

Up in Smoke? The Market for Cannabis

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June 2021

Abstract

Legal access to recreational cannabis continues to expand across the globe. With each new market comes new legal structures and regulations. In this chapter we first review the regulations and market structures of the newly legalized recreational markets in the United States, Canada and Uruguay. We then discuss the emerging literature on the industrial organization of the cannabis industry, which provides new evidence on market competition and the price elasticity of demand. We proceed to review the expanding research on cannabis taxation and the black market. This research has meaningful public policy conclusions for how tax rates and structures affect revenue generation and the black market, key arguments for legalization. We finish by reviewing the public health literature on legalization, and its findings on how legalization has affected cannabis use, dangerous driving, and the use and abuse of other drugs.

*Acknowledgements Responsible Section Editor: Dave Marcotte. The article has benefited from valuable comments of the editors and anonymous referees. There is no conflict of interest.

1 Introduction

The legal status of cannabis has changed around the globe at an astonishing pace in recent years. Canada and Uruguay were the first nations to legalize cannabis for “adult” or “recreational” use. There has been vigorous debate in the popular press and in the academic literature about the choice of words used to describe plants in genus *Cannabis* and the various intoxicating and industrial substances produced from such plants (Dufton, 2017). We use the terms “cannabis” and “marijuana” interchangeably to refer to the spectrum of intoxicating products consumed by humans. 15 states, 3 territories and the District of Columbia allow recreational use in the United States (though not all feature functioning retail marketplaces), while 36 states and 4 territories allow for medical uses of cannabis. Over 40 countries have legalized medical cannabis in some form. This chapter reviews the literature and some key policy questions surrounding legal recreational cannabis.

We first discuss how the legal markets are structured and regulated in the United States, and current evidence on how those markets operate and evolve. Then, we review the emerging public finance literature on cannabis, as revenue generation and black market elimination have emerged as two central motives and justifications for cannabis legalization. Finally, we review the public health findings of the current economics literature. This includes evidence of injuries and deaths, the substitutability or complementarity of other drugs, and the effects on crime. Given that every recreational cannabis market has been preceded by medical markets, where relevant, we reference prior evidence from studies of medical cannabis laws and how those laws or regulations were superseded with recreational cannabis legalization.

2 Market Structure

The various jurisdictions around the world which have chosen to legalize cannabis for adult use have implemented a variety of market structures, meaning that firms at different levels of the production and distribution pipeline may have different levels of market power. These differences were generated in part due to differences in pre-existing medical cannabis systems – some states had relatively liberal systems designed to offer medical cannabis broadly, whereas others were more restrictive – and in part due to the ballot initiative process which implies that structures may have been influenced by what the authors of the initiatives would sound appealing to voters. Since market power can play a key role in determining the impact of policies (Miravete et al., 2018), understanding the differences in market structure and regulation across jurisdictions is key to understanding differences in outcomes. This section outlines the legal frameworks in different jurisdictions and summarizes the current literature related to the structure of recreational cannabis markets.

2.1 Legal frameworks

In general, the frameworks through which jurisdictions have chosen to legalize cannabis sales are more restrictive than for nearly any other industry. Nearly all jurisdictions identify a three-step supply chain: production/cultivation, processing/product manufacture, and retail. Generally speaking, separate licensing requirements apply to firms participating in each part of the market, and each person or organization with a financial interest in a cannabis-related firm must obtain a license from the government. Laboratory firms which perform testing services have separate requirements as they interact with firms throughout the supply chain. Typically these restrictions include the provision that laboratory licensees must be financially independent from other licensees in the cannabis supply chain. Local authorities are often given broad latitude to impose entry restrictions (including entry bands), apply zoning restrictions, and require local licenses. Many jurisdictions have some degree of both vertical and horizontal ownership restrictions. The international variation in medical and recreational legal status and market availability is summarize in Table 1. We proceed in this section by detailing the market structure rules in jurisdictions with fully legal operating recreational markets as of June 15, 2021. Note that while the Netherlands “tolerates” the sale of cannabis products in licensed “coffeeshops,” those sales are not conducted under a framework similar to any of those described in this section.

2.1.1 Alaska

Alaska legalized adult-use sales via ballot initiative in 2014. Measures which legalized personal possession and cultivation went into effect on February 24, 2015, and the first retail sales occurred on October 29, 2016. The state does not limit entry. Licensees must be residents of the state (3 AAC 306.015(b)) and must never have been convicted of a felony, nor a misdemeanor related to cannabis within two years of submitting an application (3 AAC 306.010 (d)).

Cultivation licenses are split according to the area under cultivation to “limited” licenses which must have 500 square feet or fewer under cultivation and “standard” licenses which do not have cultivation area limits. Manufacturers of concentrate products must obtain an additional license beyond a simple “product manufacturing” license. Individuals may have multiple licenses within the supply chain – vertical integration among production, processing, and retail functions is permitted.

2.1.2 Arizona

Arizona legalized adult-use sales via ballot initiative in 2020. Personal possession and cultivation was immediately legalized upon passage of the initiative, and the first licensed retail sales occurred on January 22, 2021. Individuals previously convicted of cannabis-related offenses may petition for expungement as of July 12, 2021 (ARS §36-2862). The Arizona Department of Health Services is the state-wide regulatory authority. Localities are permitted to impose

additional zoning and related regulations on cannabis firms, including prohibiting local entry, though any local regulations may not be more restrictive than comparable rules for medical cannabis dispensaries (ARS §36-2857).

Entry is limited to one cannabis retailer per ten licensed pharmacies statewide, though additional licenses were reserved for social equity purposes (ARS §36-2854). A single “marijuana establishment” license entitles a firm to open a single retail location, a single cultivation location, and a single manufacturing location. Marijuana establishments may purchase cannabis products from each other (Ariz. Admin. Code §9-18-308) – thus vertical integration is permitted but not required. Licensees and employees of cannabis firms must not have been convicted of certain felony offenses. Individuals may obtain multiple licenses (ARS 36-2858).

2.1.3 California

California legalized adult-use sales via ballot initiative in 2016. Personal possession and cultivation was immediately legalized upon passage of the initiative, and retailers opened on January 1, 2018. The state does not limit entry. In contrast to other states, which generally allow jurisdictions to opt-out, local jurisdictions must opt-in to allowing sales. While the state does not impose a residency requirement for licensees, local jurisdictions may do so. Local jurisdictions may also impose criminal behavior requirements.

