentages were used for all categorical data. Current users refer to individuals who declared to have used light cannabis in the previous month. Information on alcohol consumption was not collected systematically in the Italian survey.

TABLE 3

Light cannabis purchase locations

	Full sample		***In the last month***	
	TOT	**FR**	**TOT**	**FR**
Internet	11	38.5	39.1	66.5
Bought/shared with acquaintances	25.3	18.7	11.8	4.8
Specialized shop	45.6	30.9	32.4	20
Tobacco shop	12.5	2.8	10.2	1.4
Domestic Cultivation	1.9	3.1	4.4	3.7
Others	3.7	6	2	3.6

Note: Percentages were used for all categorical data. Current users refer to individuals who declared to have used light cannabis in the previous month.

Table 4 shows the consumption patterns in the previous 30 days. Over half of study sample had consumed C-light more than 10 days per month, whereas about one-third had used C-light for at least 20 of the previous 30 days. The most common modes of consumption were smoking (80%), inhaling through a vaporizer (7%) and ingesting CBD oil sublingually (6%). Dried flowers are the primary C-light product smoked by respondents (91%), whereas trim[119] and resins are smoked by approximately 4% of respondents. The modes of consumption are significantly different among French respondents, with a greater proportion using sublingual oils (18%) and e-cigarettes (4%).

TABLE 4

Light cannabis use patterns in the previous 30 days

Days of consumption	**TOT**	**FR**
1-9	47.3	31.5
10-19	18.4	18.6
20-30	34.2	49.9
Primary mode of light cannabis use		
Smoking	80.6	60.7
Sublingual oil	5.7	18.5
Inhalation	6.8	10.6
Other (e-liquid, foodstuffs, etc.)	6.8	10.2
Light cannabis products smoked		
Flowers (or inflorescence)	91.2	93.9
Trim (chopped inflorescence and leaves)	4.3	2.6
Resin	4.2	3.4
Others (wax, etc.)	0.3	0.1

[119] After harvest, the cannabis plant is trimmed of its leaf matter to remove excess plant material and leave behind only the flowers. Trim refers thus to the leftover leaves, which can be used for making transformed products or sold directly to consumers.

Note: Percentages were used for all categorical data.

TABLE 5

Motivations for light cannabis consumption (first-use and in the last month)

	First-time		***In the last month***	
	TOT	**FR**	**TOT**	**FR**
Curiosity and Taste				
For curiosity	10.2	27.2	3.53	1.89
Taste and pleasure	15	17.7	3.63	2.92
Motivations related to regular cannabis				
Difficulty finding regular cannabis	11.7	18.8	26.4	9.3
To consume cannabis legally	5.81	12.5	10.7	6.8
To avoid the effects of regular cannabis	11.5	3.70	4.00	6.79
To obtain the effects of regular cannabis	0.59	2.38	2.99	0.86
To save money on regular cannabis			4.53	6.27
Wellness and health reasons				
Wellness	10.8	6.55	21	26.7
To treat my illness or to reduce its symptoms	23.6	6.05	10.4	25.2
To substitute other substances	7.57	3.05	11	12.4
Other Motivations				
To re-use the container	0.13	0.23	0.1	0
Others	3.1	1.84	1.72	0.9

Note: Percentages were used for all categorical data.

TABLE 6

Substitution effects of CBD with other substances on the first use

	Full sample		***Current users***	
	TOT	**FR**	**TOT**	**FR**
Reduce or stop alcohol				
Desired effect	5.15	3.26	5.05	3.2
Obtained effect	16.1	9.32	15	9.4
Reduce or stop tobacco				
Desired effect	11.7	8.85	9.99	8.1
Obtained effect	29.4	21.6	29	21.6
Reduce or stop other medications				
Desired effect	7.99	8.54	7.73	7.9
Obtained effect	26.6	32.5	30	34.4
Reduce or stop regular cannabis				
Desired effect	10.8	8.54	10.5	8.27
Obtained effect	16.4	21	17.9	21.6
Reduce or stop other substances				
Desired effect	0.75	1.24	1	1.5
Obtained effect	2.39	4.5	3.1	4.9

Note: Percentages were used for all categorical data. The sample only includes respondents using light cannabis for wellness and health reasons. Current users refers to individuals who have declared to using light cannabis in the previous month. 'Desired effect' refers to those individuals who started using light cannabis to reduce the consumption of other substances, but have not obtained the desired effect.

Table 5 shows how the primary motivation to initiate and currently consume C-light depends partly on the institutional framework. The six most-cited primary reasons to initiate C-light use were "for curiosity, taste or pleasure" (25%), "to treat my disease or reduce associated

symptoms" (24%), "because I had difficulties obtaining regular cannabis" (12%), "to avoid the effects of THC" (11.5%), "for my well-being" (11%) and "to substitute other substances" (7.5%). The connection with regular cannabis is more marked among current users, as the pandemic made its access more difficult. "Difficulty to find regular cannabis" became the primary reason (26%), while the other most-cited motivations to currently consume C-light were "for my wellbeing" (21%), "to substitute other substances" (11%), "to consume cannabis legally" (10.7%) and "to treat my disease or reduce associated symptoms" (10.4%).

Table 5 shows that a substantial proportion of the sample uses CBD for health reasons. Among those who reported the primary reason for initiating use as well-being or to treat a medical condition, we have analysed which substances they wanted to substitute and the medical condition for which they are seeking treatment (multiple responses allowed). Respondents who initiated use of C-light for a specific effect could report wheter or not their desired effects were obtained. Table 6 shows that the most-cited substances which were expected to be reduced when initiating C-light use were tobacco (41%), medications (34%), regular cannabis (27%) and alcohol (21%). Only about one out of 30 respondents initiated the use of C-light to substitute other psychoactive substances (3%), in line with the lower prevalence among the population using these illicit drugs.

5.5.1. Mechanisms behind the substitution effect

The respondents who used C-light in the previous month primarily to substitute other substances were asked two additional questions: (1) to what extent C-light had an impact on their substance use reduction; and (2) which CBD-related effects were involved in reducing the use of the substance (multiple responses allowed). More than 9 out of 10 of the respondents reported that C-light have been effective in reducing the consumption of tobacco and cannabis.

Table 7 show the mechanisms involved in the lowering the consumption of regular cannabis and tobacco with C-light. The most frequency cited C-light effects for the former were "reducing cannabis withdrawal symptoms", "using less regular cannabis in joints" and "delaying first regular cannabis joint of the day". Other cited mechanisms include "saving money on regular cannabis", "increasing the time between smoking joints", "better taste", "lowering of the amount of regular cannabis consumed during working hours" and "perceiving C-light as less adulterated". Other respondents mentioned other mechanisms such as (1) the similarities in term of habits and rituals which occur with the consumption of regular cannabis, but without issues in terms of addiction or psychoactive effects; (2) the purchase of a vaporizer

to consume CBD; (3) the similar taste; and (4) the balancing of the THC effect in the joint with the reduction of the THC:CBD ratio.

The mechanisms for lowering the consumption of tobacco were also multiple, namely its "better taste" and "lack of adulterants" compared to tobacco, "reducing tobacco withdrawn symptoms", "using less tobacco in joints", "lowering the *heavy lung* sensation" and "saving money on tobacco". The greatest differences in terms of mechanisms of substitution between those using C-light to reduce tobacco use and those who use it to reduce the use of regular cannabis were the perception that C-light contains less adulterants (more common among those substituting tobacco) and has a better taste (more common among those substituting tobacco).

The major mechanism for lowering the use of medications (multiple response possible) was also "reducing medication withdrawal symptoms" (42%). Similar importance in the choice of using C-light to reduce the use of other medications was its perceived efficacy for treating their medical condition (42%) and its lower side effects (40%). The ability to purchase C-light (15%) and its lower costs compared to their medications (10%) were only minor reasons reported by respondents who substitute medications with C-light.

The respondents who used C-light in the previous month primarily to substitute prescription drugs were asked an additional question regarding which medications they were substituting (multiple responses allowed). The five most-cited medications were anti-inflammatory (55%), analgesics (51%), muscle relaxants (50%), anxiolytics and hypnotics (44%), and anti-depressants or psychostimulants (40%).

TABLE 7

Mechanisms to lower the consumption of tobacco and regular cannabis with CBD

	Tobacco		***Regular Cannabis***	
In common	**TOT**	**FR**	**TOT**	**FR**
Reduction of abstinence symptoms	41.5	39.2		43.9
Better taste	46.1	39.2	13.7	11.2
More natural (lack of adulterants)	52.6	38.2	9.7	15.9
Lower consumption of joints	28.6	31.4	25.2	21.5
Saving money	17.2	23.5	20.8	19.6
Substance-specific				
Lower heaviness in the lungs	37.5	24.5		
Delaying the day's first joint consumption			23.9	24.3
More time is spent between joints			14.1	16.8
Lower consumption at work			11	10.3

Note: Percentages were used for all categorical data. Information on the "reduction of abstinence symptoms related to regular cannabis" were not collected systematically in the Italian survey.

5.5.2. Health conditions

Expected effects of C-light among users declaring health motives are given in Appendix table 1. As in table 6, the study group was constituted by respondents who reported initiating C-light for wellness or for treatment of a medical condition. The majority of the study population expected multiple effects, but the most cited were reducing stress (72%), improving sleep (75%), relieving pain/inflammation (67%) and treating anxiety, depression and other mood disorders (56%). Interestingly, the treatment of migraine and headache was the fifth most cited expected effect (52%), and was not included by Zobel et al. (2019). The decision to include this effect was driven its high reported frequency in the Italian survey[120]. Interestingly, there were also a number of productivity-related effects expected by users, such as increasing energy (27%) and concentration (34%). Other expected effects were the management of nausea and vomiting (21%), treating injuries (10%) or skin problems (12%) and reducing appetite (8%).

One out of four of the respondents who initiated C-light use for health reasons was treating the symptoms of a condition diagnosed by a physician. When the decision to initiate C-light is advised by a specialist, individuals are also more likely to continue its use. Indeed, this is the only effect which is more statistically prevalent among current C-light users than among those who did not consume C-light in the previous 30 days. Moreover, this is also the only effect that is more prevalent among among French respondents compared to Italian respondents. The larger proportion of those using C-light under physician advisement is likely driven by the illicit status of medical cannabis in France at the time of the survey administration.

5.6. Econometric model and results

Our goal here is to study the differences across C-light users regarding the likelihood to substitute a specific substance. We do not explicitly model the details of competition between substances based on monetary cost. Instead, we use a parsimonious specification to examine how the likelihood to substitute a substance responds to differences between consumers characteristics, supply channels and patterns of consumption.

We proceed in three steps. First, we investigated which determinants affect the likelihood to initiate the use of C-light to substitute other substances. We performed a probit regression with 'initiating C-light for substance use reduction' as an outcome and socio-demographic

[120] For some questions, respondents could write an alternative response if no option matched. As responses related to migraines and headache were very common, it was decided to add this motivation with the other multiple choice.

characteristics, patterns of consumption and supply channels as explanatory variables. As countries have substantially different institutional framework and market maturity, we only discuss the association between explanatory variables that are significant for the entire sample and at least one of the two sub-samples (appendix tables 2-3). Second, we examine the probability that a C-light consumer substitutes one or more substances in the previous 30 days. Compared to the regression on C-light initiation, we add dummies to distinguish across type of products (e.g. flowers, sublingual oils) and mode of consumption (inhaling) to see whether they are associated with the reduction of substances. Although there is an association between the outcome and several explanatory variables, there is considerable unexplained variance. This indicates that patterns of consumption, specific for different sub-products, play an important role. Accordingly, the empirical analysis is concluded with an estimation of how smoking C-light influences the likelihood of reducing the consumption of tobacco and regular cannabis.

5.6.1. Initiation with light cannabis to substitute other substances

In table 8, we perform logistic regressions to explain the factors associated with the initiation of C-light as a substitute for one or more substances (=outcome). The study sample was constituted of respondents who declared using C-light at least once and answered the question related to primary reason for initiating C-light use. Among the 9,155 respondents who have used C-light in their lifetime, 7,921 answered the question related to the primary reason why they use C-light and other covariates. Among these, 7,619 have reported lifetime regular cannabis use. The outcome was associated with being a woman (particularly for regular cannabis and medications), older age (particularly for medications and alcohol), being employed (particularly for tobacco and medications), being overweight (particularly for medications) and earning a low income. Smoking up to five cigarettes per day (low intensity) is positively associated with initiating C-light for reducing the use of regular cannabis, tobacco and alcohol.

Regarding supply channels, substituting alcohol and medications with C-light is negatively associated with purchasing C-light in a tobacco shop for first time use. Conversely, the association is positive for those who initiate C-light by (1) buying online (except for alcohol); (2) buying on shops specialized in C-light products (particularly for tobacco); and (3) cultivating it domestically. Finally, the r-squared tends to be the highest for the substitution of medications. As a robustness check, appendix table 2 shows the result of the regression for the two countries separately.

5.6.2. Using light cannabis as a substitute in the previous 30 days

Table 6 showed that the intention to reduce the use of substances with C-light occurs with different magnitudes for tobacco, alcohol, medications and regular cannabis. In table 9, we perform logistic regressions to explain the factors associated to C-light use as a substitution for any drugs or for a specific substance in the previous 30 days (outcome). The study sample was constituted of respondents who declared using C-light in the previous 30 days and answered the question related to primary reason to use C-light. Among the 3,772 respondents who have used C-light in the previous 30 days, 3.021 answered the questions related to the primary reason and other covariates. Among these, 2,843 reported lifetime regular cannabis use.

Respondents could report use of C-light to substitute more than one substance at the same time. Overall, using C-light to reduce the use of regular cannabis or alcohol increases the likelihood of substituting tobacco as well. Respectively, 64% and 75% of those substituting regular cannabis and alcohol with C-light were also reducing the consumption of tobacco. Conversely, only 9% and 11% of those reporting to not substitute regular cannabis or alcohol were also substituting tobacco. This outcome was associated with being a woman (only for alcohol), older age (especially for medications), being employed (only for medications), and earning a low income (only for tobacco and alcohol). Finally, those who report to be overweight are less likely to have used C-light to substitute regular cannabis in the previous month.

The usage patterns of C-light, regular cannabis, tobacco and alcohol in the previous month are included as a control and affect the likelihood to use C-light as a substitute. The outcome is associated with smoking tobacco with low intensity (especially for regular cannabis and tobacco) and with high intensity (except for alcohol), using regular cannabis daily (only for tobacco), days of C-light use in a month (especially tobacco and medications) and monthly expense on C-light (except for alcohol).

Regarding the specific means of consumption, those who report to inhale C-light (excluding those who vaporize e-liquid) are less likely to use it to substitute regular cannabis. The substitution of other drugs through sublingual oils is substance-specific: it is more likely to reduce the use of medications, but less likely to substitute tobacco and regular cannabis compared to inhalable products (flowers, trim and resins). Other types of C-light products (i.e. e-cigarettes, tinctures, foodstuffs) are more likely to be used to substitute medications. Finally, there is a positive association between the user satisfaction in terms of effect with the likelihood

to substitute other substances: its marginal effect is the highest for tobacco and the lowest for alcohol.

As a robustness check, appendix table 3 shows the result of the regression for the two countries separately. With the exception of medications (0.17), the explanatory power of the regressions (measured by the R-square) with the covariates for the substitution of any substance is very low. This suggests that, even after controlling for demographics, supply channels, patterns of use of C-light and other substances, there is a great deal of variation in the profile of respondents who decide to use C-light to substitute regular cannabis, tobacco, alcohol and medications.

5.6.3. Smoking light cannabis to substitute regular cannabis and tobacco

In table 10, we perform logistic regressions to explain the factors associated to C-light use as a substitution for any drug or for a specific substance in the previous 30 days (outcome) by only looking at those who smoke C-light. We added new covariates to explain whether specific factors related to its combustion affect the likelihood to substitute other substances. This subgroup is interesting, not only as smoking C-light is the most prevalent form of cannabis used in both samples, but also because this segment is the most likely to reduce the consumption of regular cannabis and tobacco. The results confirmed the positive association of some of the explanatory variables used in table 10. The study sample was constituted of respondents who declared smoking C-light in the previous 30 days and answered the question related to primary reason for using C-light. Among the 3,007 respondents who have smoked C-light in the previous 30 days, 2,276 answered the question related to the primary reason why they have used it and other covariates. Among these, 2,235 have reported lifetime regular cannabis use.

The outcome is associated with smoking with low intensity, monthly spending on C-light, drinking alcohol, days of use (for Italian tobacco smokers), being overweight (only for regular cannabis), and satisfaction with the effect of C-light. There are also new associations: being female is positively associated with smoking C-light to reduce the consumption of regular cannabis (in France), whereas there is a negative association with earning a high income (for regular cannabis), being employed (in France) and being overweight. Interestingly, using a substance at the intensive margin is associated only with reducing the consumption of this substance: daily use of regular cannabis is associated with C-light substitution, whereas being an intensive tobacco smoker is associated with substituting tobacco with C-light.

The supply channels used for the purchase of C-light appear to affect the likelihood to reduce the use of substances. Compared to online purchase, accessing C-light in a tobacco shop is negatively associated with reducing regular cannabis use, but positively associated with reducing the use of tobacco (in France)[121]. In parallel, specialized shops are positively associated with the substitution of tobacco with C-light (in France).

Turning to combustion-related covariates, *both* the portion of C-light used in the joint *and* trim are positively associated with consuming C-light to reduce the use of tobacco. In parallel, the number of varieties consumed in the last month increases the likelihood of reducing the consumption of regular cannabis with C-light in the French sample. Conversely, the combination of regular cannabis with C-light is negatively associated with the likelihood of using C-light as a substitute. In other words, if we divide the group of those smoking C-light without regular cannabis and those who include regular cannabis in the joint, the probability of using C-light to stop regular cannabis for the second group would be 30 percentage points higher.

To conclude, among those using C-light to substitute regular cannabis, about one out of four (26%) have not used the substance in the previous month. For those who used C-light to reduce tobacco, about one on six (15%) have not used either tobacco or e-cigarettes in the previous 30 days.

TABLE 8

Logistic regression on factors associated with initiating C-light to substitute other substances

	Any	**THC**	**Tobacco**	**Medications**	**Alcohol**
Constant	-2.280***	-2.488***	-2.106***	-2.778***	-2.268***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Female	0.210***	0.134**	0.054	0.366***	0.041
	[0.000]	[0.035]	[0.325]	[0.000]	[0.549]
Age	0.019***	0.013***	0.007***	0.021***	0.006**
	[0.000]	[0.000]	[0.002]	[0.000]	[0.015]
High income	0.181***	0.207**	0.188***	0.024	0.125
	[0.003]	[0.010]	[0.006]	[0.754]	[0.143]
Low income	0.204***	0.208***	0.227***	0.130**	0.180***
	[0.000]	[0.000]	[0.000]	[0.019]	[0.003]
Employed	0.200***	0.135**	0.137**	0.252***	0.023
	[0.000]	[0.039]	[0.016]	[0.000]	[0.756]
Underweight	0.044	-0.008	0.023	-0.012	-0.094
	[0.597]	[0.940]	[0.806]	[0.907]	[0.457]
Overweight/obese	0.097**	0.064	0.048	0.184***	0.127*
	[0.046]	[0.332]	[0.401]	[0.002]	[0.061]
Light tobacco smoker	0.039	0.151**	0.175***	-0.001	0.167**

[121] This result may be biased in view of the non-representative number of French C-light users purchasing in tobacco shops (16 observations).