California assigns regulatory authority according to the type of cannabis-related activity. The California Department of Food and Agriculture regulates cultivators, the Bureau of Cannabis Control regulates retailers, distributors, and laboratories, and the California Department of Public Health regulates manufacturers of cannabis-infused edibles. Vertical integration among producers, processors, and retailers is permitted.

2.1.4 Colorado

Colorado legalized adult-use sales via ballot initiative in 2012. Personal possession and cultivation was legalized on December 10, 2012, and retail sales began on January 1, 2014. The state does not limit entry. Licensees must demonstrate one year of residency prior to application, and must not have been convicted of crimes involving controlled substances for the ten years prior to application.

In contrast to other jurisdictions, Colorado originally required retailers to have vertically integrated production and processing facilities through a “70/30” rule under which retailers were required to self-manufacture 70% of the product it sold, those rules were sunset at the state level on October 1, 2014. Localities may still impose vertical integration requirements.

2.1.5 Illinois

Illinois legalized adult-use sales via legislative act in 2019. Provisions allowing for both personal possession and retail sales went into effect on January 1, 2020.

The state caps entry and awards licenses by population in each region identified by the Bureau of Labor Statistics. License applicants were scored by regulators based on a set of criteria including plans for employee training, security and record-keeping, operating procedures, knowledge and experience, social equity status, and environmental protection, among other criteria. Licenses were awarded to those receiving the highest scores in each region. The state does not impose a residency requirement for licensees, though applicants who could demonstrate continuous residency for 5 years received a small application score bonus. Vertical integration is permitted.

2.1.6 Maine

Maine legalized adult-use sales via ballot measure in 2016, and its provisions allowing for personal cultivation and possession became effective on January 30, 2017. However, the introduction of the retail market was delayed by political disagreements between the state’s legislature and its governor. Retail sales began on October 9, 2020 under the regulatory authority of the newly-created Office of Marijuana Policy under Maine’s Department of Administrative and Financial Services. The state does not limit entry, but localities may. License applicants must be residents – corporate applicants must be majority-held by residents (MRS 28-B Ch. 1-2 §202) – and must not have been convicted of non-cannabis-related drug offenses (18-691 CMR, Ch. 1 Sec. 2.3.1).

Maine differentiates production licenses into four tiers according to the allowed cultivation area from 500 square feet to 20,000 square feet. Vertical integration among producers, processors, and retailers is permitted though not required. Licensees are limited to a maximum of 3 cultivation facilities with a total of 30,000 square feet under cultivation. License holders may not have a financial interest in more than 4 retail locations until January 1, 2022 (MRS 28-B Ch. 1-2 §202).

2.1.7 Massachusetts

Massachusetts legalized adult-use sales via ballot initiative in 2016, and its personal consumption and cultivation provisions became effective on December 15, 2016. The first retail sales occurred on November 20, 2018. The state does not limit entry, though localities may. While residency is not required for most licensees, certain licensing programs including social equality licenses require 12 months of residency prior to application. Massachusetts bans those who have been convicted of felonies from being a ‘controlling person’ within a business, though convictions for possession of a controlled substance are exempt from this restriction.

Massachusetts issues tiered licenses to producers based on the area under cultivation; the lowest tier permits cultivation of up to 5,000 square feet and the highest tier allows up to 100,000 square feet. Vertical integration is permitted, though licensees are limited to three licenses in each category.

2.1.8 Michigan

Michigan legalized adult-use sales via ballot initiative in 2018, and its personal consumption and cultivation provisions became effective on December 6, 2018. The first retail sales occurred on December 1, 2019. The state does not limit entry, though localities may. While two years of residency were required for initial license applicants, the requirement will sunset on December 6, 2021. License applicants must not have been convicted of felonies for ten years nor crimes of any kind related to controlled substances for five years prior to application.

Michigan differentiates production licenses by the number of plants which may be cultivated simultaneously – either 100, 500 or 2,000. The fees for these licenses are both large and non-linear; a license to cultivate 100 plants costs \$4,000 per year, while a license to cultivate 2,000 plants costs \$40,000 per year. Vertical integration is permitted, though licensees may not hold more than 5 production licenses. These production licenses may be “stacked” to permit a single establishment to cultivate up to 10,000 plants.

2.1.9 Nevada

Nevada legalized adult-use sales via ballot initiative in 2016. Personal consumption became legal on January 1, 2017, though personal cultivation is banned unless the individual lives more than 25 miles from a licensed dispensary. Retail sales began on July 1, 2017. The state limits the number of licenses in each city and county according to its population. License applicants were scored by regulators based on a set of criteria including business operation experience (particularly medical cannabis experience), diversity of ownership, educational background, financial resources, plans for security, and “the amount of taxes paid and... civic and philanthropic involvement,” among other criteria. Residency is not required. Applicants must not have been convicted of a felony in the ten years before applying. Vertical integration is permitted, though individuals and firms may not hold more than 10 percent of the licenses allocated to any county in which they are operating.

2.1.10 Oregon

Oregon legalized adult-use sales via ballot initiative in 2014, and its personal use and cultivation provisions became effective on July 1, 2015. Retail sales began in medical dispensary locations on October 1, 2015; the full recreational licensing system became effective on January 1, 2017. The state did not initially limit entry (though localities could), although it restricted entry of new producers starting on September 1, 2019. Oregon’s regulatory agency “paused” the processing of new applications for processors and retailers in June 2018, and as of April 2020 has not issued any new licenses of these types. See https://www.oregon.gov/olcc/docs/news/news_releases/2018/Application_temp_stop_final.pdf Oregon does not impose residency requirements for licensees, nor does it impose strict criminal history requirements, though convictions “substantially related

to the fitness and ability of the applicant to lawfully carry out activities under the license” may be used as regulators as grounds to reject license applications.

Oregon differentiates production licenses by tiers and indoor/outdoor growing areas – the smallest tier allows for 625 square feet under cultivation indoors or 2,500 square feet outdoors, while the largest tier allows up to 10,000 square feet indoors or 40,000 square feet outdoors. Vertical integration is permitted; there are no limits on the number of licenses which may be owned by a single entity. While multiple producers may be located in the same physical location, they must *not* have any common ownership interest.