	[0.441]	[0.022]	[0.002]	[0.987]	[0.016]
Heavy tobacco smoker	-0.068	0.030	0.065	-0.093	0.064
	[0.148]	[0.639]	[0.232]	[0.113]	[0.341]
Previous-month THC user	-0.086*	-0.010	0.039	-0.180***	0.012
	[0.089]	[0.884]	[0.525]	[0.003]	[0.877]
Daily THC user	-0.125**	-0.069	0.058	-0.188***	-0.052
	[0.023]	[0.357]	[0.373]	[0.005]	[0.522]
Online	0.559***	0.512***	0.311***	0.447***	0.110
	[0.000]	[0.000]	[0.000]	[0.000]	[0.244]
Specialized shops	0.155***	0.055	0.120**	0.038	0.070
	[0.002]	[0.392]	[0.027]	[0.540]	[0.290]
Tobacco shop	-0.154*	-0.225**	-0.182**	-0.339***	-0.262**
	[0.056]	[0.041]	[0.040]	[0.004]	[0.023]
Self-grown CBD	0.591***	0.411***	0.551***	0.402***	0.447***
	[0.000]	[0.009]	[0.000]	[0.007]	[0.004]
Observations	7.921	7.610	7.921	7.921	7.921
R^2	0.090	0.057	0.031	0.135	0.023
Log-likelihood	-2.486	-1.306	-1.867	-1.469	-1.134
Marg effect female	0,035			0.030	
Marg effect age	0.003			0.002	0.0004
Marg effect low income	0.034	0.176	0.028	0.011	0.005
Marg effect employed	0.036		0.018	0.024	
Marg effect overweight	0.017			0.017	0.009
Marg effect light tobacco smoker		0.013	0.021		0.012
Marg effect online	0.092	0.042	0.037	0.037	
Marg effect specialized shop	0.026		0.014		
Marg effec tobacco shop				-0.028	-0.018
Marg effect self-grown	0.098	0.034	0.066	0.034	0.031

Notes: P-values are in brackets below estimated coefficients. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively. Coefficient estimates are generated by probit regression model. All estimates for marginal effects were calculated using the mean values for the independent variables, but are reported only if the factor is significant in at least one of the national sample. Income level was self-reported as subjectively assessed as compared to an "average level" estimated by the participants. Body mass index was calculated as the body weight (in kg) divided by the squared height (in m). A body mass index over 25 kg/m2 denotes overweight or obesity.

TABLE 9

Logistic regression on factors associated with substituting CBD for other substances

	Any	**THC**	**Tobacco**	**Medications**	**Alcohol**
Constant	-1.707***	-2.239***	-1.929***	-2.822***	-1.997***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Female	-0.032	0.010	-0.130*	0.128	-0.310**
	[0.620]	[0.911]	[0.085]	[0.143]	[0.012]
Age	0.005*	0.001	0.001	0.007*	0.004
	[0.088]	[0.835]	[0.644]	[0.055]	[0.352]
High income	0.026	-0.017	0.008	0.074	0.021
	[0.753]	[0.873]	[0.932]	[0.516]	[0.866]
Low income	0.088	-0.019	0.116*	0.122	0.169*
	[0.148]	[0.808]	[0.083]	[0.158]	[0.074]
Employed	0.093	0.038	-0.080	0.225**	-0.169
	[0.177]	[0.673]	[0.311]	[0.011]	[0.142]
Underweight	0.016	-0.073	0.095	0.008	0.027
	[0.895]	[0.647]	[0.472]	[0.965]	[0.898]
Overweight/obese	-0.043	-0.244***	-0.090	0.027	0.039
	[0.510]	[0.007]	[0.224]	[0.761]	[0.696]
Light tobacco smoker	0.312***	0.289***	0.468***	0.138	0.151

	[0.000]	[0.001]	[0.000]	[0.188]	[0.148]
Heavy tobacco smoker	0.177***	0.196**	0.250***	0.268***	-0.155
	[0.009]	[0.027]	[0.001]	[0.004]	[0.151]
Previous-month THC user	0.018	0.078	0.175**	-0.058	0.151
	[0.792]	[0.378]	[0.027]	[0.535]	[0.194]
Daily THC user	0.048	0.089	0.180**	-0.076	0.141
	[0.536]	[0.374]	[0.040]	[0.474]	[0.259]
Specialized shop	-0.053	-0.120	0.082	-0.040	0.212**
	[0.377]	[0.118]	[0.215]	[0.627]	[0.023]
Tobacco shop	-0.236**	-0.359**	-0.056	-0.802***	0.147
	[0.020]	[0.011]	[0.605]	[0.003]	[0.346]
Self-grown CBD	0.208	0.086	0.357**	0.256	0.471**
	[0.146]	[0.646]	[0.021]	[0.160]	[0.022]
Sublingual oil user	0.223*	-0.354*	-0.413***	0.696***	-0.026
	[0.054]	[0.074]	[0.010]	[0.000]	[0.901]
Vaporization	-0.047	-0.263*	-0.005	0.160	-0.008
	[0.672]	[0.097]	[0.966]	[0.273]	[0.961]
Other CBD products	0.106	0.061	0.023	0.376***	-0.036
	[0.352]	[0.698]	[0.862]	[0.007]	[0.850]
Three months experience	0.046	0.117	0.075	0.033	-0.082
	[0.477]	[0.186]	[0.311]	[0.730]	[0.425]
Days of use CBD	0.012***	0.008**	0.009***	0.014***	0.001
	[0.000]	[0.040]	[0.005]	[0.000]	[0.884]
High budget	0.149**	0.157*	0.184***	0.093	0.304***
	[0.019]	[0.061]	[0.009]	[0.308]	[0.003]
Labeling satisfaction	0.025	0.150*	0.050	-0.021	-0.041
	[0.689]	[0.074]	[0.467]	[0.812]	[0.675]
Taste satisfaction	0.027	0.131	-0.034	0.036	-0.012
	[0.662]	[0.105]	[0.621]	[0.681]	[0.903]
Effect satisfaction	0.461***	0.509***	0.414***	0.571***	0.229**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.020]
Observations	3.021	2.843	3.021	3.010	3.021
R^2	0.069	0.077	0.059	0.172	0.047
Log-likelihood	-1.466.774	-809.036	-1.137.083	-660.366	-484.205
Marg effect female					-0.023
Marg effect age	0.001				
Marg effect low income			0.024		
Marg effect employed				0.023	
Marg effect overweight		-0.032			
Marg effect light tobacco sm.	0.087	0.04	0.96		
Marg effect heavy tobacco sm.	0.046	0.025	0.45	0.025	
Marg effect daily THC user			0.035		
Marg effect days of use CBD	0.003	0.001	0.002	0.001	
Marg effect sublingual oils		-0.04	-0.067	0.1	
Marg effect vaporization		-0.032			
Marg effect other CBD products				0.042	
Marg effect specialized shop					0.016
Marg effect tobacco shop				-0.074	
Marg effect self-grown CBD	0.067		0.078		0.040
Marg effect high budget		0.022	0.036		0.022
Marg effect effect labeling		0.021			
Marg effect effect satisfaction	0.129	0.073	0.084	0.053	0.017

Notes: P-values are in brackets below estimated coefficients. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively. Coefficient estimates are generated by probit regression model. All estimates for marginal effects were calculated using the mean values for the independent variables, but are reported only if the factor is significant in at least one of the national samples. Income level was self-reported as subjectively assessed as compared to an "average level" estimated by the participants. Body mass index was calculated as the body weight (in kg) divided by the squared height (in m). A body

mass index over 25 kg/m2 denotes overweight or obesity.

TABLE 10
Logistic regression on factors associated with substituting CBD for regular cannabis or tobacco in the sub-population of light cannabis smokers

	Regular Cannabis			**Tobacco**		
	Any	IT	FR	Any	IT	FR
Constant	-1.960***	-2.118***	-3.079***	-2.045***	-1.921***	-3.079***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Female	0.080	0.021	0.284*	-0.078	-0.083	-0.020
	[0.410]	[0.870]	[0.075]	[0.379]	[0.436]	[0.904]
Age	-0.002	-0.004	-0.012	0.002	-0.002	0.006
	[0.624]	[0.537]	[0.148]	[0.548]	[0.726]	[0.374]
High income	-0.055	-0.485**	-0.054	0.024	-0.002	0.015
	[0.642]	[0.030]	[0.750]	[0.820]	[0.988]	[0.931]
Low income	-0.051	-0.116	0.021	0.122	0.108	0.205
	[0.573]	[0.336]	[0.891]	[0.110]	[0.230]	[0.168]
Employed	-0.022	0.091	-0.365**	-0.081	0.050	-0.386**
	[0.832]	[0.526]	[0.024]	[0.382]	[0.665]	[0.016]
Underweight	-0.020	-0.259	0.138	0.035	0.017	0.083
	[0.911]	[0.278]	[0.628]	[0.814]	[0.923]	[0.776]
Overweight/obese	-0.202*	-0.162	-0.242	-0.075	0.050	-0.312**
	[0.050]	[0.267]	[0.105]	[0.383]	[0.629]	[0.034]
Light tobacco smoker	0.205**	0.331**	0.112	0.381***	0.355***	0.446***
	[0.034]	[0.015]	[0.481]	[0.000]	[0.001]	[0.007]
Heavy tobacco smoker	0.121	0.206	0.020	0.192**	0.142	0.289*
	[0.224]	[0.155]	[0.898]	[0.027]	[0.176]	[0.080]
Last-month THC user	0.131	0.055	0.365**	0.177**	0.118	0.286**
	[0.190]	[0.711]	[0.015]	[0.047]	[0.324]	[0.049]
Daily THC user	0.116	0.055	0.385**	0.171*	0.156	0.150
	[0.326]	[0.748]	[0.039]	[0.092]	[0.234]	[0.397]
Alcohol user			0.570***			0.365**
			[0.000]			[0.018]
Specialized shop	-0.089	0.120	0.019	0.110	0.059	0.300*
	[0.292]	[0.301]	[0.915]	[0.141]	[0.506]	[0.064]
Tobacco shop	-0.294**	-0.051	0.614	0.002	-0.058	0.975***
	[0.044]	[0.772]	[0.138]	[0.983]	[0.645]	[0.008]
Self-grown CBD	0.220	0.354	0.444	0.155	0.250	0.033
	[0.354]	[0.276]	[0.257]	[0.500]	[0.339]	[0.941]
Three months experience	0.149	0.220	0.012	0.068	0.094	0.016
	[0.126]	[0.121]	[0.937]	[0.418]	[0.353]	[0.921]
Days of use CBD	0.006	0.008	-0.001	0.010***	0.009**	0.009
	[0.144]	[0.179]	[0.883]	[0.009]	[0.035]	[0.183]
High budget	0.264***	0.061	0.551***	0.226***	0.185*	0.405**
	[0.006]	[0.613]	[0.002]	[0.007]	[0.060]	[0.019]
Price	-0.004	-0.066	0.001	-0.001	-0.001	0.000
	[0.231]	[0.385]	[0.759]	[0.740]	[0.785]	[0.961]
CBD dosage	-0.094	0.080	-0.128	0.087	0.117*	0.081
	[0.141]	[0.372]	[0.222]	[0.111]	[0.085]	[0.430]
Mixed with substance	-0.204**	-0.021	-0.493**	-0.014	-0.027	-0.094
	[0.029]	[0.850]	[0.016]	[0.836]	[0.735]	[0.526]
Trim user	0.253	0.319	0.367	0.248	0.343*	-0.020
	[0.219]	[0.195]	[0.378]	[0.154]	[0.078]	[0.961]
Hash user	-0.394	-0.267	-0.144	-0.044	-0.057	0.270
	[0.121]	[0.404]	[0.738]	[0.805]	[0.773]	[0.505]
#Varieties used	0.023	-0.101	0.290*	-0.069	-0.080	0.010
	[0.810]	[0.399]	[0.099]	[0.399]	[0.394]	[0.955]
Effect satisfaction	0.632***	0.614***	0.589***	0.479***	0.490***	0.478***

	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
Observations	2.235	1.636	592	2.276	1.666	603
R^2	0.091	0.089	0.114	0.059	0.059	0.099
Log-likelihood	-653.245	-337.847	-264.560	-884.507	-615.268	-253.980
Marg effect female			0.072			
Marg effect high income		-0.03				
Marg effect employed			-0.085			-0.082
Marg effect overweight	-0.027					-0.067
Marg effect light tobacco sm.	0.029	0.027		0.08	0.07	0.101
Marg effect heavy tobacco sm.				0.035		0.06
Marg effect last-month THC			0.09	0.034		0.067
Marg effect daily THC user			0.096			
Marg effect alcohol user			0.145			0.085
Marg effect days of use CBD				0.002	0.002	
Marg effect CBD dosage					0.023	
Marg effect mixed with subst,	-0.3		-0.125			
Marg effect trim user					0.07	
Marg effect #varieties used			0.074			
Marg effect specialized shop						0.07
Marg effect tobacco shop	-0.043					0.228
Marg effect high budget	0.038		0.122	0.047	0.037	0.086
Marg effect effect satisfaction	0.092	0.051	0.15	0.101	0.098	0.11

Notes: P-values are in brackets below estimated coefficients. *, **, and ***indicate significance at the 90%, 95%, and 99% levels, respectively. Coefficient estimates are generated by probit regression model. All estimates for marginal effects were calculated using the mean values for the independent variables. Income level was self-reported and subjectively assessed as compared to an "average level" estimated by the participants. Body mass index was calculated as the body weight (in kg) divided by the squared height (in m). A body mass index over 25 kg/m2 denotes overweight or obesity.

5.7. Discussion

In a large convenient sample of French and Italian C-light users (7921 and 3774 lifetime and previous-month users, respectively), we found that the substitution of other substances was the reason for using C-light for more than one out of five previous-month users (21%), and the primary reason for half of these users (11%). Moreover, consuming C-light to reduce the use of other substances is associated with different socio-demographic characteristics, modes of C-light use, or preferred supply channel – according to which substance is substituted with C-light.

To the best of my knowledge, this is not only the first survey that analyses C-light users in France and Italy, but also the first which specifically investigates the substitution effect of C-light on other substances.

5.7.1. Socio-demographic and physical characteristics

Gender predicts different likelihoods of reducing substances with C-light, depending on the specific substance that is substituted. Women are more likely to initiate C-light to substitute substances and, in particular, to reduce the consumption of medications. When we consider current users, however, females have a higher likelihood of smoking C-light to substitute

regular cannabis, but are less likely to reduce alcohol. Other studies on C-light use are inconclusive regarding the association between gender and the use of C-light. In the UK, Moltke and Hindocha (2021) found that females were less likely to declare use for general health and well-being, whereas we do not find such a difference in France (Fortin et al., 2021).

Age is positively associated with substance substitution. Older respondents are more likely to initiate C-light and currently use it for lowering the use of medications. This result is consistent with the results obtained in the Swiss study (Zobel, 2019) where individuals using it for health-related motivations had an older age profile, and in the UK (Moltke and Hindocha, 2021) where those aged more than 55 were more likely to substitute medications compared to younger generations. This finding is likely due to the higher prevalence of medical conditions among older individuals.

Turning to the economic characteristics, the positive association between low income and initiating C- light to reduce substance use loses significance when we look at current C-light consumption (in the previous 30 days). Only the reduction of tobacco is still associated with low income, but this is only significant in France. This may be driven by the higher corrective tax applied on cigarettes in the country, which leads respondents to cut tobacco-related expenditures through C-light. This finding is somehow unexpected, given the reduced probability for lower socioeconomic status to stop smoking following reforms aimed at discouraging this behaviour (Pinilla and Abasolo, 2017). Overall, the provision of financial assistance to obtain C-light as a substance cessation tool is likely to stimulate its reduction among low income individuals (van den Brand et al., 2017).

Similarly, unemployment is negatively associated with initiating C-light to decrease the use of other substances, especially tobacco and medications. Looking at previous-month C-light users, students and those who are unemployed have a substance-dependent association with C-light: higher likelihood of reducing tobacco and regular cannabis use, but lower likelihood of reducing medication use. This opposite direction may be due to the stigma associated with smoking C-light – the most common mode of consumption for those reducing tobacco and regular cannabis – compared to using sublingual oils to reduce medications, particularly when consuming it in a working environment.

Among the overweight respondents, there is a higher probability of using C-light to reduce the consumption of substances, but mostly to reduce the use of medications. This may be interpreted in two ways: people experiencing overweight and obesity are more likely to suffer

sleep and mood disorders and may be affected by comorbidities (e.g; hypertension, diabetes etc). This overmedication may increase the toxicity burden and quality of life of this group. C-light may then be used to reduce the side effects of specific medication, improve mood and sleep, reduce anxiety and ultimately reduce food cravings, which is associated with the latter (Cavalheiro et al., 2021). Among C-light smokers, there is a negative association between being overweight and reducing regular cannabis use. Two hypothesis can be made to explain such an association. They may find cannabis useful to manage some symptoms related to being overweight. Alternatively, this association may derive from the lower prevalence of overweight and obesity among young adult cannabis users (Hayatbakhsh et al., 2010).

5.7.2. Patterns of use and product preferences

Among C-light users, the patterns of use of tobacco and regular cannabis appear interconnected with their current substitution. On one hand, using C-light to reduce regular cannabis is associated with tobacco smoking; on the other hand, using regular cannabis is associated with the reduction of tobacco with C-light. The more frequent use of C-light with tobacco and regular cannabis to reducing tobacco usage can be explain by the lowering of the amount within joints. Regular cannabis smokers generally include tobacco in Europe (Hindocha et al., 2014). In parallel, heavy tobacco users are associated with the reduction of medications, but not alcohol.

Interestingly, being a cannabis or tobacco user in the intensive margin does not increase the likelihood to have initiated C-light to substitute these substances. The only positive predictor with their substitution during the first use is using less than 5 cigarettes per day. This low degree of use intensity for tobacco may be explained by use reduction overtime. There is indeed a positive association between reducing tobacco use and its heavy usage in the previous 30 days. Similarly, consuming regular cannabis daily is not associated with initiating C-light in an attempt to cut down or discontinue cannabis use. Conversely, daily and previous-month cannabis use is only associated with its current reduction in France. There may be two explanations for this association: it may be due either to the lower market maturity, with respondents on average having started use more recently, or to the inclusion of alcohol consumption in the specification. Other scholars found that regular cannabis is used less frequently among those using mostly C-light, rather than regular cannabis (Fedorova, 2021). Overall, the use of alcohol predicted a higher probability of consuming C-light to reduce cannabis and tobacco use (appendix table 3).

As we have shown previously (Fortin et al., 2022a), daily C-light use is associated with reducing the consumption of other substances. A greater number of days of use per month predicts a higher probability of substitution for every substance except for alcohol. Among tobacco smokers, the association with daily C-light use does not hold for reducing cannabis use. Perhaps, due to the higher addictiveness of tobacco (Lopez-Quintero et al. 2011), curbing nicotine addiction with C-light require a larger dosage of CBD. This hypothesis is confirmed by the positive association between the fraction of C-light in the joint and the substitution of tobacco, but not regular cannabis.

Using C-light more frequently and with higher dosage implies the purchasing a larger amount of CBD products. Unsurprisingly, a high monthly expenditure on C-light (more than €40) is associated with the reduction of tobacco, alcohol and regular cannabis use alongside C-light. Monetary considerations may lie behind the association between using C-light trim and curbing tobacco use. On average, this C-light sub-product is significantly cheaper (€ 7.1) compared to flowers (€ 8.2) and resins (€ 9.9). Conversely, C-light trim is not associated with a reduction in regular cannabis use. This may have two explanations: either the lower dosage needed due to the lower addictiveness of cannabis compared to tobacco (as seen in previous paragraph); or the different perception of quality between users. Those who want to reduce tobacco may be more pragmatic and unaffected by the lower aesthetic quality of trim (compared to flowers) as long as the amount of cannabinoids and thus the perceived effect are similar (Marijuana Policy Group, 2019).

The negative association between mixing C-light with regular cannabis and the probability of reducing cannabis use deserve further consideration. This pattern of use is also prevalent among cigarettes smokers, but smoking joints that mix C-light and tobacco does not affect the likelihood of reducing tobacco use. C-light is often mixed with tobacco because of its perceived quality and superiority regarding taste and absence of contaminants. These mechanisms are much less important for those who mix C-light with cannabis. Among those who substitute regular cannabis, almost half use C-light to help manage their abstinence symptoms. The remaining segment mixes C-light in the joint either to substitute tobacco, or as a form of polysubstance use to balance the effect of regular cannabis. Indeed, C-light may affect the acute effects of THC when mixed with regular cannabis. The presence of CBD in joints may reduce intense experiences of anxiety or psychosis-like effects of regular cannabis and may impact the benefits and harms of its use (Englund et al., 2013; Freeman et al. 2019). Accordingly, the size

of the user segment who enjoys mixing C-light with regular cannabis depends on two considerations: (1) the cost-benefit analysis between the effect of THC alone, compared to its effect combined with C-light; and (2) the differential price between C-light and tobacco. On one hand, the perceived benefit is likely to increase over time, as consumers become aware of the harm reduction potential of C-light and the consequent lower risk for mental health. On the other hand, C-light price per gram will decrease as the market mature and competition increase, but could also increase with an unreasonable corrective tax (or with the prohibition of inhalable C-light).

In Belgium - the first EU country which classified C-light as tobacco substitute - the taxation level is identical to tobacco at 30%. Switzerland was the first to take this approach by applying a tax of the same magnitude for tobacco, but the Swiss Federal Court revoked this tax, as C-light was not intended to be smoked in all forms[122]. Accordingly, policymakers should not impose a corrective tax on C-light products that may be ingested or vaporized, such as flowers. A corrective tax should only be imposed on products whose final means of consumption produce harms (e.g. pre-rolled cigarettes).

A clear classification of C-light based on the actual purpose of use will be beneficial for consumers, but this should be done without banning inhalable products. Our findings show that smoking C-light is the preferred means of consumption for those substituting tobacco and regular cannabis. Accordingly, reforms that restrict the use of flowers as raw materials would not only lower the number of individuals curbing or stopping the use of these substances, but is also likely to increase the product portfolio of the illicit market. As a consequence of the greater contact with illicit dealers, the initiation of C-light users towards more harmful substances may increase among C-light users, with repercussion for public health and public order (see next chapter for details).

The reduction of the use of medications was declared as a reason for using C-light by 7% of current users. Interestingly, this result is perfectly in line with the Moltke and Hindocha (2021) sample in the UK, despite the de facto ban of inhalable products in the country (Fortin et al., 2021). Other findings present several implications for healthcare practitioners interested in understanding the underlying reasons behind the choice of C-light users to substitute other medications. For example, the minimization of side effects appears to be as important for the

[122] https://www.swissinfo.ch/eng/court-ruling_tax-on-legal-weed-repealed/45567738

patient as the effectiveness in treating the medical condition[123]. This elicited preference is in contrast with the current paradigm in evidence-based medicine, which investigates mostly the effectiveness of products for its marketing approval, rather than the degree of side effects[124]. Whether these preferences are specific to C-light users, or can be generalized to the general population should be the subject of future research. Another interesting aspect highlighted from this study is the potential of self-reporting surveys as a cost-effective tool to create a new epistemology for herbal medicines (Fortin et al., 2022b). Given the market failure in private investment on clinical trials occurring in this market (Fortin and Massin, 2020), this type of qualitative research may support not only the investigation of how different use patterns affect the effectiveness of herbal medicine for different illness, but also to decide for which medical conditions to allocate public resources in a way that satisfies the largest number of individuals in need of an effective therapy without substantial side effects.

5.7.3. Varieties

Among C-light smokers, 7 out of 10 have used more than one variety in the last 30 days. In France, this pattern of use is associated with curbing the use of regular cannabis, but not tobacco. This may be the consequence of high degree of brand stability among tabagists estimated at 90% (Cowie et al., 2014), and that the majority choose the first brand they smoked as their regular brand (DiFranza et al., 1994). In general, it is more likely that when users find a specific C-light variety with a taste or effect which is effective in reducing tobacco use, they tend to continue with the same variety. Conversely, those who substitute regular cannabis may have a preference for diversification of varieties and may have a tendency to continuously test new ones[125]. This difference may be partly due to the institutional differences between cannabis and tobacco markets. The latter is legal and has been standardized over a long period of time: tobacco shops sell relatively few varieties through different brands. As regular cannabis is illicit, consumers cannot consume the same variety for long periods, given the information asymmetry between dealers and producers – unless they self-grow at home. It cannot be excluded, however, that the specific nature of the two substances may be the most important explanation of the different preferences elicited by tobacco and cannabis users. Rahn et al.

[123] It is even considered as the main motivation to substitute medications in the French sample.
[124] This may be especially important for individuals which have to undergo therapies which require poly-drugs use (e.g. cancer treatment) as side effects are rarely investigated when multiple medications are taken together to treat different symptoms.
[125] Both types tend to combine C-light in joints mixed with regular cannabis or tobacco (or both), or smoke C-light alone.

(2016) list more than 600 different varieties of cannabis and currently even the number of C-light varieties is increasing exponentially (Marijuana Business Daily, 2020) to not only satisfy heterogeneous consumer preferences, but also to account for the new therapeutic evidence of minor cannabinoids. A final explanation for the choice of using multiple varieties may be more pragmatic: consumers may attempt to reduce the loss of sensitivity or tolerance to the behavioural effect of CBD, or even to reduce cross-tolerance for the action of THC. By continuously changing the combination of active principles contained across different varieties, they may lower their average daily dosage of C-light and in turn reduce their cannabis-related expenditure.

In the EU, there is a substantial level of red tape that slows down varietal innovation on C-light. Only varieties listed in the common EU catalogues can be marketed, and these requirements are applied regardless of whether the final output is used as an input for industrial uses by other firms or is sold directly to the final consumers[126]. This market distortion may have two potential effects: first, to lower the substitution potential of C-light on regular cannabis if consumers do not find a variety that satisfies their preferences in terms of aroma and cannabinoid content (Gilbert and DiVerdi, 2018); second, to create a grey market of C-light flowers produced in countries which only require low levels of THC using varieties outside the EU catalogue. This may partly explain the high prevalence of inhalable products perceived to be produced in Switzerland from consumers in France (53%).

5.7.4. Supply channels

Most consumers in our sample purchase C-light, but some (4%) have decided to grow C-light plants domestically and have initiate use by consuming their own harvest. Our results suggest those initiating and currently using self-produced C-light are more likely to substitute other substances, compared to those purchasing it at retailers such as tobacconists or specialized shops. Two hypotheses may explain the positive association between home cultivation and the reduction in use of these substances. First, the greater availability of C-light post-harvest may increase daily consumption, as was found during COVID-19 lockdowns with users stockpiling cannabis (EMCDDA, 2020b). As a result, the increased amount of CBD may have lowered attentional bias toward substance-related cues and in turn reduced the use of these substances. Second, cultivating cannabis for medical reasons is a widespread practice among cannabis

[126] https://ec.europa.eu/food/plant/plant_propagation_material/plant_variety_catalogues_databases_en

growers (Hakkarainen et al., 2015). Thus, the portion of C-light users motivated by health-related reasons may simply be greater among those involved in home cultivation compared to the general population of C-light users. Therefore, as production technology affects the perceived quality of cannabis (Belackova, 2020), users who consume what they grow may perceive their harvest as a better substitute for addictive substances than C-light bought at specialized or tobacco shops.

Among those who are not cultivating C-light, purchasing it the first time from specialized shop or on the Internet increases the likelihood of curbing the consumption of any substance, compared to purchasing C-light from tobacconists. For current users, purchasing C-light in tobacco shops predicts a lower probability of reducing the use of any substance compared to buying it from specialized shops (except for tobacco) or online (except for tobacco and alcohol)[127]. The lower probability of curbing the use of substances among those who buy C-light from tobacconists compared to those buying from specialized shops may be explained through three mechanisms. First, the lower average price per gram of C-light flowers sold in specialized shops (€ 8.8) compared to tobacco shops (€ 9.8) will bring those who buy large quantities of C-light towards the former[128]. Second, retailers of tobacco shops are unlikely to be well-informed about the properties of C-light and provide useful advice to those using it to treat a medical condition or its symptoms. Those consuming C-light for substituting substances (or for other health motivations) may prefer to buy from specialized stores where sellers are more likely to be knowledgeable with the products and may provide advice regarding dosages, varieties or mode of consumption (e.g. vaping, ingestion) which may be beneficial for users. Third, many C-light users may not find their favorite product due to the lower diversification of C-light items and variety of flowers available in tobacco shops.

In terms of distribution channels, some EU countries have monopolized the sale of C-light products towards specific licensed distributors. This is the case in Finland, where CBD is classified as a medicinal product, restricting its access to pharmacies. Other regulatory approaches that limit the access of specific C-light products towards certain marketplaces would appear to be more appropriate. In Denmark, for instance, certain types of C-light

[127] There are some signs that purchasing from tobacconists may increase the likelihood of substituting tobacco in France, but the low variation in the sample demonstrates a need for further evidence.
[128] This price differential is likely due to the higher quantity discount applied in specialized shops, whose main product sold is C-light, compared to tobacconists, where it is just one of dozens of products available.

products (e.g. oils) with a high dosage of CBD are considered to have a pharmaceutical effect, and are thus sold only through pharmacies (EMCDDA, 2020a), whereas other product types containing lower doses of CBD may be sold through other suppliers. From a public health perspective, policymakers may want to explore regulating the availability of specialty items to minimize poly-drug use and maximize the substitution of other substances. For instance, trim and pre-rolled cigarettes appear to be more appropriate than raw flowers to be sold in tobacco shops, whereas the contrary may be true for specialized shops. The impossibility of finding raw C-light flowers in tobacco shops would lower their co-use with tobacco, while pre-rolled C-light cigarettes may facilitate the switch towards C-light, given their similarity with tobacco cigarettes (e.g. presence of filters, no need to roll). Once these consumers become familiar with C-light, they may decide to try new varieties of C-light flowers through specialized shops, particularly if they can be found at cheaper price. There, consumers would have a lower risk of co-using C-light with tobacco, given the impossibility of purchasing cigarettes, thus increasing the likelihood of tobacco cessation.

5.7.5. Strength and limitations

This work has several strengths, including sample size, wide age range of the respondents, geographic representation of the sample and a focus on the specific motivations behind the substitution effect. In part, this was the result of using multiple recruitment methodologies and the time of launching during the first wave of COVID-19 lockdown.

This study has several limitations. First, the study population was a self-selected convenience sample of mostly young adult C-light users in Southern Europe, thus the results may not be generalizable to adult users in the general population. Second, the study was conducted in a setting with low access to cannabis products, as recreational cannabis use is not legal in France and Italy. Our findings may not be applicable to countries with more progressive legal environments surrounding the use of cannabis. Third, the French and Italian populations have a high prevalence of tobacco, alcohol and regular cannabis use, and the majority mixes tobacco with regular cannabis. Our findings on C-light smokers may not be applicable to countries with lower use prevalence and greater social stigmatization for drug use. Fourth, in the question regarding the motivation behind the consumption of CBD in the previous month, we only allow one choice. Therefore, it is likely that individuals who repond with “to use it legally” or “taste and pleasure” are lowering their consumption of other substances, particularly tobacco and THC. Despite this, we assume that those who consider substitution as their primary reason are

likely to be those for which C-light tends to be most effective, as proven by their high level of satisfaction with its effect.

5.8. Conclusion

The use of C-light for general wellbeing and to treat specific health conditions is widespread and will likely grow as cannabis markets evolve. One out of five current users use C-light as a substitute. These findings demonstrate its potential in reducing the use of more harmful substances, which may be influenced by several factors relating to socio-demographic characteristics, patterns of use and preferred supply channels.

Overall, a major contribution from the survey relates to identification of the patterns of use of inhalable C-light products. Rather than prohibiting these products, policymakers should put in place regulations based on the expected harms. One, by testing the presence of contaminants in the products. Additionally, by designing a distribution and taxation scheme. This could maximize the substitution of harmful substances with C-light through different types of products across different supply channels, and use a differential taxation level that is based on both composition of the products and on the expected mode of consumption to incentivise the usage of less harmful cannabis forms.

Together, (1) the differential interest for the diversification of varieties between those substituting tobacco and those substituting regular cannabis; (2) the positive association between using C-light trim and the reduction of tobacco use; (3) the negative association between tobacco shops and the reduction of the use of substances; and (4) the need to impose differential taxation based on the purpose of use calls for a rethinking of the most adequate distribution channels for specific C-light sub-products. Accordingly, C-light could be sold in tobacco shops when it is packaged in a way which discourages the co-use of the product. For instance, in pre-rolled cigarettes containing only C-light that cannot be easily mixed with tobacco. Their taxation should be lower compared to tobacco cigarettes, given their lower expected harm to consumers. On the other hand, specialized shops would offer an extensive number of C-light varieties, similar to the US framework. Given that C-light is also used for therapeutic reasons, it might be necessary to impose a mandatory education for personnel to guarantee a minimum level of expertise to advise customers purchasing through specialized shops. Given the diversification in their offering, tobacco shop owners are unlikely to have the adequate knowledge to help individual in choose the best C-light products/varieties for their condition or the proper dosage. Specialized shops selling only flowers and derivatives could

provide basic information to users, discourage the co-use of tobacco and perhaps incentivize its customers towards healthier modes of use (e.g. inhalation).

In conclusion, the reduction in the use of medications is driven by their perceived effectiveness as well as lower side effects. Future studies should investigate the efficacy of various forms and cannabinoid combinations for substituting specific substances in naturalistic settings.

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5.10. Appendices

Appendix 1: Details in Survey Design

The 52-item survey started with a question about the amount of times they have used CBD, if they responded with "Never", they were exited from the survey. The second question was about age. If they responded "1-17 years old", they were exited from the survey. If the respondents declared to have used CBD *and* to be at least 18 years old, they completed the first part of the survey related to their first consumption of CBD. The eighth question asked their motivation for their first consumption. If the respondents declared it was related to "wellness", "to treat a medical condition" or "to substitute other substances", they answered an additional question related to their desired effect. The next question asked how many days they used CBD in the previous 30 days. If the respondents did not use it, they were excluded from the questions related to consumption in the previous month and routed directly to the consumption of other substances. If they responded to have use CBD at least once in the previous month, they

completed additional questions about when they used it and through which supply channel. If they declared to self-grow what they consumed, they were presented with an additional question about the reason for doing so and the provenience of the seeds/cuttings used. The next question asks which product they used the most in the previous month. If the respondents did not answer "flowers", "resins" or "trim", they were excluded from the questions related to varieties, price, provenience as well as mean of consumption, and routed directly to questions related to budget. The 21st question asks about the principal means of consumption in the previous 30 days. If the respondents did not smoke light cannabis, they were excluded from the questions related to percentage of CBD smoked in their joint as well as the substance with which it was combined and routed directly to questions related to budget. If they responded with "combustion", they completed all sections of the survey.

APPENDIX TABLE 1.

Desired and obtained effects of light cannabis on medical condition at the first use

	Full sample		***Current users***	
	TOT	**FR**	**TOT**	**FR**
Improve sleep and reduce insomnia				
Desired effect	13	13.2	12.3	12.8
Obtained effect	61.9	58.2	64	60.5
Reduce stress				
Desired effect	11.8	11.8	11.2	11.8
Obtained effect	60.15	48.1	59.5	48.7
Increase concentration				
Desired effect	8.36	5.28	7.73	5.8
Obtained effect	26.1	17.4	21.1	18.1
Increase energy				
Desired effect	9.33	4.5	8.06	4.89
Obtained effect	18.4	14.3	19.9	15.4
Treat or reduce symptoms of a disease diagnosed by a physician				
Desired effect	8.28	9.94	9.02	9.96
Obtained effect	17.7	22.3	20.6	24.62
Treat pain or inflammations				
Desired effect	11.6	13.7	11.1	13.2
Obtained effect	55.6	50.8	56.9	52.4
Treat or reduce symptoms of my anxiety or depression or other mood problems				
Desired effect	11	11.3	9.56	10.1
Obtained effect	45.2	39.6	47.7	40
Treat migraines and headache				
Desired effect	21.1	5.9	17.5	5.83
Obtained effect	26.6	19.25	26.9	19.7
Relieve my nausea or vomiting				
Desired effect	4.8	1.55	3.87	1.32
Obtained effect	16.1	7.14	16.3	7.71
Treat injuries or fractures				

Desired effect	4.63	2.33	4.19	2.26
Obtained effect	6.79	6.21	7.73	6.77
***Treat acne,* psoriasis or other skin problems**				
Desired effect	5.37	3.26	4.73	3.38
Obtained effect	7.99	4.5	8.81	5.08
Reduce appetite				
Desired effect	6.19	1.24	5,91	1.5
Obtained effect	2.69	2.02	2.9	2.26

Note: Percentages were used for all categorical data. The sample only includes respondents using light cannabis for wellness and health reasons. Current users refer to individuals who declared to have used light cannabis in the previous month. 'Desired effect' refers to those individuals who started using light cannabis to reduce the consumption of other substances, but have not obtaineded the Desired effect.