2.1.11 Washington

Washington legalized adult-use sales via ballot initiative in 2012, and its personal possession and cultivation provisions became effective on December 6, 2012. Retail stores opened on July 8, 2014. The state limited the number of entrants in each city and county according to its population; in locations with more applicants than allocated licenses, licenses were awarded by lottery. Applicants must have resided in the state for six months prior to application. Criminal records were grounds for application denial based upon the number and severity of felony convictions within the past 10 years and misdemeanor convictions within the past three years.

Washington differentiates production licenses by tiers – the smallest tier allows for cultivation of up to 2,000 square feet, and the largest tier allows up to 30,000 square feet. Vertical integration between producers and processors is allowed, though retailers must be independent from all other licensees. An individual may have a financial interest in up to five retail licenses or three processor and/or processor licenses.

2.1.12 Canada

Canada legalized cannabis for adult use at the federal level via legislation on June 19, 2018. The provisions concerning individual possession came into effect on October 17, 2018; home cultivation is allowed in all provinces except Quebec and Manitoba. While all commercial production is done by private firms, the law allowed individual provinces broad authority to either regulate private retail outlets, open government-owned stores, or both. Alberta, British Columbia, Manitoba, Newfoundland and Labrador, Ontario, and Saskatchewan allow private retailers, while Alberta, British Columbia, New Brunswick, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, and Yukon have government-owned retail locations. Online sales are available in all provinces through government-operated sites, except in Manitoba and Saskatchewan where online offerings are through private firms.

Production and processing operations are federally regulated and may be integrated. Provinces with private sales generally have restrictions on the number of permitted entrants (though that number varies substantially across provinces) and do not permit licensees to have substantial financial interests in producers.

Some limited connection may be allowed; for example, Ontario allows producers to have a 25% stake in retailers (O. Reg. 468/18, s. 7; O. Reg. 426/19, s. 2.).

2.1.13 Uruguay

Uruguay legalized cannabis for adult use in December 2013 – its personal cultivation and consumption provisions went into effect in August 2014. Much private production takes place through “growers’ clubs” which were authorized to grow up to 99 cannabis plants per year starting in October 2014. Retail sales are heavily regulated by the government, which permits two firms to cultivate cannabis plants and sixteen pharmacies to sell usable marijuana to Uruguayan citizens.

2.2 Literature

Given the relatively recent legalization of adult-use cannabis, its unique position as a previously illegal recreation drug, and the unclear relationship between cannabis and other substances, much of the existing literature in the area of market structure and evolution has focused on understanding supply and demand primitives. Prior to legalization, researchers largely focused on surveys of cannabis use to estimate demand primitives – see Pacula & Lundberg (2014) for a review. For example, Jacobi & Sovinsky (2016) used data from the Australian National Drug Strategy Household Survey between 2001 and 2007 to estimate a price elasticity of demand of roughly -0.2 and to predict that legalization in Australia would increase participation from 13.1% to 19.4%. On the supply side, Caulkins (2010) used agricultural industry comparators to estimate a total wholesale commercial production and processing cost of \$90-\$240 per pound.

Post-legalization, researchers have focused on analyses of Washington’s market as the state releases comprehensive “seed-to-sale” data on its adult-use market collected through its traceability system. While the U.S. federal enforcement regime requires all states to closely monitor their adult-use market (Cole, 2013), as of this writing only Washington has made their data freely available to researchers. See Hansen et al. (2020,c) for an overview of these data and Williams et al. (2017) for a critique of some of the details of Washington’s data reporting and processing systems. Figure 1, reprinted from Hansen et al. (2020), summarizes the evolution of Washington’s cannabis market from its opening in early July, 2014, to June 2017. Mean prices for “usable marijuana” – the dried flower buds of the cannabis plant – were initially between \$25-\$28 per gram, but quickly dropped. By July 2015, mean retail prices were approximately \$12 per gram and by June 2017, the mean price had fallen below \$10 per gram. At the same time, potency, as measured by the concentration of THC (one of the primary psychoactive elements of cannabis) increased from a mean of approximately 13% shortly after the market opened to over 20% by June 2017. Over the same period, quantities increased from less than 100 kilograms per week to nearly 2,000 kilograms per week.

Hansen et al. (2020b) study the response of Washington’s market to the opening of a neighboring market in Oregon, arguing that the shock represents an exogenous negative shock to demand in Washington. Using a differences-in-discontinuities estimator, they estimate that prices at retailers immediately along the border decreased by approximately 3.5% and the weight of cannabis sold decreased by 36% and infer that the short-term price elasticity of supply is 10, though they caution that the institutional details of the cannabis industry may imply that a response to an unexpected increase in demand may differ significantly from their estimate. Mace et al. (2020) use the same demand shock along with data on the distance between retail locations to estimate a price elasticity of supply between 1.38 and 1.46. Furthermore, they use data taken from a survey of cannabis retailers in Colorado, Oregon, and Washington to estimate a price elasticity of demand of -1.84.

A separate series of papers focus on using the broader time series to estimate demand conditions. Smart et al. (2017) and Caulkins et al. (2018) describe the variation in prices and potency in the raw data over time. Hansen et al. (2020) focus on demand for potency – they estimate a log-log model of demand for cannabis flower that includes comprehensive fixed effects and instrument for prices using wholesale prices. They find a market-level price elasticity of -1.20 and a THC-elasticity of 0.61. These results align with those of Shi et al. (2019), who use an online survey with discrete choice experiments to elicit preferences for different cannabis products and find that price is generally perceived as a more important product attribute than THC concentration. Miller & Seo (2018a) examine the relationship between cannabis, alcohol, and tobacco. Using the Washington traceability data and Nielsen scanner data on retail alcohol and tobacco sales, they estimate a price elasticity of demand for cannabis flower of -1.74 and that cannabis, broadly speaking, substitutes for alcohol and tobacco – mostly through liquor (as opposed to wine or beer) and cigarettes (as opposed to other tobacco products). Irvine & Light (2020) use these estimates to forecast the effects of legalization on tax revenues in Canada and conclude that due to the relatively large taxes on existing sin goods, much of Canada’s cannabis revenue may be offset by losses elsewhere – though income and corporate taxes may increase as well.