APPENDIX TABLE 2. Robustness check on factors related to the initiation of light cannabis for substitution of other substances

	Any		**Regular Cannabis**		**Tobacco**		**Medications**		**Alcohol**	
	Italy	France	Italy	France	Italy	France	Italy	France	Italy	France
Constant	-2.105***	-1.890***	-2.327***	-1.958***	-2.110***	-1.566***	-2.514***	-2.245***	-2.205***	-2.347***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Female	0.122**	0.266***	0.082	0.147	0.103	-0.087	0.230***	0.440***	0.125	-0.216
	[0.041]	[0.001]	[0.332]	[0.159]	[0.113]	[0.389]	[0.003]	[0.000]	[0.106]	[0.117]
Age	0.008***	0.017***	0.004	0.003	0.003	0.001	0.009***	0.021***	0.002	0.010**
	[0.001]	[0.000]	[0.217]	[0.497]	[0.351]	[0.750]	[0.008]	[0.000]	[0.560]	[0.031]
High income	0.134	0.039	0.187*	0.028	0.143	0.118	-0.258*	0.054	-0.016	0.268*
	[0.102]	[0.684]	[0.088]	[0.825]	[0.112]	[0.303]	[0.065]	[0.627]	[0.890]	[0.063]
Low income	0.166***	0.304***	0.131*	0.339***	0.214***	0.211**	0.049	0.280***	0.161**	0.236*
	[0.002]	[0.000]	[0.077]	[0.001]	[0.000]	[0.042]	[0.482]	[0.005]	[0.020]	[0.083]
Employed	0.164**	0.071	0.065	0.017	0.167**	-0.017	0.208**	0.135	0.059	-0.101
	[0.010]	[0.400]	[0.483]	[0.874]	[0.016]	[0.864]	[0.011]	[0.160]	[0.495]	[0.458]
Underweight	0.126	-0.183	0.177	-0.431**	0.048	-0.158	0.125	-0.238	-0.094	-0.147
	[0.186]	[0.277]	[0.161]	[0.046]	[0.648]	[0.427]	[0.308]	[0.236]	[0.511]	[0.596]
Overweight/obese	0.119*	0.070	0.153*	-0.054	0.097	-0.009	0.225***	0.127	0.196**	0.028
	[0.056]	[0.392]	[0.075]	[0.611]	[0.156]	[0.928]	[0.005]	[0.159]	[0.014]	[0.823]
Light tobacco smoker	0.091	-0.044	0.184**	0.151	0.168**	0.195*	0.139*	-0.168	0.218***	-0.011
	[0.133]	[0.646]	[0.031]	[0.187]	[0.012]	[0.085]	[0.092]	[0.134]	[0.007]	[0.940]
Heavy tobacco smoker	-0.008	-0.143*	0.082	0.005	0.065	0.047	0.021	-0.164*	0.084	0.022
	[0.889]	[0.095]	[0.329]	[0.963]	[0.320]	[0.654]	[0.792]	[0.087]	[0.295]	[0.872]
Previous-month THC user	-0.010	0.026	-0.097	0.263**	-0.022	0.263**	-0.046	-0.134	-0.125	0.412***
	[0.878]	[0.765]	[0.295]	[0.013]	[0.764]	[0.014]	[0.594]	[0.180]	[0.147]	[0.002]
Daily THC user	-0.017	-0.065	-0.061	0.030	0.009	0.262**	-0.046	-0.122	-0.134	0.171
	[0.816]	[0.512]	[0.535]	[0.810]	[0.907]	[0.025]	[0.628]	[0.271]	[0.150]	[0.259]
Alcohol user		0.029		0.077		0.046		-0.159*		0.087
		[0.716]		[0.461]		[0.643]		[0.077]		[0.514]
Online	0.267**	0.347***	0.121	0.343***	0.302***	0.114	0.076	0.289***	0.018	0.131
	[0.014]	[0.000]	[0.432]	[0.005]	[0.008]	[0.327]	[0.605]	[0.008]	[0.907]	[0.405]
Specialized shops	0.185***	0.161	0.070	0.143	0.145**	0.136	0.013	0.115	0.039	0.294*
	[0.001]	[0.112]	[0.371]	[0.262]	[0.020]	[0.251]	[0.861]	[0.326]	[0.592]	[0.063]
Tobacco shop	-0.078	-0.169	-0.173	0.049	-0.125	-0.081	-0.284**	-0.387	-0.222*	0.000
	[0.370]	[0.505]	[0.161]	[0.867]	[0.190]	[0.781]	[0.022]	[0.296]	[0.062]	[.]
Self-grown CBD	0.670***	0.437**	0.297	0.505**	0.639***	0.321	0.273	0.502**	0.476**	0.395
	[0.000]	[0.039]	[0.175]	[0.038]	[0.000]	[0.164]	[0.196]	[0.028]	[0.014]	[0.146]
Observations	6.472	1.429	6.338	1.252	6.472	1.429	6.472	1.429	6.472	1.390
R^2	0.027	0.059	0.018	0.036	0.025	0.024	0.034	0.114	0.022	0.047
Log-likelihood	-1.590.383	-804.806	-744.212	-486.326	-1.307.467	-520.726	-807.977	-591.031	-831.400	-280.860

APPENDIX TABLE 3.

Robustness check on substitution of substances with light cannabis in the previous month

	Any		**Regular Cannabis**		**Tobacco**		**Medications**		**Alcohol**	
	Italy	France	Italy	France	Italy	France	Italy	France	Italy	France
Constant	-1.426***	-2.332***	-2.200***	-2.269***	-1.743***	-3.023***	-2.716***	-2.830***	-2.039***	-2.836***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Female	-0.125	0.101	-0.073	0.096	-0.122	-0.103	0.122	0.147	-0.085	-0.846***
	[0.168]	[0.309]	[0.553]	[0.450]	[0.202]	[0.411]	[0.385]	[0.188]	[0.530]	[0.002]
Age	-0.001	0.007*	-0.003	-0.011*	-0.001	0.003	0.004	0.005	-0.002	0.021***
	[0.885]	[0.095]	[0.568]	[0.071]	[0.874]	[0.562]	[0.512]	[0.288]	[0.719]	[0.007]
High income	0.038	-0.065	-0.335	-0.065	0.004	-0.002	0.231	-0.076	0.258	-0.338
	[0.753]	[0.568]	[0.109]	[0.639]	[0.975]	[0.988]	[0.237]	[0.583]	[0.107]	[0.105]
Low income	0.038	0.166	-0.098	0.069	0.085	0.257**	0.108	0.104	0.165	0.146
	[0.627]	[0.110]	[0.375]	[0.580]	[0.300]	[0.031]	[0.423]	[0.389]	[0.147]	[0.381]
Employed	0.031	0.054	0.119	-0.240*	0.040	-0.331***	-0.043	0.280**	-0.132	-0.152
	[0.752]	[0.601]	[0.375]	[0.063]	[0.699]	[0.008]	[0.799]	[0.016]	[0.397]	[0.407]
Underweight	-0.074	0.139	-0.257	0.000	0.055	0.161	-0.185	0.093	-0.148	0.386
	[0.645]	[0.501]	[0.268]	[1.000]	[0.736]	[0.499]	[0.545]	[0.720]	[0.576]	[0.288]
Overweight/obese	0.023	-0.104	-0.232*	-0.237*	0.019	-0.240**	0.080	-0.004	0.135	-0.113
	[0.799]	[0.283]	[0.091]	[0.058]	[0.839]	[0.047]	[0.575]	[0.969]	[0.276]	[0.496]
Light tobacco smoker	0.304***	0.282**	0.386***	0.222*	0.406***	0.575***	0.191	0.072	0.149	0.108
	[0.001]	[0.016]	[0.002]	[0.097]	[0.000]	[0.000]	[0.229]	[0.626]	[0.233]	[0.607]
Heavy tobacco smoker	0.107	0.253**	0.258**	0.155	0.179*	0.348***	0.240	0.279**	-0.222*	-0.017
	[0.235]	[0.018]	[0.049]	[0.240]	[0.063]	[0.010]	[0.129]	[0.023]	[0.096]	[0.926]
Previous-month THC user	0.061	0.087	0.021	0.261**	0.144	0.194	0.113	0.003	0.164	-0.058
	[0.553]	[0.385]	[0.877]	[0.030]	[0.189]	[0.111]	[0.512]	[0.979]	[0.307]	[0.745]
Daily THC user	0.097	0.144	0.034	0.311**	0.145	0.252*	0.055	0.011	0.104	0.130
	[0.392]	[0.233]	[0.824]	[0.028]	[0.224]	[0.070]	[0.774]	[0.936]	[0.540]	[0.485]
Alcool user		0.234**		0.337***		0.386***		0.088		0.314
		[0.015]		[0.008]		[0.002]		[0.414]		[0.128]
Specialized shops	-0.008	0.137	0.050	0.096	0.017	0.322**	-0.026	0.188	0.083	0.533***
	[0.923]	[0.204]	[0.641]	[0.477]	[0.834]	[0.012]	[0.828]	[0.137]	[0.462]	[0.002]
Tobacco shop	-0.162	-0.038	-0.153	0.236	-0.118	0.760**	-0.855**	-0.377	0.088	0.000
	[0.150]	[0.911]	[0.361]	[0.521]	[0.320]	[0.037]	[0.011]	[0.484]	[0.588]	[.]
Self-grown CBD	0.308*	0.243	0.257	0.194	0.430**	0.237	0.308	0.459*	0.421	0.676*
	[0.090]	[0.307]	[0.290]	[0.508]	[0.022]	[0.414]	[0.259]	[0.080]	[0.104]	[0.051]
Sublingual oils user	0.165	0.098	0.000	-0.509**	-0.035	-0.357**	1.059**	0.525***	0.438	0.052

	[0.729]	[0.472]	[.]	[0.018]	[0.951]	[0.049]	[0.041]	[0.000]	[0.441]	[0.856]
Vaporization	-0.121	-0.054	-0.540*	-0.256	-0.127	0.149	-0.036	0.143	-0.015	0.015
	[0.446]	[0.739]	[0.056]	[0.209]	[0.452]	[0.434]	[0.889]	[0.449]	[0.947]	[0.954]
Other CBD products	-0.075	0.169	-0.063	0.090	-0.073	0.177	0.224	0.369**	-0.029	-0.027
	[0.680]	[0.270]	[0.818]	[0.653]	[0.709]	[0.354]	[0.387]	[0.028]	[0.909]	[0.935]
3 months experience	0.038	0.030	0.155	0.026	0.092	0.054	-0.024	0.065	-0.069	0.027
	[0.652]	[0.780]	[0.215]	[0.844]	[0.309]	[0.688]	[0.862]	[0.606]	[0.559]	[0.893]
Days of use CBD	0.008**	0.015***	0.009*	0.003	0.008**	0.010*	0.003	0.019***	0.001	0.003
	[0.044]	[0.000]	[0.100]	[0.586]	[0.043]	[0.075]	[0.678]	[0.000]	[0.860]	[0.691]
High Budget	0.142*	0.152	-0.050	0.311**	0.118	0.364***	0.121	0.043	0.385***	0.127
	[0.081]	[0.147]	[0.665]	[0.021]	[0.172]	[0.007]	[0.380]	[0.718]	[0.002]	[0.498]
Labeling satisfaction	0.037	-0.055	0.199*	0.115	0.034	0.055	0.021	-0.114	-0.071	0.146
	[0.642]	[0.607]	[0.090]	[0.382]	[0.681]	[0.670]	[0.879]	[0.366]	[0.536]	[0.452]
Taste satisfaction	-0.113	0.131	-0.088	0.187	-0.127	0.165	-0.161	0.040	-0.033	0.082
	[0.154]	[0.213]	[0.424]	[0.174]	[0.127]	[0.217]	[0.235]	[0.747]	[0.772]	[0.661]
Effect Satisfaction	0.488***	0.399***	0.572***	0.417***	0.474***	0.316**	0.549***	0.580***	0.270**	0.177
	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.019]	[0.000]	[0.000]	[0.017]	[0.391]
Observations	2.002	1.007	1.944	881	2.002	1.007	1.993	1.005	2.002	992
R^2	0.047	0.063	0.077	0.084	0.051	0.118	0.091	0.115	0.054	0.129
Log-likelihood	-841.475	-593.699	-385.191	-372.433	-740.767	-373.622	-238.494	-395.873	-335.791	-129.048

CHAPTER SIX

6. GENERAL CONCLUSIONS

Abbreviations:

MC	Medical Cannabis
CSC	Cannabis Social Club
C-Light	Light Cannabis
RCT	Randomized Clinical Trial

Cannabis has been used by humanity for 12,000 years as textile, food and medicine. Napoleon was the first to regulate cannabis use due to its negative effect on the motivation of his soldiers. The fear surrounding its new recreational purpose—inspired by artistic circles such as *club des Hashischins*—eventually drove its global prohibition (Kozma, 2011). Currently in the Western world, the negative externality resulting from its illicit status has become a greater concern than its potential abuse among a minority of users. Combined with the increased awareness of its therapeutic properties, perception has slowly changed and hemp has become a leading symbol of sustainable agriculture (Strzelczyk et al., 2021). Accordingly, a growing number of jurisdictions have decided to re-institutionalize certain cannabis markets; Canada, Malta, Uruguay and 21 US states have now legalized adult use. The evidence gathered from these new legalized systems has highlighted that, although each cannabis sub-market operates with different regulations, they can often satisfy consumer demand interchangeably and create market distortions.

This dissertation aims to comprehensively discuss the optimal regulatory framework for each cannabis market. Building on microeconomic theory, the functioning of the markets is examined to improve efficiency through market design. This exercise consists on the examination of several frameworks which depend on the type of cannabis, the purpose of use and the expected damages or benefits that can result from its utilization. The study is conducted in five chapters. In each one, after identifying the main distortions across different cannabis sub-markets (and with other addictive substances), we propose solutions to increase social welfare. The first chapter theoretically introduces the interrelation across cannabis markets. The second attempts to define the boundaries of the medical cannabis (MC) market focusing on the North American and European models. The third uses quantitative sales data to identify the impact of adult retailers in the MC market in the first jurisdiction, which regulates them

separately. The fourth chapter theoretically discusses the role of the Cannabis Social Club (CSC) model as a supplier in both medical and recreational markets. The fifth chapter examines the interrelation between light cannabis (C-light) and other substances through an online survey in France and Italy, and discusses some policy issues.

The first chapter presents the theoretical framework related to the institutionalization of four legal cannabis sub-markets: industrial (or hemp), C-light (or CBD), medical (or pharmaceutical) and recreational (or adult use), and their potential as substitutes for other substances and agricultural commodities. We then explore how its unique nature as a multi-purpose commodity with negative externalities and internalities makes its regulation extremely complex. As these legal markets evolve it has become clear that their design should be based on the expected purpose of use, rather than exclusively intoxication potential. Once the final use of a sub-market is defined, its interaction with other segments must be taken into account to evaluate its social cost and minimize it through regulatory tools such as differential taxation, licensing, and minimum pricing. Following this, we discuss how different groups across the supply chain and among industries which may be displaced have opposite vested interests, and may pressure policymakers towards unnecessary restrictions and market concentrations. Whereas some degree of market power is acceptable with high fixed costs such as for industrial hemp or MC, this is not the case for C-light and recreational cannabis. An example of inefficient regulation is the de facto oligopsony applied to the C-light farmers in France. Without careful policy considerations, the risk that the cannabis industry's trajectory could repeat tobacco's where powerful corporate interests wield disproportionate influence on regulation against consumer interest may become a reality. The chapter continues by identifying the specific interrelations based on raw material, type of product, purpose of use and complementarity/substitutability with other markets or cannabis segments. We conclude by demonstrating the different challenges related to cannabis market design. First, only the achievement of the stated policy objectives will determine its success. Second, we explain the regulatory tools: taxes and quantity regulation. Among the latter, we highlight the importance of sin licenses as an instrument which can complement sin taxes as a form of nudging. Lastly, we list the market design difficulties which will be considered in the dissertation, such as the substitution of C-light with other substances, the imposition of quantity regulation on hemp and the difficult institutional balance not only between taxation and subsidies, but also between product diversity and efficiency.

The second chapter theoretically investigates the design of the MC market in the EU, in comparison with North American model. The intrinsic characteristics of herbal cannabis calls for a rethinking of its integration in the European health system. CSC would become a complementary supply channel to pharmacies within a new medical paradigm that relies more on patients' experience than on physicians' expertise.

In the third chapter we use county-level data to investigate how sales at MC outlets in Colorado were affected by the opening of retail stores. We found a displacement in MC sales by approximately 10 percent. A number of users who may have previously purchased MC through a prescription have shifted to the adult market. It is plausible that a portion of these users were using MC for recreational purposes, and that the introduction of retail stores has discouraged this distortion. Our findings indicate that medical and recreational cannabis outlets can co-exist, but it seems likely that the lower taxation of the medical market is an important requisite. Even relatively small tax differentials can separate user segments. Those requiring large amounts of the product for medical reasons will tend to use the medical market, while less frequent users will purchase from retail stores.

Considering this interrelation, the fourth chapter discusses how the presence of an intermediate supplier may improve market segmentation. The CSC model is analyzed within the broader marketplace, where patients purchase in pharmacies while general adults purchase in retail stores. We identified price and transaction costs as the parameters which must be considered to maximize market segmentation between medical and recreational users. The resulting user-controlled discrimination scheme would not only reduce distortions between these two markets, but also reduce illicit market participation overall.

The fifth chapter explores the consumption of C-light across French and Italian consumers. Through online surveys, we show that non-psychoactive components are attractive for both wellbeing and as a treatment for specific medical conditions. One out of three users consume it as an alternative to other substances. The substitution of tobacco with C-light is associated with the combustion of flowers, whereas those who use it as a substitute for medications tend to use it orally. Product diversity is appreciated mostly by those who reduce their consumption of cannabis. Substitution for alcohol is less frequent, but this usage pattern is likely to increase over time, as user experience is a significant factor. The reduction of the use of medications appear to be driven by the alleviation of withdrawal symptoms as well as the perception of higher efficacy and lower side effects.

The goal of this dissertation is to establish informed public policy recommendations for cannabis market design that focus on taxation and supply architecture. While the contributions of this research to the field(s) of study have been articulated throughout this manuscript, few points warrant further policy reflections.