Hollenbeck & Uetake (2019) focus on the question of market power within Washington’s industry. Using a random coefficient nested logit demand model and instrumenting for the retail price with upstream prices and weather shocks, they estimate product-level price elasticities of demand between -2.8 and -3.5 and an aggregate elasticity of cannabis close to -1. On the supply side, using the sufficient statistic framework of Weyl & Fabinger (2013), they estimate that retail margins in the industry are 89% of a hypothetical monopolist’s margins, and conclude that Washington’s cap on entry has resulted in substantial retail monopoly power at the local level.

Thomas (2018) examines the welfare impacts of the retail license quotas imposed by Washington’s legal framework. They construct a model of endogenous entry with a nested logit model of demand and estimate product-level demand elasticities for flower products between -2.4 and -3.4 and a market-level demand

elasticity of -0.78. They take advantage of geographic differences in the degree to which the quotas bound the ability of entrepreneurs to enter in order to estimate that free entry increases surplus by 18% over Washington’s system – mostly by reallocating resources across geographies according to local demand characteristics.

Giroldo & Hollenbeck (2020) consider another outcome of Washington’s lottery: random variation in the size of firms, as measured by the number of retail licenses allotted to each firm. They find that, relative to single-store firms, multi-store firms pay lower wholesale prices, offer larger product assortments, charge lower margins, and earn higher per-store profits. They conclude that concentration in the retail sector offers efficiencies which benefit both the concentrated firms and consumers.

Escudero (2018) examines pricing behavior in the industry and challenges the usual assumption of the industrial organization literature that the observed prices set by firms are optimal responses to external conditions. They use the linkage between retail and wholesale prices in the Washington data to argue that cannabis retailers predominantly follow “keystone pricing” in which the retail price is set at double the wholesale price. They write a mixed-logit demand model with transportation costs and estimate a mean product-level price elasticity of demand of -4.38. They perform a counterfactual profit maximization exercise and conclude that the keystone pricing strategy nets firms approximately 75% of the variable profits they could obtain through profit maximization.

Berger & Seegert (2020) focus on financial frictions within the cannabis industry which arise from conflicts between state legalization statutes and federal laws which effectively forbid banks organized as national associations from interacting with cannabis-related businesses. Jensen & Roussell (2016) interview a number of actors within the cannabis industry and detail these frictions qualitatively. Using the distance between dispensaries and state credit unions which chose to accept cannabis-related accounts in Washington state as an instrument to measure access to banking, they find that such access increases profits by 40%-50%, largely through allowing dispensaries to interact with suppliers more easily.

Several papers examine the effect of adult-use cannabis laws and dispensaries on housing prices. Cheng et al. (2018) exploit variation in the adoption of municipal retail laws in Colorado and estimate that legalization leads to a 6% increase in housing values. Kim et al. (2020) use an identification strategy based on the staggered construction of dispensaries in Washington and Colorado and similarly conclude that retail entry increases home prices in the surrounding neighborhood by 6% – across all states they find that successful legalization ballot initiatives increase prices by 10% for the top half of the home price distribution. Indeed, Zambiasi & Stillman (2020) use data from the American Community Survey along with a synthetic control method to examine migration patterns in and out of Colorado around legalization and conclude both that potential in-migrants viewed legalized cannabis as a positive amenity and that legalization did not affect out-migration. However, Thomas & Tian (2020) employ a triple difference model and take advantage of Washington’s random

assignment of retail licenses in areas where entrepreneurial demand outstripped Washington’s population-based quota to estimate that home prices very close to dispensaries – within a third of a mile – drop by between 3-4.5%. These differences are possibly driven by increases in nuisance-related crimes or changes in local consumption behavior: Ambrose et al. (2019) use survey data from the Behavioral Risk Factor Surveillance System and estimate an elasticity of use with respect to travel time of -0.12.

3 Taxation and the black market

Jurisdictions are generally motivated to move from decriminalization to legalizing the retail sale of cannabis products for a number of reasons. Two points commonly raised by advocates for legalization are the potential for taxation and the possibility of eliminating the black market. The former has been especially salient when setting up recreational cannabis markets, although medical markets are also sometimes taxed. These two goals are often at odds with one another – to the extent that increasing taxes on legal cannabis increases the price, those increases may encourage substitution from legal retailers to black-market suppliers. This is particularly salient when legal markets first open as prices are often quite high. In this section, we provide a background on taxation, the black market, their interplay, and the lessons we have learned from jurisdictions that have started selling cannabis as of June 15, 2021.

3.1 Taxation

Jurisdictions have decided to sell recreational cannabis partly for the tax revenue. There has been tremendous variation in tax rates by jurisdiction, and implicitly, the trade off between revenue and reducing the size of the black market. Recreational cannabis tax rates by jurisdiction can be found in Table 2. Beyond raising revenue, cannabis taxes have also been suggested as a way to address the potential negative externalities of cannabis. We discuss what we know about the existence and magnitude of externalities in Section 4. While all of the jurisdictions which have legalized cannabis for recreational use have imposed taxes on that use, a number of jurisdictions also tax medical cannabis, which we will discuss at the end of this section.

Uruguay is at one end of the taxation spectrum – the government has decided to focus on crowding out the black market and so have set a “variable fee” instead of a fixed tax rate. This way Uruguay can set the rate in real time, so that it can keep legal cannabis prices competitive with those in the black market (Walsh & Ramsey, 2016). Another unique feature of the Uruguayan system is that foreigners cannot purchase cannabis, which eliminates the possibility of raising revenue from cross-border shopping, which Hansen et al. (2020b) find is substantial in the United States.

Canada and U.S. states are more equally focused on raising tax revenue and eliminating the black market. In the U.S., most states with recreational

cannabis markets have legalized them by ballot initiative, which means that tax policy has been determined partly by what was believed by the authors of those initiatives to sound best to voters in those states. Allegedly, Graham Boyd, an attorney, consultant, and the former director of the ACLU's Drug Law Reform Project (along with a lot of market research) has played a dominant role in designing these initiatives. Two ballot initiatives in two states – Ohio and Arizona – with which he was not involved have failed. See e.g. Iannuzzi et al. (2003) and Piomelli et al. (2018). This has led to an incredibly diverse set of tax schemes across states in the U.S.

The diversity of policies across the U.S. states have provided a testing ground for different taxation schemes (and market structures). Both the tax rates and tax bases vary substantially across states. Most states have a retail excise tax and these rates vary from 10 percent to 37 percent (see Table 2). Many states also have taxes on cultivators. Three states have changed their tax rates since legalization – Washington eliminated its gross receipts tax in favor of an increased retail excise tax, Massachusetts increased its tax rate from 3.75 percent to 10.75 percent and Colorado increased its excise tax rate from 10 to 15 percent. California also implicitly increased its tax rate by increasing the markup rate, which is used in the formula to calculate its retail excise tax. Hansen et al. (2020c) show that Washington's original gross receipts tax encouraged excess vertical integration and decreased output relative to the 37 percent excise tax Washington has now.

Only Alaska, Arizona, Massachusetts, Michigan, and Oregon initially imposed taxes at a single point in the supply chain – all at retail except Alaska who has imposed a cultivation tax (and an optional local retail sales tax). In a market with no formal cross-border trade, such as this one, a standard economic model predicts taxing at multiple points in the supply chain will increase enforcement costs without changing who ultimately bears the burden of the tax. The only other potential justification for taxing at multiple stages of production is if this system effectively creates a third-party reporting system, as it does for the VAT (Kleven et al., 2016, Kopczuk & Slemrod, 2006, Slemrod, 2008). However, no set of taxes in this market has that design. The fact that we see so many states implementing these taxes at multiple stages of production suggests voters have either missed a fundamental lesson of tax incidence – in a standard model, you don't need need to tax every point in the supply chain for all firms to bear some of the tax burden – or that they don't believe that tax invariance holds in practice. There is increasing evidence that tax invariance does not hold in practice under certain conditions (Slemrod, 2008, Chetty et al., 2009, Kopczuk et al., 2016). And Hansen et al. (2020) finds that invariance does not hold in the cannabis market in Washington state.

Hollenbeck & Uetake (2019) examine tax incidence, revenue maximization, and deadweight loss in Washington state. Washington state has the highest recreational cannabis tax rate worldwide – a 37 percent retail excise tax (plus state and local sales taxes) – and Hollenbeck & Uetake (2019) demonstrate that Washington's market structure has given retail firms substantial market power. Hollenbeck & Uetake (2019) finds that even this extremely high rate is on the

right side of the Laffer curve, meaning that raising the tax rate will still increase tax revenue. Moreover, tax revenue is substantially higher in Washington given its firms' market power than it would be if the state had set up a structure that encouraged perfect competition. Consumers bear about two-thirds of the tax burden in Washington state – they would bear substantially less in a perfectly competitive market. Given the substantial market power in this market, the lost surplus for each dollar raised they estimate is large – for every dollar increase in revenue lost consumer and producer surplus is \$2.40. This calculation would obviously change with changes in market power, tax rates, and if there were positive or negative externalities associated with cannabis consumption, among other things.

Prices in many states have fallen over time, which has been helpful for driving out the black market – we will discuss this in more detail in Section 3.2. However, this has caused many states to start to worry about revenue declines. It is not the case that states are seeing actual declines in revenue, but rather a decline in revenue per gram, and so revenue is not growing as fast as it would have if prices (and hence revenue per gram) had remained constant. For example, in 2016, Washington state generated roughly 20% less revenue than it anticipated before legalization (Miller & Seo, 2018b, Washington Office of Financial Management, 2013). The initial prices often reflect an industry ramping up production and access and were never going to reflect prices in the long-run, but this has not dampened frustration felt by lawmakers. Cannabis prices may continue to fall dramatically. Jonathan Caulkins has suggested that prices may ultimately fall as low as other easy-to-produce plants and the tax revenue stream may ultimately be lower than the administration costs to the state (Humphreys, 2018). Of course, this partly depends on the market structures that each state has chosen to adopt and, as discussed in Section 2, the market structures adopted by many states are not likely to be conducive to such low prices any time soon.

Declining prices, along with increasing THC content (Chandra et al., 2019, Hansen et al., 2020) and worries about whether highly potent cannabis creates the largest externalities, has induced states, such as Washington and California to start considering potency taxes (Liquor and Cannabis Board, 2019, Petek, 2019, Sheeler, 2019). And New York, whose market is slated to open in 2022, intends to have a potency tax. Hansen et al. (2020) examines the possibility of a potency tax for usable marijuana and finds that a potency tax is unlikely to raise more revenue than Washington state's current excise tax. Potency in usable marijuana is much more difficult to measure reliably than alcohol content, for example, both because the tests are less reliable – two tests on the same sample may come back with different results – and THC content varies across plants and even within an individual plant. Trying to tax such a base is extremely challenging for a number of reasons, not the least of which is that it opens up the possibility of substantial tax avoidance or hard-to-detect evasion. These challenges are mostly specific to the usable marijuana category of cannabis sales. Canada imposes taxes based on THC only for categories other than usable marijuana – oils, extracts, edibles, and topicals.

Canada has another answer to the conundrum of falling prices that is related

to what some U.S. states have also tried – taxing cannabis on weight rather than price – but Canada has added an additional wrinkle. Like Uruguay, Canada also legalized cannabis federally through legislation. Their tax rate is the maximum of 10 percent or \$1 per gram. This effectively put in a tax revenue per gram floor – when cannabis prices fall below \$10 per gram, tax revenue per gram will be stopped from falling any further. Without further regulation, this may do the opposite of a potency tax – encourage more potent products to deliver the same experience while owing less in taxes.

Whether medical cannabis is taxed, and if so, at what rate, varies tremendously by jurisdiction as well. Within the U.S., almost two-thirds of states tax medical cannabis by either leaving the state and local sales taxes imposed, imposing a separate excise tax, or occasionally both. The legalization of recreational cannabis has increased the taxation of medical cannabis because multiple states that previously did not tax medical cannabis, now impose at least some of their recreational cannabis excise taxes on medical cannabis as well. Alaska, California, Nevada, and Washington have done this. Michigan is the only state to introduce a net tax cut for medical cannabis when introducing a legal recreational market. Washington state imposes the highest medical cannabis taxes in the United States – they impose the same 37 percent retail excise tax on their medical and recreational cannabis. Canada also taxes medical cannabis at the same rate as recreational cannabis, but they have recently introduced a partial tax subsidy for medical users. In other countries, such as Germany, medical cannabis is not taxed.