6.1. Policy recommendations on cannabis market design

6.1.1. Establish different quality standards based on final purpose

The dissertation demonstrated how different market segments can satisfy the demand of consumers interchangeably, and identified the distortions that exist among four different cannabis markets. As each regulation is based on a specific purpose, gray areas within each segment remain. For instance, when certain components of C-light or its derived products are placed in the market as food, additional regulations may apply, such as those for novel food, flavoring, additives, contaminants, food supplements or feed for animal. Whenever the product is consumed by humans, there should be minimum quality standards regarding the presence of contaminants as well as accurate labelling for the main ingredient (e.g. CBD, THC, CBG). We recommend that quality requirements are based on the final consumer group. Similar requisites should be imposed for products sold in the recreational and light cannabis market, whereas more rigorous specifications should be imposed to products used by patients, in light of their vulnerable health status. Currently, regulations in the EU only consider quality standards for the MC market. There is a lack of testing on the content of contaminants and active ingredients, even among EU countries who regulate the inhaled use of C-light (e.g. Belgium).

6.1.2. Design the MC system for those suffering from a condition with inconclusive evidence

The regulatory framework of MC is the most important among the cannabis sub-markets, not only because it affects all other markets, but also because patients are arguably those who enjoy the greatest benefits from its consumption. Reimbursement policies should be implemented to maximize patient access while minimizing the diversion to non-medical users. In most EU countries, the latter objective has thus far prevailed. As an example, the estimated EU consumption of flowers from pharmacies in 2019 was equal to two months of consumption by patients in Colorado[129]. In the Netherlands, MC has been available since 2003, but the number

[129] https://sbg.colorado.gov/med-updates; https://mjbizdaily.com/wp-content/uploads/2021/09/Medical_Cannabis_in_Europe_MJBizDaily.pdf

of registered patients has remained stagnant[130]. In this case, coffee shops appear to better satisfy patient demand due to their greater product diversity.

In parallel, the majority of the Dutch MC production is sold to Italian and German pharmacies. In both countries, it has been possible to obtain MC for almost a decade, but their regulatory approach has been rather different. In Italy, a minimal share of patients obtain reimbursement and there is continuous MC shortage, leading patients towards the black market. Conversely, a recent Supreme court decision in Germany allowed certain patients to grow their therapy domestically. Afterwards, a new reform integrated MC in the German health system by allowing reimbursement for any type of condition. With no need for RCTs, the only requirement is minimal evidence of cannabis efficacy. On a case-by-case basis, insurance determines reimbursement for the cannabis-based therapy. In four years, the number of German MC patients has increased substantially compared to Italy.

We could speculate that the underlying reason for German MC policy reform was that policymakers were less concerned about seeing MC used recreationally than they were about letting patients to grow MC domestically. Despite its underpinnings, the German model has provided a usable framework for integrating MC within the health system by recognizing *therapeutic patients*[131] and may be considered as the policy benchmark in Europe.

6.1.3. Establish a non-profit supply channel to increase segmentation and diversity

Our theoretical model has examined how the setting of prices and transaction costs (e.g. sin licenses) across supply channels is fundamental to designing cannabis markets. We demonstrated how an intermediate supplier—such as CSCs—can increase market segmentation and product diversity. European pharmacies cannot fully substitute American MC dispensaries, as they also supply other types of medications and therefore have fewer cannabis varieties available[132]. Patients may then have to travel across jurisdictions to find their favorite products or resort to the illicit market[133]. This issue was acknowledged in a resolution from the European Parliament (2019) which stated the need to "…provide a safe and equal choice for patients between different types of cannabis-based medicine...".

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[130] As of March 2015, about 1200 patients have received their medicinal cannabis at the pharmacy, using a prescription from their doctor, at a cost of about EUR 45 for five grams (Hughes, 2016).
[131] Patients who suffer from a condition for which the evidence is inconclusive.
[132] Given the high number of varieties as well as conditions for which cannabis is used medically, search costs would increase if pharmacies are the only suppliers for both 'therapeutic' and 'medical' segments.
[133] In Italy and the US, certain patients moved to specific jurisdictions for better access to certain MC products.

An additional MC supplier would offer a greater number of varieties. This would not only increase the chance to find the best product to treat their condition, but also attract the fraction of patients who believe in the entourage effect. A second supplier for patients would also benefit the whole health system in terms of efficiency: if *therapeutic patients* are not required to obtain a prescription to access CSCs, physicians would have more time for *medical patients*. Another advantage is the reduction of distortion that stems from treating patients as 'alcoholics'. If they buy their medication in retail stores, they pay a corrective tax. Conversely, if they can buy their medication from the CSCs, the cost would be lower and more in line with its expected externality.

In general, scholars have shown that a non-profit model is viable healthcare. This model is able to offer products or services that are not very profitable and tend to be more responsive to changes in profitability (Horwitz, 2005). In the case of MC, this depends on the evolution of the evidence base. Once a specific MC product has been proven to be effective on a specific condition, *therapeutic patients* suffering from the condition become *medical patients* and potentially shift to pharmacies because of the lower monetary cost.

Finally, a non-profit supply channel would have an advantage in terms of innovation. Due to a lack of research among *therapeutic patients*, different avenues for evidence are needed. Non-profit supply models, such as CSCs, should be involved in medical research. Commercial dispensaries may not have enough economic incentive to collect patient data. Once products are proven to be effective, their supply may shift to the medical market (e.g. marketing authorization), reducing the product variety in retail stores. It is likely that this data collection would be easier to implement in a non-profit environment where members are rewarded by non-monetary values, such as increasing evidence of MC potential.

6.1.4. Adjust the medical paradigm by expanding the type of acceptable evidence

> *"Cannabis remains a mystery, a medically unexplained medicine whose therapeutic effects are not well understood but are deeply felt by users (...) a contested medicine." (Zarhin et al., 2020; p. 492).*

In another part of the EU resolution (2019), policymakers asked members to "...address the regulatory, financial and cultural barriers that weigh on scientific research into the use of cannabis for medicinal purposes". Overall, the illegal status of drugs under the UN Conventions and national legislation has had a hugely negative impact on research and clinical innovation. An additional problem relates to the private interests involved in providing efficacy evidence

for a medication. Indeed, the economic incentive to invest in RCTs depends on its patentability and the subsequent possibility of its sale at a monopoly price for a certain period. In addition to these institutional frictions, its heterogeneous nature and its entourage effect makes it difficult to interpret the current evidence base. Taken together, the private incentive to perform RCTs is lacking. This lack of private research must be taken into account for the MC market, as well as other medicinal plants – especially when they are promoted as a panacea.

The epistemology used to determine the efficacy of cannabis and other herbal preparations – those which do not have the 'magic bullet' functionality of Western medicine – should be expanded. The current medical paradigm, where RCTs are the only valid evidence, need to be widened to become more in line with real patient experiences using global database registries and other patient reported outcomes (Fortin et al., 2022b). This type of evidence should supplement RCTs to bridge the current gaps in evidence (Schlag et al., 2021). Physicians who prescribe cannabis or other herbal preparations should receive specialized training and follow mandatory courses that are not common in medical school, such as the cannabinoid system[134]. These new medical figures could use traditional knowledge along with RCTs to adapt therapies to specific patient's needs. The health system would then subsidize medications differently based on their cost-effectiveness and the severity of the treated disease. To facilitate the process, there should be a dual distribution system characterized by different levels of reimbursements. Medications with strong clinical evidence of cost-effectiveness for severe conditions would be fully reimbursed through pharmacies, while medications with either lesser evidence - or that are used to treat mild diseases - would only obtain partial reimbursement (or no coverage for extremely non-severe conditions). While CSC would specialize on cannabis, other medicinal plants could be supplied by herbalists, given their previous experience with these preparations.

6.1.5. Define light cannabis: 1% THC limit as a benchmark

In the fifth chapter, we have seen that the C-light market is defined in different ways around the world and across European countries. While the upper limit in France is 0.2%, Italian farmers can cultivate hemp containing up to 0.6% THC. Switzerland has chosen an even greater threshold of 1%, whereas in the US the limit is 0.3%. The lack of an international consensus on the toxicological definition of C-light has originated from political rather than scientific

[134] The first course of cannabinology at a university was performed in the Department of Neuroscience at the University of Padua in 2021.

reasons. Historically, it was imposed without an evaluation of the actual THC content levels that would cause intoxication in humans.

The UNODC (2009) approach suggests considering also the content of CBD and CBN in calculations[135]. Considering a ratio of cannabinoids substantially lowers the risk that farmers will throw away their crops[136]. In unusual seasons, even certified EU varieties can produce illicit crops with THC content higher than the legal threshold. The so-called 'hot hemp' is not sellable in the legal market without remediation to create compliancy by reducing its THC content – a process which requires specialized expertise (Alovisetti et al., 2020). Intermediate transformers, however, are not interested in using this crop due to its illicit status. The only remaining option for non-compliant hemp appears to be players in the illicit market. For instance, there is evidence that synthetic cannabinoids has been added to C-light flowers to be sold as illicit cannabis in Europe (Oomen et al., 2022). In terms of public health, these types of products are considered more dangerous and addictive than cannabis, and their supply may have a negative impact on cannabis prices over time.

To prevent the illicit market benefitting from the lack of harmonization in THC levels, it is necessary to impose an upper limit that minimizes farmers' risk of producing illicit crops. Internationally, the 1% level is now considered the benchmark, and the Czech Republic has been the first EU member adopt this limit in 2022[137]. Even the US considers this THC level as the minimum to define a *negligent violation.* American policymakers list three reasons for increasing the threshold: (1) to assist producers when requesting financial assistance; (2) to lower the barrier to entry for new or small farmers lacking experience with hemp; and (3) to incentivize innovation by research institutions and producers, which would in turn bring more stability to stakeholders (Federal Register, 2021). Indirectly, a lower THC limit will create red tape on varietal innovation. As a higher presence of THC is related to a higher level of other non-psychoactive cannabinoids, geneticists are interested in working on varieties closer to 1% THC. The biomass obtained from these varieties would have a greater cannabinoid content, which would in turn make their extraction more efficient.

[135] Thus far, no jurisdictions have followed the UNODC approach, perhaps to minimize the transaction costs involved with testing multiple cannabinoids.
[136] Light cannabis varieties always have a greater amount of CBD than THC.
[137] https://www.addictionjournal.org/posts/czech-republic-establishes-1-thc-limit-on-cannabis-based-products

6.1.6. Provide a licit exit to 'hot hemp'

Since the legalization of hemp in the US, approximately 12% of cultivated area has been discarded as THC concentrations were greater than the legal threshold in a portion of tested lots. Accordingly, the U.S. Department of Agriculture's final ruling has authorized alternate methods for disposing of non-compliant plants, beyond for its destruction through a DEA-registered reverse distributor. The remediation of 'hot hemp' is possible through a process of either removing and destroying flower material while retaining the remaining parts, or by shredding the entire plant into biomass (Federal Register, 2021).

In the EU, hemp regulations are silent about addressing lots from which plants were sampled and found to be above the legal THC threshold. Regardless of the THC limit, every country where C-light is cultivated should establish a system that authorizes alternative methods for farmers to dispose of non-compliant hemp. If the product satisfies the quality requirements necessary for human consumption (e.g. lack of contaminants), it could be used to produce cannabinoids. For instance, in Italy – where state authorities have a monopoly on MC domestic production – they could use 'hot hemp' as an input to produce cannabinoids for the medical sector. If law enforcement were to buy non-compliant hemp from farmers at a fixed price, this could repay their production cost and reduce their incentive to sell outside the licit marketplace.

6.1.7. Tax - rather than ban - cannabis products based on their expected externality

In the previous decades, drug policy scholars have discussed how the supply of cannabis could be organized with the consideration of specific public health objectives (Caulkins and Kilmer, 2016; Caulkins et al., 2016; Wilkins, 2018). Pacula et al. (2014) suggest regulating the product content and providing an upper limit on THC content. Nevertheless, unless a cannabis-based product fails to satisfy certain quality requirements (e.g. lack of contaminants), it is unreasonable to ban its trade. A better solution is to regulate these products according to their expected negative externality. To elaborate, I provide two opposite approaches from the regulation of the recreational market in the Americas and C-light in France. Starting from the former, some policymakers argue that products above a certain THC content (e.g. 15%) should not be allowed because of their public health risk[138]. While these products are arguably more dangerous for consumers, such a policy would have the undirect effect of increasing their perceived status as a 'forbidden fruit' as well as shifting their supply towards the illicit market.

[138] https://www.coloradopolitics.com/legislature/bill-on-limits-of-high-potency-marijuana-wins-unanimous-approval-in-committee/article_5edf78fc-b810-11eb-a18f-23496deef4f5.html

Alternative solutions to disincentivize harmful products were adopted by the state of New York and Uruguay. The former decided to impose differential taxation on cannabis products based on their specific typology and THC amount, similar to what is applied to alcoholic beverages[139]. In Uruguay, the content of THC in varieties sold through pharmacies does not exceed 9%, but flowers with higher potency can be obtained through CSCs, applying a de facto sin license on these products.

An opposite approach was recently taken by French policymakers, who were the first to prohibit marketing of CBD. Following the decision of the European Court of Justice, who declared the ban against the principle of free movement, the French government put a new reform in place that prohibits C-light flowers. Whereas the stated objective of the ban is to protect consumers (from combustion) and to maintain the capacity of internal security forces to fight drug trafficking[140], its effect is likely the opposite. Its illicit status will lower the access to C-light in term of availability and price (e.g. risk premiums). The increased transaction costs for the consumer is likely to push a significant number of those who were able to substitute illicit cannabis and tobacco back towards these substances, which are arguably more dangerous. It is also possible that the supply of these flowers will simply shift to the illicit market, with a consequence of not only increasing the initiation of other psychoactive substances, but also poly-drug use among C-light users.

In the future, it is unclear whether cannabis will increasingly be consumed in combination with other substances. In any case, regulators may want to explore regulating the availability of specialty items to disincentivize this behavior and separate the supply of complementary substances. Moreover, a differential taxation level, based on the composition of the cannabis product *and* on the expected mode of consumption, would be a good way to incentivize usage of less harmful cannabis forms. Accordingly, combinations with herbal tea should be taxed differently than combinations with tobacco. For instance, if the marginal damage is proportional with the amount of tobacco, product bundling with tobacco should be subject to increased taxation to discourage their co-use. In parallel, when C-light is sold in its herbal form, rather than in pre-rolled cigarettes, a lower taxation should be imposed. While it is impossible to know whether the final consumer will be smoking or vaping the flowers, the vaporization of

[139] https://taxfoundation.org/new-york-marijuana-tax/
[140] The latter is due to the costs necessary to equip law enforcement with tests capable of differentiating illicit cannabis from C-light. https://www.drogues.gouv.fr/actualites/cbd-notification-projet-de-nouvel-arrete

cannabis should be considered less harmful, as it may alter the complementary relationship between cannabis and nicotine consumption.

Moreover, the impact of the mandatory presence of C-light in stores selling tobacco, alcohol and other addictive substances should be further investigated as a nudging strategy. There is some evidence that these measures may be effective for promoting healthier eating behavior (Bucher et al., 2016). Research is also needed to evaluate whether these interventions may be also a cost-effective way to nudge users of addictive substances towards healthier behavior choices.

6.1.8. Establish a supply architecture to minimize poly-drug use

Pacula et al. (2014) suggested regulating the bundling of cannabis with other inputs. Based on an analysis of the current supply architecture of C-light, it appears inappropriate to sell raw flowers in tobacco shops, as this would incentivize their co-usage. Conversely, imposing mandatory stocking of pre-rolled packets of C-light cigarettes may help certain individuals reduce their tobacco cigarette consumption. At tobacconists, the bundling of nicotine and C-light should be allowed, but taxed more heavily due to the presence of tobacco. This could be a form of nudging to incentivize tobacco users towards healthier choices – such as buying C-light cigarettes - because of their lower price. An even lower taxation should be imposed to those consumers buying raw flowers in specialized shop, where tobacco sales are not allowed, and the expected harm would be lower (or absent) in view of the possibility of vaping them.

6.1.9. Liberalize light cannabis varieties to foster innovation

The differing nature of industrial hemp as a search good and C-light as an experience good with credence quality calls for differential regulation. Accordingly, the first is characterized by homogenous preference. The transformation firm would require a certain level of standardization to produce industrial pieces that require stable varieties. On the contrary, C-light tastes are heterogeneous and dynamically changing. Therefore, demand should decide which varieties are registered, based on their perceived properties[141]. These varieties may move to the medical market if RCTs confirm anecdotal evidence. Using the Chamberlin (1950) trade-off, the loss of satisfaction from a more standardized product is offset by the production gain of industrial hemp units – whereas the contrary is true in the C-light market.

[141] For instance, there is no available variety with high CBG in pharmacies. Patients who believe this rare cannabinoid is more effective of THC and CBD for the their medical condition have the only option to buy it in the C-light market.

As a consequence, specific industrial usage should be incentivized with subsidies to assist the creation of international standards and the development of transformation centers. Only through the standardization of these products will cannabis be able to compete with other raw materials. In contrast, non-industrial uses of non-intoxicating cannabis should be liberalized from the certification requirement to satisfy consumer preferences. There are hundreds and perhaps thousands of different C-light varieties, all characterized by different combinations of active principle components. Thus far, this limit for farmers on varietal choice has created an oligopolistic environment and disincentivizes innovation, even for industrial usage.

6.1.10. Create a specific cannabis agency

As initial regulatory frameworks will affect other cannabis sub-markets, the best option for reducing distortions may be to organize them comprehensively from the outset. This can be done through a temporary task force and with the creation of a national agency. The first was created in the Netherlands, with the goal of regulating the horticulture aspects of cannabis and perform RCTs (Scholten, 2001). Basic public research has had a positive impact on the entry of new drugs (Toole, 2012) and would be incentivized by a national agency – perhaps using revenues from the taxation of the cannabis industry.

Legislators recommend to create a centralized agency in view of the variety of public health and economic issues associated with cannabis trade. The first experiences of legalization have demonstrated the need for the continued engagement to promote timely policy changes as new health or safety issues arise. This requires a competent workforce and close collaboration among government agencies responsible, among the others, for agricultural, law enforcement, health, public safety and finance (Ghosh et al., 2016). At least four EU countries have created a centralized agency to facilitate the collection of data and to organize the emerging cannabis market. Other joint collaborations between cabinet departments and ministers have not worked thus far. First, Italy initiated the production of MC under a pilot project at the Military Chemical-Pharmaceutical Plant. After almost seven years, the military-run agency can only supply one variety, satisfying approximately 10% of the patient demand[142]. Second, the three US departments involved in hemp regulation have incompatible goals. Whereas the US

[142] https://ricerca.repubblica.it/repubblica/archivio/repubblica/2020/10/21/il-fabbisogno-terapeutico-servono-1950-chili-ne-vengono-prodotti-15017.html

Department of Agriculture should design and implement a profitable hemp production program, the Health and Justice departments are advocating for the opposite. The Drug Enforcement Agency continues to focus on products that exceed THC limits. In contrast, the Food and Drug Administration focuses on the approval requirement for products containing cannabinoids.

All in all, it is extremely difficult to educate public servants as experts in cannabis production or regulation due to its complexity and stigmatization. Specialized professionals from different disciplines should be involved in its design. Importantly, economists should be included in the discussion to minimize distortions and improve market efficiency (Roth, 2018).

6.2. New Directions

This thesis raises new questions for future research. Some of these build directly on data that we have already collected, while others call for further exploration and the collection of new data.

Estimate the size of black market post-legalization

The continued increase in sales within the legal cannabis market may indicate the displacement of not only the black market, but also the use of other substances. In the absence of solid indicators of the demand for illicit cannabis, indirect consumer survey measures appear to be the most feasible indicators. C-light users could be an important source of information, as the nature of the product has already been destigmatized and thus the response bias would be negligible. Another population which would help to elicit the impact of legalization on the illicit market are domestic growers. Within the Global Cannabis Cultivation Research Consortium, we have collected information from more than 10’000 cultivators in 18 countries. Results from the survey may provide useful information regarding to the current state of home-growing. Overall, the monitoring of these phenomena before legalization is important for identifying its potential impact on the black market. The establishment of a specific licensing system for home cultivation is also an aspect that warrants further investigation.

Impact of legalization on law enforcement activities

Law enforcement costs dominate public expenditures in the effort to reduce drug problems. Cannabis legalization decriminalizes a series of actions, which will in turn not be punishable by law enforcement. An evaluation of the impact of drug-use criminalization on law enforcement costs could be performed by using data on drug crimes and prison admissions.

Currently, the majority of European countries either depenalize minor offences or even fully decriminalize the consumption of cannabis, and sometimes even the use of other psychoactive drugs. At least 20 countries have legalized the use of cannabis for medical purposes, while others have adopted semi-legal systems, de facto allowing legal access to consumers. Germany, Luxembourg, Malta, the Netherlands and Switzerland are even discussing forms of full legalization to be implemented in the next years. However, certain European countries continue to treat cannabis use as a criminal act—even for minor quantities—by either using specific legal incrimination or holding no legal differentiation between cannabis and other hard drugs.

This project aims to provide a complete account of the various features of European cannabis laws to understand which socio-economic characteristics of the population are leading cannabis reforms. Based on the legal protection of cannabis users and access to MC, a legal classification will be established. Given the wide range of MC provisions and the varying degrees of criminalization for users, the development of a consistent classification will reduce the legislative complexity for future investigations.

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7. Résumé en Français

Le cannabis est la substance illégale la plus consommée dans le monde. Cependant, le terme de cannabis reste entouré de confusion. Il est couramment employé pour désigner les fleurs séchées et les feuilles de l'espèce *cannabis sativa*, mais aussi la plante elle-même. Ses graines et sa fibre sont utilisées depuis des siècles pour produire des aliments et des biens manufacturés, notamment des cordes, des textiles, des chaussures, du papier. L'utilisation de cette plante s'est récemment élargie à la production de bioplastiques, de matériel d'isolation et de biocarburant.

Au siècle dernier, les scientifiques ont découvert que les fleurs et les feuilles de cannabis contiennent des quantités concentrées de produits chimiques psychoactifs connus sous le nom de cannabinoïdes, dont les effets varient en fonction des caractéristiques génétiques de la plante. Les cannabinoïdes peuvent ainsi avoir des effets euphorisants, ou simplement relaxants. Ils peuvent avoir une action dépressive ou stimulante. Ils peuvent diminuer la productivité du travail de certains consommateurs, alors qu'ils sont indispensables pour traiter les symptômes épileptiques chez certains enfants.

Outre les cannabinoïdes, les feuilles et les fleurs sont la source d'autres principes actifs, tels que les terpénoïdes et les flavonoïdes. Ces composants ne sont pas des substances psychoactives, mais ils caractérisent l'arôme et sont importants pour l'effet global perçu par les consommateurs. En outre, il existe des effets synergiques potentiels entre les différentes entités chimiques présentes dans les fleurs. On parle « d'effet d'entourage » : la combinaison des effets des différents composants est supérieure à l'effet de la molécule individuelle. En d'autres termes, les observations cliniques ont suggéré que les extraits de plantes entières ont une efficacité supérieure dans le traitement de maladies ou d'autres états pathologiques à la somme des composants isolés extraits des plantes ou produits synthétiquement (Russo, 2019). D'autres études ont également montré que les consommateurs de cannabis sont affectés différemment par le même chémotype de cannabis (Atakan, 2012), mais aussi que différents chémotypes ont des taux d'efficacité différents pour une même pathologie (LaVigne et al., 2021).

En raison de la variété des usages et des effets du *cannabis sativa*, s'intéresser à l'économie du cannabis conduit à distinguer quatre types de marchés légaux du cannabis aux caractéristiques distinctes :

- premièrement, le marché du chanvre, qui utilise les graines et les fibres pour produire des ingrédients alimentaires ou des matières premières à usage industriel ;

- deuxièmement, le marché médical (ou thérapeutique) pour les patients, qui comprend des fleurs et d'autres dérivés du cannabis pouvant avoir des propriétés psychoactives et dont l'accès nécessite une prescription médicale ;
- troisièmement, le marché (le plus connu) des fleurs et dérivés ayant des propriétés psychoactives, consommés dans un but récréatif ;
- et enfin, le marché du cannabis léger, qui concerne l'utilisation de fleurs et dérivés ayant des propriétés non psychoactives.

Le cannabis léger contient de faibles niveaux de THC, mais une teneur élevée en cannabidiol (CBD), un composé non psychoactif présentant une multitude d'avantages potentiels pour les humains (Britch et al., 2022). L'émergence du marché du cannabis léger était inattendue, car les fleurs à faible teneur en THC n'étaient pas considérées comme une substance intéressante jusqu'à ce qu'elles soient classées comme substituts du tabac en Suisse. Dans l'UE, leur vente n'est généralement pas interdite par les lois sur les drogues, sauf si leur teneur en THC est supérieure au seuil légal. Le cannabis léger est souvent présenté comme le "cannabis légal" et cette légitimation institutionnelle a déclenché le développement d'une nouvelle industrie qui fournit une gamme de produits à base de CBD, tels que des huiles, des crèmes et des lotions. Actuellement, les produits du cannabis léger sont vendus par des magasins spécialisés dans le chanvre, des bureaux de tabac et d'autres détaillants à travers l'Europe (EMCDDA, 2020). Globalement, la création de ce marché résulte de l'évolution constante de l'industrie du cannabis, qui modifie à son tour la nature du produit en s'adaptant à l'évolution de la réglementation afin de satisfaire les préférences des consommateurs.

De la prohibition à la réglementation : le nouveau paradigme politique

Au cours des 50 dernières années de prohibition, la plupart des pays qui ont signé la Convention unique sur les stupéfiants ont adopté une approche plus douce à l'égard du cannabis[143]. Cela s'est traduit non seulement par une moindre application de la loi, mais aussi par des réformes radicales du marché. Un nombre croissant de juridictions ont décriminalisé la possession de petites quantités à des degrés divers en supprimant les sanctions pénales. En 1996, les Californiens ont voté pour autoriser les patients à utiliser le cannabis pour certaines indications médicales. Suite à cela, au moins 50 pays ont légalisé l'utilisation du cannabis médical sous

[143] A l'initiative de l'ONU, la Convention unique sur les stupéfiants est ratifiée en 1961. Elle vise à unifier les réglementations nationales sur les stupéfiants. Dans sa version actuelle (2022), elle compte 186 pays signataires.

certaines formes avec vente aux patients, dont les pathologies varient de sévères à complètement fictives, dans la plupart des juridictions à travers les Amériques et l'Europe. En 2020, les propriétés médicinales et thérapeutiques du cannabis ont été reconnues par l'ONU à travers sa déclassification de la catégorie de stupéfiants la plus restrictive. Depuis 2012, au moins deux pays et 18 États américains ont légalisé la vente de cannabis récréatif, permettant ainsi à au moins 150 millions d'individus de connaître un régime totalement légal.

Alors que le cannabis est toujours illégal au niveau fédéral aux États-Unis, le marché du cannabis récréatif a été principalement légalisé par des référendums initiés par les citoyens. Les décideurs politiques ont dû mettre en œuvre la proposition de vote, qui imposait l'adoption d'un système commercial, avec des ventes autorisées dans des magasins spécialisés sous licence. Le modèle à but lucratif a été conçu en référence au marché du cannabis médical existant qui fonctionne en parallèle avec le marché récréatif dans la plupart des États. Au niveau mondial, seuls deux pays (l'Uruguay et le Canada) ont légalisé le marché récréatif du cannabis, mais ont choisi des modèles différents pour réglementer son offre. L'Uruguay a été le premier à lever la prohibition en choisissant deux options intermédiaires : les pharmacies et les Cannabis Social Clubs (CSC) (Pardal, 2022).

Les CSC sont un modèle d'approvisionnement non commercial, qui existe sous différentes formes dans d'autres pays sud-américains ainsi qu'en Europe. Au Canada, les provinces et les territoires sont responsables de leur modèle de vente au détail, avec une distribution par le biais de magasins de détail exploités par le gouvernement et/ou titulaires d'une licence. Dans la plupart des juridictions, deux autres canaux d'approvisionnement sont disponibles : la culture domestique à petite échelle et la vente en ligne. Les deux sont autorisés au Canada, tandis que l'Uruguay et la plupart des États américains n'autorisent que l'auto-culture - jusqu'à un certain nombre de plantes.

Des travaux universitaires soutiennent que la classification légale d'une drogue comme "narcotique" est fonction de sa détermination sociale et culturelle, plutôt que de ses propriétés intrinsèques (Bergeron and Nouguez, 2015). Aujourd'hui, des dispensaires ont ouvert leurs portes dans la plupart des États américains ayant adopté des réformes concernant le cannabis médical. Les adultes peuvent y acheter légalement des produits à base de cannabis sur recommandation d'un médecin (Duff, 2016). La légitimité du cannabis médical a fondamentalement sapé le raisonnement de la prohibition, selon lequel la consommation de cannabis est nuisible à la santé, quelle que soit son intensité. En conséquence, le cannabis s'est

normalisé dans la société occidentale, passant du statut de drogue à celui de médicament. Indirectement, ces réformes affectent aussi le marché du chanvre en supprimant les difficultés administratives causées par sa ressemblance avec le cannabis psychoactif. Compte tenu de son potentiel environnemental, le chanvre est susceptible de retrouver son statut historique de produit agricole compétitif en tant que produit de base pour différentes industries. Du fait de la puissante influence des États-Unis dans la politique mondiale en matière de drogues et de l'acceptation croissante de la consommation de cannabis par les adultes, les décideurs politiques sont de plus en plus mis au défi de réévaluer l'approche prohibitionniste actuelle.

Depuis que la part des citoyens demandant une réforme du marché du cannabis est devenue majoritaire dans certaines juridictions, le statut du cannabis évolue d'une façon inédite. Le cannabis était principalement utilisé comme plante médicale et sa prohibition ultérieure est un phénomène commun à d'autres marchandises contestées tout au long de l'histoire récente : il commence par exister un marché libre pour le produit ; ensuite, les effets négatifs du marché libre conduisent à une réglementation, qui finit par devenir une interdiction totale. Ce qui s'est passé au cours des dernières décennies est donc tout à fait unique. On assiste à une inversion du phénomène et le statut du cannabis est en fait en train d'être réinstitué comme légal non seulement sur le plan médical et récréatif, mais même à des fins de bien-être (Subritzky, 2018).

Un produit à usages multiples potentiellement dangereux

Dans une certaine mesure, la consommation de presque tous les biens peut être nuisible. Trop manger mène à l'obésité, conduire des voitures mène à des accidents, l'alcoolisme mène à des dommages au foie et fumer du tabac mène au cancer du poumon (Pudney, 2010). L'abus d'opioïdes est considéré comme le principal facteur de diminution de l'espérance de vie aux États-Unis (Muenning et al., 2018). Compte tenu des risques potentiels pour la santé publique découlant de leur abus, le marché de ces "produits du péché" ("*sin goods*") est strictement réglementé à l'aide d'instruments politiques qui imposent des coûts de transaction plus élevés (par exemple, taxation, barrières à l'entrée) afin de limiter leur surconsommation.

Les régulateurs ont traité le cannabis de manière similaire, avec des approches tirées de l'industrie de l'alcool - le cadre de référence pour les substances addictives (Hall, 2017). Les propriétés enivrantes du cannabis ont attiré de nombreux individus vers sa consommation récréative et pourraient être considérées comme similaires à celles de l'alcool et d'autres drogues illicites. Néanmoins, la variété des usages du cannabis en fait un type de marchandise différent. La plante est utilisée médicalement car le système cannabinoïde - un groupe de

récepteurs cannabinoïdes situés dans le système nerveux - est stimulé par les cannabinoïdes. On a découvert que ce système est impliqué dans une variété de processus physiologiques et de fonctions cérébrales, notamment l'appétit, la sensation de douleur, l'apprentissage, la mémoire, l'émotion et le comportement motivé (National Academies of Sciences, Engineering, and Medicine, 2017). En conséquence, il y a eu une explosion de recherches scientifiques sur le potentiel du cannabis médical, concluant qu'un système cannabinoïde fonctionnel est essentiel pour la santé (Ng and Chang, 2022).

Outre ses fins thérapeutiques, il existe tout un éventail d'utilisations techniques et de bien-être dérivées du chanvre. Les milliers d'utilisations potentielles de la production de la plante de cannabis rendent sa réglementation extrêmement complexe. La même plante peut être récoltée à des fins extrêmement différentes, comme les graines pour les denrées alimentaires ou les huiles combustibles, les tiges pour la litière des animaux, les fleurs et les feuilles pour les compléments alimentaires ou les produits pharmaceutiques et les fibres pour la pâte de cellulose ou la fabrication industrielle. Cette caractéristique distingue le cannabis des plantes utilisées pour obtenir de l'alcool et du tabac qui sont récoltées principalement pour obtenir des produits psychoactifs (par exemple, le vin, la bière, les cigarettes). Dans l'ensemble, la réglementation existante relative aux modes de culture et aux normes de qualité tient insuffisamment compte de l'objectif d'utilisation prévu. Les modèles réglementaires qui ne reconnaissent pas la variété des usages du cannabis seront incapables de réguler le marché de manière optimale.

Comparé à d'autres produits agricoles à usages multiples (par exemple, le blé, le maïs), le chanvre a la particularité d'être affecté par les stigmates dérivés du fait qu'il est généralement identique en apparence au cannabis de type psychoactif et que ses fleurs ont une odeur similaire. Néanmoins, lorsque la concentration de THC est inférieure au seuil conduisant aux effets psychoactifs, le produit peut être considéré comme banal, étant donné son absence attendue de propriétés psychotropes. Malgré cela, la plupart des pays qui autorisent le chanvre ont mis en place un système de licence pour la culture légale.

Il existe une autre caractéristique majeure qui différencie le cannabis des produits traditionnels et des autres substances psychoactives légales : ces dernières n'ont aucune utilité médicale apparente. En revanche, le cannabis est considéré cliniquement et par le biais d’observations individuelles comme un analgésique à large spectre - qui pourrait être utilisé en toute sécurité pour traiter de multiples affections douloureuses chroniques. Récemment, il a été constaté que

le cannabis léger peut être aussi efficace que le cannabis psychoactif pour de nombreuses pathologies sans l'effet psychotrope.

Si aucun préjudice apparent n'est associé à la commercialisation de cannabis léger et de cannabis médical, le contraire est vrai pour la consommation non médicale de cannabis. Les preuves existantes sont cohérentes avec les affirmations selon lesquelles elle peut entraîner soit des externalités par le biais des interactions des utilisateurs avec d'autres personnes, soit des internalités lorsque les utilisateurs ne sont pas conscients des méfaits sur leur santé future. Par exemple, des coûts sociaux externes peuvent être imposés aux individus qui ne consomment pas de cannabis, tels que l'inhalation de fumée secondaire, les accidents de la route causés par les effets du cannabis et des dépenses de santé plus élevées. Il peut également y avoir des internalités découlant d'une forte consommation de cannabis. En plus d'entraîner des déficiences cognitives et motrices, une consommation exagérée semble avoir un effet négatif sur les performances scolaires et le développement du cerveau des adolescents (Crean et al., 2011; Marie and Zölitz, 2017; Prashad and Filbey, 2017; Volkow et al., 2014; Wright and Krieg, 2018). Un autre préjudice potentiel pour la santé physique comprend les maladies pulmonaires résultant de l'inhalation, notamment en association avec le tabac. D'autres motifs d'inquiétude concernent la santé mentale, qui semble être moins bonne chez les personnes consommant du cannabis par rapport à la population générale. Les preuves reliant la consommation de cannabis à la manifestation de troubles psychotiques ne sont pas encore claires, car les gènes prédisposants semblent avoir une importance significative (Di Forti et al., 2019). Il existe toutefois un consensus concernant le risque différentiel entre les variétés de cannabis. Le risque de psychose augmente de façon exponentielle avec la teneur en THC et diminue avec une teneur plus élevée en CBD (Schubart et al., 2011). Un certain nombre d'études ont montré que le CBD a l'effet inverse du THC, à la fois sur le plan comportemental et pharmacologique. Néanmoins, d'après les avis d'experts sur les effets internes et externes, le cannabis est moins nocif et moins addictif que d'autres substances légales, comme le tabac et l'alcool (Nutt et al., 2010).

D'un point de vue théorique, l'addiction rationnelle reste le modèle de référence de la demande de biens addictifs (Becker and Murphy, 1988). Il suppose que les utilisateurs reconnaissent leur nature addictive et que, par conséquent, la décision de commencer et de poursuivre la consommation maximise leur utilité actualisée. Toutefois, compte tenu des biais comportementaux, les économistes sont de plus en plus sceptiques quant à sa validité

(Rogeberg, 2020). Le modèle a été étendu au fil du temps pour prendre en compte, dans des modèles à rationalité limitée, différents types de biais, comme l'incohérence temporelle ou le rôle des signaux environnementaux (Bernheim and Rangel, 2005). Alors que le modèle d'addiction rationnelle implique que le niveau de taxation optimal devrait dépendre uniquement des externalités que la consommation de biens addictifs impose à la société, les modèles ultérieurs qui prennent en compte les biais comportementaux suggèrent une taxe beaucoup plus élevée qui dépend également des internalités que cette consommation impose à certains utilisateurs (Gruber and Koszegi, 2001).