3.2 Shrinking the black market

Shrinking the black market has been another salient reason for cannabis legalization. In this section, we consider black market activity and what may determine its decline. We divide black market activity in the context of legal markets into three main types: (1) black market production and sales which take place in a jurisdiction which has legalized (2) growing cannabis in the legal jurisdiction and transporting it to sell in other jurisdictions where it remains illegal, and (3) consumers in jurisdictions where it is illegal traveling to purchase it in jurisdictions where it is legal and bringing it back to their home jurisdiction.

All three aspects of the black market likely exist in any taxed and tightly regulated market. For example, the WHO developed an international treaty in 2012 to address illicit cigarette sales and there is a substantial literature on consumers engaging in cigarette smuggling from neighboring jurisdictions or the Internet to avoid high local tax rates (e.g. Chernick & Merriman, 2013, Goolsbee et al., 2010, Harding et al., 2012, Lovenheim, 2008, Merriman, 2010). However, we expect that the black market is a particularly salient issue for cannabis because it had a well-established black market prior to the creation of a legal market and cannabis remains illegal (not just highly taxed) in some jurisdictions.

When legal cannabis is first sold in a new jurisdiction, it typically sells at

higher prices than illicit cannabis. For a jurisdiction to shrink their domestic black market, we expect that market structure and enforcement decisions are crucial to making legal cannabis accessible, illegal cannabis inaccessible, and bringing down the price of legal cannabis. How close legal and illicit cannabis prices must be before users switch depends on the relative accessibility and desirability of these two different products. Shrinking the exporting black market is also importantly tied to market structure and enforcement. Unlike for the domestic black market, falling legal prices are expected to exacerbate, rather than shrink the incentives to export to another jurisdiction where the price may be higher. For example, in 2019, Californian wholesale firms could get 2 to 3 times as much for a pound of weed if sold back East where cannabis is still illegal than legally in California (Fuller, 2019b).

We are aware of no research that has directly systematically studied how changes in enforcement, market structure, or tax-inclusive prices have affected the black market over time. Nonetheless, the news and individual state reports have certainly covered a number of potential mis-steps by states that likely exacerbated their domestic or exporting black markets. A few examples include: (1) California chose to allow municipalities to opt in rather than opt out of selling recreational cannabis, which has limited legal access (Fuller, 2019a). (2) Oregon allowed all firms to enter, which drove down prices, but has also led to substantial oversupply, which in turn is believed to have led to substantial black domestic and exporting black market activity (Crombie, 2019). (3) Colorado allowed extensive medical home cultivation – up to 99 plants with a doctor’s permission – and individuals could have someone else grow it for them. These two facts combined, meant that there could be a large grow within a residential neighborhood that didn’t immediately appear illegal. It is believed that this is largely to blame for Colorado’s struggles with illegal cross-state exports (Brittany Freeman & Ferrugia, 2018).

Although still limited, there is somewhat more research and released statistics that document the price changes over time as well as the magnitudes of likely black market activity. In response to market structure decisions, we have seen cannabis prices change in substantially different ways following legalization in different jurisdictions. In Washington, prices have fallen dramatically since legalization (Hansen et al., 2020). Colorado has also seen prices fall dramatically (Humphreys, 2018). Caulkins et al. (2019) compare survey reports of cannabis consumption in Washington State from July 2016 - June 2017 with the amount sold in the legal recreational market and find that 25 to 40 percent more is reportedly consumed than is reportedly sold in the state, suggesting that there is still some black market activity occurring. Other studies have also examined how legalization in Washington and other states has affected the illegal market, but a variety of methodological challenges makes it hard to draw clear conclusions from these studies. There are two studies that look at whether illegal grows on national forests decrease in response to cannabis legalization and other related changes (Klassen & Anthony, 2019, Prestemon et al., 2019), but neither control for time invariant unobservables in each state. There is another paper that finds wastewater measures of THC in Washington state are approximately

flat through 2014 and 2015, not rising significantly until the very end of 2016, suggesting that the black market is being roughly fully replaced by the legal market; however, their measure self-admittedly cannot appropriately scale to total THC consumed, and so cannot be a measure that is used to directly back out the black market at different points in time (Burgard et al., 2019).

In contrast to Washington, legal cannabis prices in Canada started roughly where the legal Washington market was in 2017, but by the third quarter of 2019, Canadian cannabis prices had actually risen by about 5 percent according to Statistics Canada crowd-sourced price estimates. Compounding the issue, we know from Statistics Canada crowd-sourced price estimates that when the market first opened prices in the illicit market were about 33 percent lower than the legal ones. Moreover, over time, black market prices have fallen by more than 10 percent in response to the opening of the legal market, based on data from Canadian crowd-sourced price data. Even so, legal cannabis is making inroads on the black market – Statistics Canada reports that in the second and third quarters of 2019 purchases of all cannabis (either medical or recreational) from legal firms had risen by 30 percentage points relative to a year earlier when recreational sales had yet to begin in Canada. (Using wastewater-based analysis to monitor the effects of legalized retail sales on cannabis consumption in Washington State, Sta) Cervený & van Ours (2019) provides suggestive evidence that the Canadian experience with declining black market prices following legalization may play out in other jurisdictions, too. They find that cannabis prices on the dark web are consistently lower in jurisdictions with legal or decriminalized cannabis.

How close legal and illegal prices needs to be before users switch from the black to the legal market depends on the relative desirability of legal and illicit cannabis. Consumers, not surprisingly, place some premium on legal cannabis – as we saw above, even with price gaps upwards of 33 percent, the legal market has made some inroads in the black market in Canada. Some aspects of the legal market may drive up both the cost of production and consumers’ willingness to pay – for example, a state may have strict guidelines surrounding the use of pesticides and effective enforcement. It is also likely that many consumers are willing to pay a price premium simply due to the legality of retail sales. There are several papers in the literature that speak to this premium in various ways. When Italy accidentally effectively legalized medical cannabis, called C-light, monthly confiscations of illicit cannabis fell by more than 10 percent despite these products being relatively poor substitutes for typical recreational cannabis (Carrieri et al., 2019). Hollenbeck & Uetake (2019) find aggregate demand elasticities in Washington state’s legal market slightly above negative one – if illegal cannabis were a good substitute, they note we would expect these elasticities to be substantially higher. Amlung et al. (2019) finds that black market demand is lower than legal demand and black market demand is substantially more elastic to changes in the legal market than the other way around, again suggesting that black market cannabis is not a particularly good substitute for legal market cannabis. Even though Oregon had a readily accessible black and medical market prior to their own legalization, Oregonians often

still chose to drive over the border to Washington to purchase legal cannabis – in the week Oregon started selling recreational cannabis, sales in Washington along the Oregon border fell by almost 40 percent (Hansen et al., 2020b).