Les interrelations des marchés d'un bien à usages multiples

Depuis les années 90, un certain nombre de pays ont autorisé la culture du chanvre et le marché du cannabis léger a récemment émergé parallèlement à l'intérêt des consommateurs pour ses composants. De plus en plus, les pays ont réglementé la consommation de cannabis à des fins médicales et certains pays ont autorisé l'exploitation du marché du cannabis à des fins récréatives. Le fonctionnement de ces nouveaux marchés légaux peut être influencé de manière significative par leurs interrelations avec les marchés existants et par la relation entre les différents sous-marchés du cannabis.

Les interrelations entre les marchés n'étaient pas considérées comme un problème lorsque le commerce du cannabis opérait sur un seul marché illicite. Avant la légalisation complète, la concurrence légale avec le marché illicite s'est faite par l'institutionnalisation de deux marchés. Le premier marché légal visait à établir une offre de cannabis médical pour les patients. Théoriquement, seules les personnes souffrant d'une pathologie pour laquelle le cannabis est efficace peuvent accéder à ce marché par le biais d'une prescription ou d'une recommandation d'un médecin. En concurrence avec le marché illicite, le deuxième marché légal s'est formé en Europe pour le cannabis léger. Bien que les lois sur les drogues n'aient jamais explicitement interdit le cannabis léger, ses propriétés inhérentes étaient inconnues de la plupart des consommateurs et des fournisseurs. Même les producteurs de chanvre ont longtemps minimisé l'utilisation des fleurs pour différencier leur production de la plante psychoactive. Leur objectif a été de maximiser la capacité des forces de l'ordre à distinguer leurs activités légales de celles des acteurs du marché illicite. Dans certains pays de l'UE, les fleurs de chanvre doivent encore être jetées pour obtenir des subventions agricoles. Le gaspillage d'une partie précieuse de la récolte est le résultat de la mauvaise conception du marché du cannabis, qui a longtemps fait obstacle à l'efficacité du marché.

L'Organisation internationale de normalisation (ISO) conseille d'adapter les normes de qualité du cannabis en fonction de l'objectif d'utilisation prévu. Les normes les plus basses devraient être exigées pour l'utilisation industrielle, tandis que les normes les plus élevées devraient être maintenues pour les produits utilisés par les patients à des fins médicales. Les exigences pour les objectifs de bien-être (par exemple les aliments, les cosmétiques) devraient se situer entre les deux. D'un point de vue juridique, les pays adoptent une classification plus simple en distinguant deux types : l'un, sans effets psychotropes, qui caractérise la production de chanvre, historiquement cultivé pour ses graines et sa fibre à des fins industrielles et alimentaires, mais parfois aussi pour les fleurs afin de produire du cannabis léger ; l'autre, avec effets psychotropes, qui caractérise le cannabis à forte teneur en THC, utilisé sur le marché médical et récréatif hautement réglementé. Les fleurs des deux types peuvent avoir des effets thérapeutiques, l'efficacité variant selon l'état du consommateur (Baram et al., 2019). Par conséquent, la taille du marché du cannabis médical sera influencée par la réglementation non seulement du marché récréatif, mais aussi par la réglementation du marché du cannabis léger.

La principale caractéristique distinctive du marché du cannabis nouvellement légalisé est l'existence de multiples marchés interdépendants, qui fonctionnent avec des cadres juridiques différents et peuvent souvent satisfaire la demande des consommateurs de manière interchangeable. Par conséquent, la réforme institutionnelle des marchés du cannabis et leur délimitation ne sont pas seulement fonction de la finalité du produit, mais aussi des marchés légaux adjacents (Kjellberg & Olson, 2017).

Le cannabis léger est l'exemple parfait de ce phénomène unique. Il peut être classé dans plusieurs catégories, à savoir produit agricole, substitut du tabac, médicament, aliment, stupéfiant, drogue récréative ou cosmétique. Il peut donc être acheté avec des exigences de taxation et de qualité différentes sur chaque marché légal (EMCDDA, 2020).

La variété d’usages du cannabis accroît l’opposition à la formation de son marché, car elle implique plusieurs groupes d'intérêt aux intérêts divergents. La substituabilité entre les sous-marchés du cannabis, combinée à la recherche du profit, conduit les groupes industriels à faire pression pour, non seulement maximiser la gamme de produits qui peuvent être vendus dans leur segment spécifique, mais aussi pour restreindre la portée d'autres marchés potentiellement concurrents. Aux deux extrêmes de la production se trouvent les petits producteurs de chanvre et l'industrie pharmaceutique ; cette dernière fait pression pour obtenir les exigences les plus élevées en matière de certification du produit et pour éviter sa vente sous forme de plantes,

alors que les cultivateurs préfèrent des politiques avec un niveau moins élevé de bureaucratie. Du côté de la distribution, il existe de nombreux groupes d'intérêts spécifiques en concurrence : pharmacies, bureaux de tabac et même supermarchés.

Au-delà des différents segments du marché du cannabis, l'organisation de ce dernier subit l'influence des autres industries de substances addictives, notamment l'alcool, les produits pharmaceutiques et le tabac. Premièrement, la conception de la réglementation (par exemple, les taxes, les restrictions d'âge, les licences de vente au détail, le suivi de la semence à la vente) et la nécessité de surveiller les coûts sociaux sont empruntées aux marchés légaux de substances addictives. Deuxièmement, le marché noir est cité comme source d'inspiration sur la façon de structurer la production pour éviter le "Big Cannabis". Le marché légal du cannabis est également susceptible d'avoir des effets sur d'autres marchés. Ces effets d'entraînement seront positifs pour certains marchés qui vendent un produit ou un service complémentaire au cannabis, pour lesquels la légalisation peut entraîner des retombées positives en termes de revenus et d'emplois (par exemple, pour le secteur de la sécurité, du transport, les laboratoires d'analyse, les équipements de culture). À l'inverse, pour les produits et services de substitution au cannabis, l'impact sera négatif (par exemple, cannabis illicite, alcool, tabac, produits pharmaceutiques) (Kjellberg & Olson, 2017).

En résumé, l'identification des interrelations spécifiques est fondamentale pour optimiser la conception du marché. Les types de produits qui peuvent être dérivés de la plante *Cannabis sativa L*. sont le chanvre, le cannabis léger, le cannabis médical et le cannabis récréatif. Les principales interrelations découlent de : la matière première (type de plante) utilisée pour les produire ; le but de l'utilisation (industriel, bien-être, médical, récréatif) et le cadre juridique (légal/illégal). Les interrelations avec d'autres produits pouvant jouer le rôle de complément ou de substitut (tabac, alcool, produits pharmaceutiques) seront également examinées.

Les défis de la conception du marché

Le lauréat du prix Nobel 2012 Alvin E. Roth soutient que les économistes devraient avoir un rôle à jouer dans la création de nouveaux marchés ou dans l'amélioration de ceux qui sont déficients. Il considère la conception des marchés comme une nouvelle partie de l'économie qui s'efforce de comprendre comment la conception des marchés influence leur fonctionnement. Le cannabis est un cas pratique de marché inefficace, car ses transactions sont depuis longtemps criminalisées, ce qui contribue à la formation du marché illicite. Le problème est que, tandis que certaines personnes veulent s'engager dans ce marché en dépit de ses

internalités négatives potentielles, d'autres veulent l'interdire par crainte de ses externalités négatives potentielles. L'impossibilité ex ante de mesurer ces externalités, ainsi que la reconnaissance des coûts et de la perte de recettes fiscales causés par la prohibition, ont conduit les économistes à affirmer que la légalisation du cannabis augmentera le bien-être social, mais que l'ampleur de cette augmentation dépendra principalement des caractéristiques du régime juridique ainsi que des détails politiques spécifiques (Rogeberg, 2018: Ben Lakhdar & Kopp, 2019).

Si certains pensent que la légalisation équivaut à la libéralisation, la réalité est tout autre. La légalisation du marché du cannabis s'accompagne en effet de davantage de réglementation que pour d'autres marchés, car il existe une incertitude quant aux dommages associés à sa consommation. Plusieurs dimensions doivent être prises en compte dans le débat, à savoir la production, la recherche de profit, la promotion des produits du cannabis, la prévention de la consommation à risque, le maintien de l'ordre, les sanctions, la puissance du THC, la pureté (absence de contaminants), l'usage public, la permanence des politiques et le prix (Kilmer, 2019). La conception du marché choisie découlera principalement des différentes priorités politiques qui sous-tendent la légalisation. La santé publique n'est pas le seul objectif, car de nombreux décideurs politiques veulent atteindre d'autres objectifs qui sont en conflit potentiel, comme l'obtention de recettes fiscales, la perturbation du marché illicite, le développement économique ou la maximisation de l'accès des patients.

Globalement, une mise en œuvre réussie se produit lorsque les règles, les institutions et les processus produisent un système conforme aux objectifs politiques (Hudak, 2014). En d'autres termes, ce qui définit une bonne conception dépend de l'objectif que l'on choisit. Dans la plupart des États américains, plutôt que de minimiser la forte consommation, la proposition de légalisation était fondée sur l'objectif de générer des revenus pour les caisses de l'État en choisissant un modèle commercial inspiré de celui de l'alcool. En Uruguay, le président visait à lutter contre le crime organisé et à protéger les usagers, notamment les mineurs : le choix s'est porté sur une architecture d'offre très contrôlée où les consommateurs doivent être enregistrés pour accéder au cannabis et où le gouvernement fixe le prix de détail. Quant au Canada, les objectifs ont varié d'une province à l'autre ; l'État fédéral a défini les règles du jeu, mais le système de distribution est resté sous la responsabilité de chaque province.

Si l'objectif politique est de maximiser l'accès à ceux qui utilisent le cannabis à des fins médicales, le système établi doit impliquer des coûts de transaction minimaux pour obtenir une

prescription médicale, maximiser la disponibilité des variétés de cannabis médical à un prix compétitif (avec remboursement éventuel) et permettre la culture domestique (Pacula et al., 2014). D'autres objectifs tels que la génération de revenus, le développement économique et la minimisation du marché noir peuvent être atteints avec chaque régime légal, mais les caractéristiques de ce dernier dépendront de la combinaison du nombre d'acteurs, du taux d'imposition correctif ainsi que du niveau des ressources consacrées à l'application de la réglementation et à la poursuite des producteurs illégaux (Caulkins et al. 2015).

Cette thèse étudie principalement trois aspects du marché du cannabis : la taxation, l'architecture de l'offre et le type de produit à base de cannabis disponible sur les différents marchés du cannabis. L'objectif est de maximiser le bien-être social pour chacun des sous-marchés du cannabis en les considérant de manière globale et, en parallèle, de réduire la demande de substances plus nocives. Pour ce faire, l'analyse tiendra compte du compromis entre l'efficacité et la diversité de chaque marché en fonction de son objectif d'utilisation prévu. Les principaux outils microéconomiques pour analyser ces aspects sont l'organisation industrielle, le nudging et la discrimination par les prix.

Résumé des chapitres

Cette thèse vise à discuter de manière exhaustive du cadre réglementaire optimal pour chaque marché du cannabis. En s'appuyant sur la théorie microéconomique, le fonctionnement des marchés est examiné dans le but d'améliorer leur efficacité grâce à une meilleure conception. Cet exercice consiste en l'examen de plusieurs situations qui dépendent du type de cannabis, du but de l'utilisation et des dommages ou bénéfices attendus. Il est réalisé en six chapitres. Dans chacun d'eux, après avoir identifié les principales distorsions entre les différents sous-marchés du cannabis (et avec d'autres substances addictives), nous proposons des solutions pour augmenter le bien-être social.

Le premier chapitre présente le cadre d'analyse permettant d'étudier les interrelations entre quatre sous-marchés légaux du cannabis : le chanvre industriel, le cannabis léger (ou CBD), le cannabis médical (ou pharmaceutique) et le cannabis récréatif. Leur potentiel en tant que substituts d'autres substances et produits agricoles est aussi évoqué.

Le deuxième chapitre étudie la conception du marché du cannabis médical en comparant les modèles européen et américain. Il soutient que le degré élevé de diversité des produits, combiné à l'absence d'incitation privée pour les essais cliniques randomisés (RCT), appelle à repenser

son intégration dans le système de santé européen. Dans cette perspective, les Cannabis Social Clubs (CSC) pourraient constituer un canal d'approvisionnement complémentaire aux pharmacies ouvrant droit à un remboursement. Cela conduirait à faire émerger un nouveau paradigme médical reposant davantage sur l'expérience des patients que sur l'expertise des médecins.

Dans le troisième chapitre, nous utilisons des données collectées à l'échelle des comtés du Colorado pour étudier la façon dont les ventes de cannabis médical ont été affectées par l'ouverture de magasins de détail proposant du cannabis récréatif. Nous avons constaté une cannibalisation des ventes de cannabis médical d'environ 10 %. Un certain nombre d'utilisateurs qui achetaient auparavant du cannabis médical sur ordonnance se sont tournés vers le marché du cannabis récréatif. Il est plausible qu'une partie de ces utilisateurs utilisaient le cannabis médical à des fins récréatives et que l'introduction de magasins de détail ait permis de limiter cette distorsion. Nos résultats indiquent que les points de vente de cannabis médical et récréatif peuvent coexister, à condition que le cannabis médical soit plus faiblement taxé que le cannabis récréatif. Des écarts de taxation même faibles peuvent permettre de séparer des segments d'utilisateurs. Ceux qui ont besoin de grandes quantités de cannabis pour des raisons médicales auront tendance à utiliser le marché médical, tandis que les utilisateurs moins fréquents achèteront dans les magasins de détail.

Compte tenu de cette interrelation, le quatrième chapitre examine comment la présence d'un fournisseur intermédiaire peut améliorer la segmentation du marché. Le modèle des CSC est analysé dans un cadre de marché plus large, où les patients achètent dans les pharmacies tandis que les consommateurs récréatifs achètent dans les magasins commerciaux. Nous identifions le prix et les coûts de transaction comme les paramètres à prendre en compte pour maximiser la segmentation du marché entre les utilisateurs médicaux et récréatifs. Le système de discrimination contrôlé par le consommateur qui en résulte permettrait non seulement de réduire les distorsions entre ces deux marchés, mais aussi de réduire la participation au marché illicite dans son ensemble.

Le cinquième chapitre explore la consommation de cannabis léger chez les consommateurs français et italiens en se concentrant sur la combustion des fleurs. Grâce à des enquêtes en ligne, nous montrons que les composants non psychoactifs sont attrayants à la fois pour le bien-être et comme traitement pour des pathologies spécifiques. Un utilisateur sur trois consomme du cannabis léger comme une alternative à d'autres substances. La substitution du tabac par le

cannabis léger est associée à la combustion de fleurs, tandis que ceux qui l'utilisent comme substitut de médicaments ont tendance à privilégier la voie orale. La diversité des produits est surtout appréciée par ceux qui réduisent leur consommation de cannabis récréatif. La substitution à l'alcool est moins fréquente, mais ce mode d'utilisation est susceptible d'augmenter avec le temps, l'expérience de l'utilisateur étant un facteur important. La réduction de la consommation de médicaments sur ordonnance est motivée par leurs effets secondaires.

Recommandations de politiques publiques sur la conception des marchés du cannabis

L'objectif de cette thèse est d'établir des recommandations de politique publique éclairées pour la conception des marchés du cannabis, en étudiant particulièrement la taxation et l'architecture de l'offre.

1. *Établir des normes de qualité différentes en fonction de l'objectif final*

Cette thèse a démontré comment différents segments de marché peuvent satisfaire la demande des consommateurs de manière interchangeable et a identifié les distorsions qui existent entre quatre marchés du cannabis différents. Chaque réglementation étant fondée sur un objectif spécifique, des zones grises subsistent dans chaque segment. Par exemple, lorsque certains composants du cannabis léger ou de ses produits dérivés sont mis sur le marché en tant qu'aliments, des réglementations supplémentaires peuvent s'appliquer, telles que celles relatives aux nouveaux aliments, aux arômes, aux additifs, aux contaminants, aux compléments alimentaires ou aux aliments pour animaux. Lorsque le produit est consommé par des humains, il doit y avoir des normes de qualité minimales concernant la présence de contaminants ainsi qu'un étiquetage précis de l'ingrédient principal (par exemple CBD, THC, CBG). Nous recommandons que les exigences de qualité soient basées sur le groupe de consommateurs finaux. Par exemple, des spécifications rigoureuses devraient être imposées aux patients, compte tenu de leur état de santé vulnérable. A l'inverse, des exigences plus légères pourraient s'appliquer aux consommateurs récréatifs. Actuellement, les réglementations de l'UE ne prennent en compte que les normes de qualité pour le marché du cannabis médical. Il y a un manque de tests sur la teneur en contaminants et en CBD, même parmi les pays de l'UE qui réglementent l'usage inhalé du cannabis léger (par exemple, la Belgique).

2. *Concevoir le système de cannabis médical pour les personnes souffrant de maladies pour lesquelles l'efficacité du cannabis n'est pas démontrée*

Le cadre réglementaire du cannabis médical est le plus important parmi les sous-marchés du cannabis, non seulement parce qu'il affecte tous les autres marchés, mais aussi parce que les patients sont sans doute ceux qui bénéficient le plus de sa consommation. Les politiques de remboursement doivent être mises en œuvre pour maximiser l'accès des patients tout en minimisant le détournement vers des usages non médicaux. Dans la plupart des pays de l'UE, c'est ce dernier objectif qui a prévalu jusqu'à présent. À titre d'exemple, la consommation estimée de fleurs en pharmacie dans l'UE en 2019 était égale à deux mois de consommation par les patients du Colorado. Aux Pays-Bas, le cannabis médical est disponible depuis 2003, mais le nombre de patients enregistrés est resté quasiment constant depuis. Dans ce cas, les coffee shops peuvent mieux satisfaire la demande des patients en raison de leur plus grande diversité de produits.

Parallèlement, la majorité de la production néerlandaise de cannabis médical est vendue à des pharmacies italiennes et allemandes. Dans ces deux pays, il est possible d'obtenir du cannabis médical depuis près de dix ans, mais leur approche réglementaire a été assez différente. En Italie, une part minime des patients obtient le remboursement et il y a une pénurie permanente de cannabis médical, ce qui amène les patients à se tourner vers le marché noir. À l'inverse, une récente décision de la Cour suprême allemande a permis à certains patients de s'auto-approvisionner en cultivant eux-mêmes le cannabis nécessaire à leurs besoins thérapeutiques. Par la suite, une nouvelle réforme intègre le cannabis médical dans le système de santé en permettant le remboursement pour tout type de maladie. Les essais cliniques randomisés n'étant plus nécessaires, la seule exigence est une preuve minimale de l'efficacité du cannabis. Au cas par cas, l'assurance détermine le remboursement de la thérapie à base de cannabis. En quatre ans, le nombre de patients allemands consommateurs de cannabis médical a considérablement augmenté par rapport à l'Italie.

Nous pourrions supposer que la raison sous-jacente de la réforme de la politique allemande en matière de cannabis médical est que les décideurs politiques étaient moins préoccupés par l'utilisation récréative du cannabis médical que par la possibilité pour les patients de cultiver le cannabis médical à domicile. Malgré ses faiblesses, le modèle allemand a fourni un cadre utilisable pour l'intégration du cannabis médical dans le système de santé en reconnaissant les « patients thérapeutiques » (soit les patients souffrant d'une maladie pour laquelle l'efficacité du cannabis n'est pas démontrée, par opposition aux « patients médicaux »). Il devrait être considéré comme la référence de politique publique en Europe.

3. *Établir un canal d'approvisionnement à but non lucratif pour accroître la segmentation et la diversité*

Notre modèle théorique a examiné comment la fixation des prix et des coûts de transaction (par exemple, *sin license*) à travers les canaux d'approvisionnement est fondamentale pour concevoir les marchés du cannabis. Nous avons démontré comment un fournisseur intermédiaire - comme les CSC - peut augmenter la segmentation du marché et la diversité des produits. Les pharmacies ne peuvent pas se substituer entièrement aux dispensaires de cannabis médical, car elles fournissent également d'autres types de médicaments et disposent donc de moins de variétés de cannabis. Les patients peuvent alors être amenés à se déplacer d'une juridiction à l'autre pour trouver leurs produits préférés ou avoir recours au marché illicite. Ce problème a été reconnu dans une résolution du Parlement européen qui a déclaré la nécessité de "fournir un choix sûr et égal pour les patients entre différents types de médicaments à base de cannabis" (European Union, 2019).

Un fournisseur supplémentaire de cannabis médical offrirait un plus grand nombre de variétés. Cela augmenterait non seulement les chances de trouver le meilleur produit pour traiter une maladie spécifique, mais attirerait également la fraction de patients qui croient en l'effet d'entourage. Un deuxième fournisseur pour les patients serait également bénéfique pour l'ensemble du système de santé en termes d'efficacité : si les *patients thérapeutiques* ne sont pas obligés d'obtenir une ordonnance pour accéder aux CSC, les médecins auraient plus de temps à consacrer aux *patients médicaux*. Un autre avantage est la réduction de la distorsion qui découle du fait de traiter les patients comme des "alcooliques". S'ils achètent leurs médicaments dans des magasins de détail, ils paient une taxe corrective. À l'inverse, s'ils peuvent acheter leurs médicaments auprès des CSC, le coût serait plus faible et plus conforme à l'externalité attendue.

En outre, des chercheurs ont montré qu'un modèle sans but lucratif est viable dans le domaine des soins de santé (Horwitz, 2005). Ce modèle est capable d'offrir des produits ou des services qui ne sont pas très rentables et tend à être plus réactif aux changements de rentabilité. Dans le cas du cannabis médical, cela dépend de l'évolution des preuves scientifiques. Une fois qu'un produit spécifique a démontré son efficacité sur une pathologie spécifique, les *patients thérapeutiques* souffrant de cette pathologie peuvent officiellement demander à en bénéficier. Ils deviennent alors des *patients médicaux* et se tournent vers les pharmacies en raison du coût monétaire inférieur.

Enfin, un canal d'approvisionnement à but non lucratif aurait un avantage en termes d'innovation. En l'état actuel, en raison de l'insuffisance des recherches menées sur les patients thérapeutiques, on manque de preuves sur l'efficacité des produits consommés. Les modèles d'approvisionnement à but non lucratif, tels que les CSC, devraient être impliqués dans la recherche médicale. Les dispensaires commerciaux peuvent ne pas avoir suffisamment d'incitations économiques pour collecter des données sur les patients. En effet, une fois l'efficacité des produits prouvée, leur offre risque de se tourner vers le marché médical (par exemple, vers les autorisations de mise sur le marché), réduisant ainsi la variété de produits dans les magasins commerciaux. Il est probable que cette collecte de données serait plus facile à mettre en œuvre dans un environnement à but non lucratif où les membres sont récompensés de façon non monétaire, par exemple en contribuant à l'augmentation des essais cliniques sur l'efficacité du cannabis pour le traitement de nouvelles maladies.

4. Ajuster le paradigme médical en élargissant le type de preuves acceptables

Dans une autre partie de la résolution de l'UE, les décideurs politiques ont demandé aux membres de "s'attaquer aux obstacles réglementaires, financiers et culturels qui pèsent sur la recherche scientifique concernant l'utilisation du cannabis à des fins médicales". Le statut illégal des drogues en vertu des conventions de l'ONU et des législations nationales a eu un impact extrêmement négatif sur la recherche et l'innovation clinique. Un problème supplémentaire est lié aux intérêts privés impliqués dans la fourniture de preuves d'efficacité d'un médicament. En effet, l'incitation économique à investir dans les essais cliniques randomisés dépend de la brevetabilité du produit testé et de la possibilité ultérieure de le vendre à un prix de monopole pendant une certaine période. En plus de ces freins institutionnels, la nature hétérogène du cannabis et l'existence de l'effet d'entourage rendent difficile l'interprétation des preuves actuelles. Dans l'ensemble, l'incitation privée à réaliser des essais cliniques randomisés est insuffisante. Ce manque de recherche privée doit être pris en compte pour le marché du cannabis médical, ainsi que pour d'autres plantes médicinales - surtout lorsqu'elles sont promues comme une panacée.

L'épistémologie utilisée pour déterminer l'efficacité du cannabis et d'autres préparations à base de plantes - celles qui n'ont pas la fonctionnalité de "magic bullet" de la médecine occidentale - devrait être repensée. Le paradigme médical actuel, où les essais cliniques randomisés sont les seules preuves valables, doit être élargi pour être plus conforme aux expériences réelles des patients en utilisant des registres de bases de données mondiales et d'autres résultats rapportés

par les patients (Fortin et al., 2022). Ce type de preuves devrait compléter les essais cliniques randomisés pour combler les lacunes actuelles (Schlag et al., 2021). Les médecins qui prescrivent du cannabis ou d'autres préparations à base de plantes devraient recevoir une formation spécialisée et suivre des cours obligatoires peu dispensés dans les écoles de médecine, sur le système cannabinoïde par exemple. Ils pourraient ainsi utiliser les connaissances traditionnelles ainsi que les essais cliniques randomisés pour adapter les thérapies aux besoins spécifiques des patients. Le système de santé subventionnerait alors les médicaments différemment en fonction de leur rentabilité et de la gravité de la maladie traitée. Pour faciliter le processus, il devrait y avoir un double système de distribution caractérisé par différents niveaux de remboursements. Les médicaments présentant des preuves cliniques solides de leur rentabilité pour les maladies graves seraient fournis par les pharmacies et entièrement remboursés, tandis que les médicaments présentant des preuves moindres - ou utilisés pour traiter des maladies légères - n'obtiendraient qu'un remboursement partiel (ou aucun remboursement pour les maladies très peu graves). Alors que les CSC se spécialiseraient dans le cannabis, d'autres plantes médicinales pourraient être fournies par les herboristes, compte tenu de leur expérience antérieure de ces préparations.

5. *Fournir un débouché licite au chanvre non conforme*

Depuis la légalisation du chanvre aux États-Unis, environ 12 % des surfaces cultivées ont été écartées car les concentrations en THC étaient supérieures au seuil légal dans une partie des lots testés. En conséquence, pour éliminer les plantes non conformes, le ministère américain de l'agriculture a autorisé d'autres méthodes que leur destruction par un opérateur enregistré auprès de la Drug Enforcement Agency. L'assainissement du *chanvre non conforme* est possible par le biais d'un processus consistant à retirer et à détruire le matériel floral tout en conservant les autres parties, ou à broyer la plante entière pour en faire de la biomasse (Federal Register, 2021).

Dans l'UE, la réglementation sur le chanvre ne dit rien sur le traitement des lots dont les plantes ont été échantillonnées et se sont révélées être au-dessus du seuil légal de THC. Indépendamment de la limite de THC, chaque pays où l'on cultive du chanvre devrait mettre en place un système qui autorise des méthodes alternatives permettant aux producteurs d'éliminer le chanvre non conforme. Si le produit satisfait aux exigences de qualité nécessaires à la consommation humaine (par exemple, l'absence de contaminants), il pourrait être utilisé pour produire des cannabinoïdes. Par exemple, en Italie, les autorités publiques ont le

monopole de la production nationale de cannabis médical. Elles pourraient utiliser le *chanvre non conforme* comme intrant pour produire des cannabinoïdes pour le secteur médical. Si les autorités compétentes achetaient du chanvre non conforme aux agriculteurs à un prix fixe, cela pourrait rembourser leurs coûts de production et réduire leur incitation à vendre en dehors du marché licite.

6. *Taxer - plutôt qu'interdire - les produits du cannabis en fonction de leur externalité attendue*

Au cours des décennies précédentes, les spécialistes de la politique en matière de drogues ont discuté de la manière dont l'offre de cannabis pourrait être organisée en tenant compte d'objectifs spécifiques de santé publique (Caulkins and Kilmer, 2016). Par exemple, le contenu du produit devrait être réglementé en imposant une limite supérieure à la teneur en THC (Pacula et al., 2014). Néanmoins, à moins qu'un produit à base de cannabis ne satisfasse à certaines exigences de qualité (par exemple, l'absence de contaminants), il n'est pas raisonnable d'en interdire le commerce. Une meilleure solution consiste à réglementer ces produits en fonction de leur externalité négative attendue. Plus précisément, je présente deux approches opposées de la réglementation, portant sur le marché du cannabis récréatif en Amérique et sur le marché du cannabis léger en France. Concernant le premier marché, certains décideurs politiques affirment que les produits dépassant une certaine teneur en THC (par exemple 15 %) ne devraient pas être autorisés en raison de leur risque pour la santé publique. Bien que ces produits soient sans doute plus dangereux pour les consommateurs, une telle politique aurait pour effet indirect de renforcer leur statut de "fruit défendu" et de déplacer leur offre vers le marché illicite. Des solutions alternatives pour dissuader les produits nocifs ont été adoptées par l'État de New York et l'Uruguay. Le premier a décidé d'imposer une taxation différenciée des produits du cannabis en fonction de leur typologie spécifique et de leur teneur en THC, à l'instar de ce qui est appliqué aux boissons alcoolisées. En Uruguay, la teneur en THC des variétés vendues en pharmacie ne dépasse pas 9 %, mais les fleurs à puissance plus élevée peuvent être obtenues par le biais des CSC, appliquant de facto une *sin license* sur ces produits.

Une approche opposée a récemment été adoptée par les décideurs politiques français, qui ont été les premiers à interdire la commercialisation du cannabis léger. À la suite de la décision de la Cour européenne de justice, qui a déclaré l'interdiction contraire au principe de libre circulation, le gouvernement français a mis en place une nouvelle réforme qui interdit les fleurs de cannabis léger. Alors que l'objectif déclaré de l'interdiction est de protéger les

consommateurs (de la combustion) et de maintenir la capacité des forces de sécurité intérieure à lutter contre le trafic de drogue, son effet est probablement inverse. Son statut illicite réduira l'accès au cannabis léger en termes de disponibilité et de prix (du fait, par exemple, des primes de risque). L'augmentation des coûts de transaction pour le consommateur est susceptible de s'opposer à ce que des consommateurs de cannabis récréatif ou de tabac se reportent sur le cannabis léger, qui est pourtant sans doute moins dangereux. Il est également possible que l'offre de ces fleurs se déplace simplement vers le marché illicite, avec pour conséquence d'augmenter non seulement l'initiation à d'autres substances psychoactives, mais aussi la poly-consommation chez les utilisateurs de cannabis léger.

À l'avenir, il est difficile de savoir si le cannabis sera de plus en plus consommé en association avec d'autres substances. Quoi qu'il en soit, les régulateurs pourraient envisager de réglementer la disponibilité des articles spécialisés pour dissuader ce comportement et séparer l'offre de substances complémentaires. En outre, un niveau de taxation différentiel, basé sur la composition du produit du cannabis et sur le mode de consommation prévu, serait un bon moyen d'inciter à l'utilisation de formes de cannabis moins nocives. En conséquence, les associations avec des tisanes devraient être taxées différemment des associations avec du tabac. Par exemple, si le dommage marginal est proportionnel à la quantité de tabac, les associations de produits avec du tabac devraient être soumises à une taxation plus forte afin de décourager leur utilisation conjointe. Parallèlement, lorsque le cannabis léger est vendu sous la forme d'herbe, plutôt que sous forme de cigarettes pré-roulées, une taxation plus faible devrait être imposée. Bien qu'il soit impossible de savoir si le consommateur final fumera ou vapotera les fleurs, le vapotage du cannabis devrait être considéré comme moins nocif, car il peut modifier la relation de complémentarité entre la consommation de cannabis et de nicotine.

En outre, l'impact de la présence obligatoire de cannabis léger dans les magasins vendant du tabac, de l'alcool et d'autres substances addictives devrait être étudié plus avant en tant que stratégie de nudging. Il existe certaines preuves que ces mesures peuvent être efficaces pour promouvoir un comportement alimentaire plus sain (Bucher et al., 2016). Des recherches sont également nécessaires pour évaluer si ces interventions peuvent constituer un moyen rentable d'inciter les consommateurs de substances addictives à adopter des comportements plus sains.

7. *Établir une structure d'approvisionnement visant à minimiser la polyconsommation de drogues*

Des travaux universitaires suggèrent de réglementer la vente simultanée de cannabis et d'autres produits (Pacula et al., 2014). L'analyse de la structure actuelle de l'offre de cannabis léger montre qu'il semble inapproprié de vendre des fleurs brutes dans les bureaux de tabac, car cela inciterait à leur co-consommation. À l'inverse, imposer le stockage obligatoire de paquets pré-roulés de cigarettes de cannabis léger pourrait aider certains individus à réduire leur consommation de cigarettes de tabac. Chez les buralistes, le regroupement de la nicotine et du cannabis léger devrait être autorisé, mais taxé plus lourdement en raison de la présence de tabac. Il pourrait s'agir d'une forme de nudging pour inciter les consommateurs de tabac à acheter des cigarettes de cannabis léger, en raison de leur prix plus bas.

8. Libéraliser les variétés de cannabis léger pour favoriser l'innovation

La nature différente du chanvre en tant que *bien de recherche* et du cannabis léger en tant que *bien d'expérience* avec une dimension de croyance appelle une réglementation différenciée. Ainsi, le premier est caractérisé par une préférence homogène. L'entreprise de transformation aurait besoin d'un certain niveau de standardisation pour produire des pièces industrielles qui nécessitent des variétés stables. Au contraire, les préférences en matière de cannabis léger sont hétérogènes et changent constamment. Par conséquent, l'expérience des consommateurs est probablement le moyen le plus efficace d'identifier les variétés qui méritent d'être enregistrées, en fonction des conditions médicales (ou nutraceutiques) pour lesquelles la substance est utilisée et de leurs propriétés perçues. Ces variétés peuvent passer sur le marché médical si des essais cliniques randomisés confirment les preuves anecdotiques.

Si l'existence de nombreuses variétés de cannabis léger permet de mieux satisfaire les préférences des consommateurs, et donc d'augmenter potentiellement le bien-être social, c'est l'inverse qui se produit pour les utilisations industrielles du chanvre. Si nous utilisons la règle de Chamberlin (1950) liée au compromis entre la standardisation et la diversité pour le chanvre industriel, les gains liés à l'augmentation de la production permise par la standardisation l'emportent sur les éventuelles pertes de satisfaction résultant d'une moindre diversité - alors que c'est le contraire qui est vrai sur le marché du cannabis léger.

En conséquence, l'usage industriel spécifique devrait être encouragé par des subventions pour aider à la création de normes internationales et au développement de centres de transformation. Ce n'est que grâce à la standardisation de ces produits que le cannabis pourra concurrencer les autres matières premières. En revanche, les utilisations non industrielles du cannabis non-psychoactif devraient être libérées de l'exigence de certification pour satisfaire les préférences

des consommateurs. Il existe des centaines, voire des milliers de variétés différentes de cannabis léger, toutes caractérisées par des combinaisons différentes des principaux composants actifs. Jusqu'à présent, cette limitation du choix de variétés pour les producteurs de chanvre a créé un environnement oligopolistique et a découragé l'innovation, même pour les usages industriels.

9. Créer une agence centralisée spécifique au cannabis

Comme les cadres réglementaires initiaux affecteront d'autres sous-marchés du cannabis, la meilleure option pour réduire les distorsions pourrait être de les organiser de manière globale dès le départ. Cela peut se faire par le biais d'un groupe de travail temporaire et avec la création d'une agence nationale. La première a été créée aux Pays-Bas, dans le but de réglementer les aspects horticoles du cannabis et de réaliser des essais cliniques randomisés (Scholten, 2001). La recherche publique fondamentale a eu un impact positif sur l'entrée de nouveaux médicaments et serait encouragée par une agence nationale - peut-être en utilisant les revenus de la taxation de l'industrie du cannabis.

Les législateurs recommandent de créer une agence centralisée au vu de la variété des problèmes de santé publique et économiques associés au commerce du cannabis. Les premières expériences de légalisation ont démontré la nécessité d'un engagement continu pour promouvoir des changements de politique publique opportuns lorsque de nouveaux problèmes de santé ou de sécurité apparaissent. Cela nécessite une main-d'œuvre compétente et une collaboration étroite entre les agences gouvernementales responsables, entre autres, de l'agriculture, de la santé, de la sécurité publique et des finances (Ghosh et al., 2016). Au moins quatre pays de l'UE ont créé une agence centralisée pour faciliter la collecte de données et organiser le marché émergent du cannabis. D'autres collaborations conjointes entre départements ministériels n'ont pas fonctionné jusqu'à présent. Ainsi, l'Italie a lancé la production de cannabis médical dans le cadre d'un projet pilote mené dans un centre chimique-pharmaceutique militaire. Après presque sept ans, l'organisme géré par l'armée ne peut fournir qu'une seule variété, satisfaisant environ 10 % de la demande des patients. Autre exemple, celui des trois départements américains impliqués dans la réglementation du chanvre qui ont des objectifs incompatibles. Alors que le département américain de l'agriculture devrait concevoir et mettre en œuvre un programme de production de chanvre rentable, les départements de la santé et de la justice préconisent le contraire. La Drug Enforcement Agency continue de se concentrer sur les produits qui dépassent les limites de THC. En revanche, la Food and Drug

Administration se concentre sur l'obligation d'approbation des produits contenant des cannabinoïdes.

Dans l'ensemble, il est extrêmement difficile de former des fonctionnaires en tant qu'experts de la production ou de la réglementation du cannabis en raison de sa complexité et de sa stigmatisation. Des professionnels spécialisés de différentes disciplines devraient être impliqués dans sa conception. Il est important que des économistes soient inclus dans les débats afin de minimiser les distorsions et d'améliorer l'efficacité du marché (Roth, 2018).