The last aspect of black market activity we highlighted in the opening of this section is that consumers may come to purchase cannabis in jurisdictions where it is legal and bring it back to consume in their home jurisdictions where it remains illegal. Hansen et al. (2020b) find that this form of cross-border shopping has had substantial effects on the *de facto* legalization rates of neighboring U.S. states, with parts of Idaho experiencing up to 72 percent *de facto* legalization and the region around Massachusetts experiencing roughly 45 percent *de facto* legalization. This is likely very hard to address except by legalizing cannabis nationally (although we would still have cross-border shopping to avoid high tax jurisdictions) or by taking Uruguay’s approach of refusing to sell to those outside the jurisdiction in which it is legal.

4 Public Health and Societal Implications

One of the biggest questions surrounding the legalization of cannabis is the effects of such a policy on public health. Indeed, cannabis remains (at the time of this writing) a Schedule I substance in the United States – in other words the federal government considers it to have no accepted medical use and a high potential for abuse. Efforts to legalize the substance naturally lead to questions about the effects of consumption, both alone and in conjunction with other recreational substances. These questions often include the effects on direct and indirect mortality (e.g. traffic accidents), human capital accumulation, and violent and non-violent crime. In this section, we summarize the available evidence of the effects of legalization on these outcomes. As recreational cannabis regimes are so new, we include evidence from medical cannabis where appropriate.

4.1 Cannabis Use

Given the vast change in the legality of cannabis use, and the growth of supply chains in emerging legal markets, one of the fundamental questions is how has the quantity of cannabis demanded shifted. Answering this question is complicated in part due to underlying endogeneity of the adoption of policies legalizing recreational use. From the 2002 through 2015, past month cannabis use increased in the population from a baseline of 6.0 to 8.0 percent (Chawla et al., 2018). Cerdá et al. (2020) find that cannabis use disorder has risen substantially in recent use in states with recreational cannabis markets.

Miller et al. (2017) provide compelling evidence about changes in the patterns of use among young adults. Using a difference-in-difference approach using the National College Health Assessment, a health survey of college students and focusing particularly on Washington State University, they find past month cannabis increased from 20 percent to 27 percent over a 4 year span. Notably, this increase begins before legal markets open (July of 2014), but after cannabis

possession became legal (December of 2012). This suggests cannabis consumption may change both due to changes in supply (i.e. falling prices), and due to the shift in legal status.

While these and other similar analyses suggest cannabis legalization increases the quantity of cannabis demanded for adults (Mark Anderson et al., 2013, Chu, 2014), different mechanisms could apply for youth. While illegal black markets might favor selling to youth because they are unlikely to be undercover police, the regulatory regimes in legal markets might set up more barriers for potential buyers to overcome. For instance, regular ID checking would require teens to either acquire a fake ID or a proxy buyer as is common with cigarette markets (Hansen et al., 2013). Indeed, prior research on medical cannabis laws found that while they have may have led to lower prices due to increases in supply, youth usage did not increase (Anderson et al., 2015). Moreover, in a recent follow up to their earlier work, Anderson et al. (2019) use a generalized difference-in-difference model with updated data from the Youth Risk Behavior Survey and find that medical cannabis laws did not increase teen cannabis use, and recreational cannabis laws may have lead to a *decrease* in teen cannabis use.

4.2 Other Drug Use

Data on aggregate causes of death reveal that drugs like alcohol or opioids pose a far greater risk to health than does cannabis. One of the key economic questions, therefore, is the extent to which cannabis is a complement or substitute to other drugs. In other words, is cannabis a “gateway” to the use of drugs with greater risks, or is a substitute in the presence of exogenous price changes?

While some early pre-legalization studies of usage patterns among college students suggest complementarity between alcohol and cannabis (Williams et al., 2004), other studies exploiting variation in the minimum legal drinking age (MLDA) have come to opposite conclusions. For instance, DiNardo & Lemieux (2001) use a difference-in-difference approach when the MLDA decreases, cannabis use falls while alcohol uses rises. Likewise, Crost & Guerrero (2012) use a regression-discontinuity approach and find that when individual alcohol use increases at age 21, cannabis use drops. While Yörük & Yörük (2011) originally found evidence of complementarity of alcohol and cannabis using a regression discontinuity, Crost & Rees (2013) found this was due to missing a skip pattern in a survey questionnaire. Yörük & Yörük (2013) found no evidence of complementarity after correcting this data issue.

The evidence generated by medical cannabis laws largely favors a story of substitution between cannabis and other legal substances. Mark Anderson et al. (2013) find medical cannabis laws led to decreases in cannabis prices, decreases in alcohol related traffic accidents, and reductions in beer sales. However Wen et al. (2015) find evidence that while beer sales may have fallen, spirit sales and usage may have increased – perhaps due to increased home consumption. Choi et al. (2019) find that while medical cannabis laws increase cannabis use, they lead to a decrease in tobacco consumption.

More recently, Miller & Seo (2018b) study variation in local prices for alcohol, cannabis and tobacco in Washington state after recreational cannabis markets were established. Using scanner data on alcohol and tobacco purchases and a variety of instruments for local prices, they largely find evidence supporting substitution. Finally, Hansen (2019) focuses on regions experiencing increased access due to cross state spillovers (Hansen et al., 2020b). He finds regions close to cannabis retailers see decreases in alcohol related traffic accidents.

Many medical studies and advocates for the prohibition of cannabis have long pointed to the substance’s potential role as a “gateway” drug. According to the gateway drug hypothesis, a person who regularly experiences the relative mild effects of cannabis intoxication may consider it less risky and more desirable to consume other substances than a person who does not have experience with cannabis (Pacula, 1997, DeSimone, 1998). While people who eventually abuse harder drugs might initially use cannabis, this does not imply that cannabis is necessarily a complement with harder drug use if drug use is driven by underlying preferences. Indeed, Chu (2015) find little evidence that medical cannabis laws significantly decrease hard drug use, and some evidence they may decrease treatment admissions for heroin. More recently, Powell et al. (2018) find medical cannabis laws are associated with fewer opioid overdoses, and Chan et al. (2020) finds this pattern of substitution continues for recreational cannabis laws being implemented.

4.3 Traffic Accidents

Traffic accidents are a common focal point in debates surrounding cannabis legalization. Those favoring legalization argue that alcohol poses clear public health harms and that the potential harms created by cannabis are at most significantly smaller than those created by alcohol, while those opposing legalization argue that society does not need “another alcohol.” Some of the central questions in this debate involve the relative risks of drivers impaired by different substances and the corresponding optimal mitigation strategies including civil and criminal penalties (Levitt & Porter, 2001, Hansen, 2015). While these issues are well-studied in the context of alcohol consumption, our knowledge for cannabis is still limited and growing every year.

It has been difficult for medical researchers to isolate the impairing effects of cannabis consumption under the current scheduling regime, though simulator studies conducted largely in Europe have found that cannabis use impairs driving performance through increasing lane weaving and the mean distance between vehicles (Bondallaz et al., 2017). Economists have largely focused on the net impact of law changes. Mark Anderson et al. (2013) were the first to find an association between medical cannabis laws and decreases in traffic fatalities, largely due to a decrease in alcohol related crashes. More recently, Hansen et al. (2020a) implement a synthetic control design approach to test whether recreational cannabis legalization lead to increases in fatal traffic accidents in Colorado and Washington – while overall accidents increased around the time of legalization, these increases may have been due to improvements in economic

conditions. They fail to reject the null hypothesis that the rate of traffic fatalities was unaffected by recreational cannabis legalization. Moreover, while crashes related to drunk driving fell in both states, those crashes also fell in the synthetic control units.

4.4 Crime

Given the long-standing criminal penalties surrounding the production, distribution, and possession of cannabis, and the association between these activities and other criminal acts, the effects of legalization on crime are another central concern. Chang & Jacobson (2017) study a sudden large and exogenous closure of medical cannabis retailers in Los Angeles. They find an increase in crime immediately around retailers which were forced to close relative to those which remained open, potentially due to a decrease in the deterrence effects of “eyes on the street.” Dragone et al. (2019) study regions legalizing cannabis with close-bordering neighbors where cannabis remains illegal. They find decreases in violent crime rates, particularly in the category of sexual assaults.

Gavrilova et al. (2019) focus on systemic violence related to drug trafficking. They find the border region of Mexico sees decreases in violent crime following the adoption of legal medical cannabis regimes. Similar evidence emerges from Carrieri et al. (2019), who study an unintended legalization of certain forms of cannabis in Italy and found that the policy led to decreases in crimes related to organized crime.

4.5 Productivity

There is a long-standing stereotype of cannabis users as less productive (e.g. potheads are lazy) and a common perception that the use of cannabis reduces educational achievement (Dufton, 2017, Bray et al., 2000). These concerns have often entered the debate surrounding legalization (Inciardi, 1999). Unfortunately, we are unaware of any causal evidence linking cannabis legalization to changes in educational outcomes for high school students – perhaps because the “first stage” evidence linking cannabis liberalization policies to increases in cannabis *use* by teens is limited at best. Marie & Zölitz (2017) investigate college students. They take advantage of a natural experiment in which the city of Maastricht in the Netherlands banned foreigners from purchasing cannabis from local shops. Using data on student performance from Maastricht University, they find that the GPAs of foreign students improved relative to domestic students, particularly for lower students, women, and low performing students. They also found stronger effects for courses that require greater mathematical skills, in line with medical research on the effects of the psychoactive ingredients of cannabis on cognitive function (see, e.g. Curran et al., 2002).

Measuring worker productivity can often be challenging. To-date, researchers searching for evidence of links between cannabis legalization and productivity have largely focused on workers’ compensation claims. Anderson et al. (2018)

find that medical cannabis laws are associated with a slight decrease in fatal workplace accidents, while Ghimire & Maclean (2020) find that medical cannabis laws are associated with fewer overall claims. We conclude that while there is some evidence cannabis legalization or access may decrease achievement and learning in individuals, there is less evidence of an effect on labor force productivity.

5 Summary

While marijuana markets continue to expand across the globe many questions remain. How regulations affect both market structure, public finance, and social welfare outcomes will continue to be a fruitful and active area for research in years to come.

The differences in market structures across jurisdictions offer a multitude of opportunities for future work. As mentioned above, empirical work on adult-use cannabis markets has largely focused on Washington due to data availability. However, as Washington's legal structure differs from many other jurisdictions, particularly in its strict entry caps and its requirement that retail and production be vertically disintegrated, its market outcomes in terms of prices, quantities, available varieties, and qualities may differ from those in other states as well. In particular, the results of several studies are consistent with the hypothesis that retailers in Washington may have significant market power which in theory implies that Washington's prices are should be higher than in other jurisdictions, assuming constant marginal costs across geographies. As prices and quantities are key statistics with public health implications, careful and systematic descriptions of market conditions in other jurisdictions would contribute substantially to our overall understanding of adult-use cannabis. The policy differences across jurisdictions also offer a number of opportunities to test theories of double-marginalization, productivity differences across firms, competitive market definitions, and other classic hypotheses of the industrial organization literature. To the extent that adult-use cannabis comes with public health costs, insights gained by studying these differences may have direct policy relevance.

In a similar vein, we hope to see future research in taxation that goes beyond Washington state. As mentioned above, firms in Washington state have substantial market power. Additionally, policy-makers have implemented only ad valorem taxes. It would be valuable to see some analyses of potency and weight-based taxes in other jurisdictions. As part of these studies, we would like to learn how weight and potency-based taxes influence potency. Moreover, what are the revenue maximizing tax rates in a jurisdiction, such as Canada, that taxes on the maximum of an ad valorem and weight-based tax? Does this indeed raise more revenue than an ad valorem tax alone as prices continue to fall in this market?

We hope that future research on the cannabis black market develops a reliable proxy of black market activity over time (obviously easier said than done!) across numerous jurisdictions in the U.S. This would enable research that iden-

tifies what changes in prices, taxes, market structure, and enforcement have been most influential in shrinking the black market.

Finally, our knowledge about the potential public health and societal consequences of legalization remains limited. As larger states with denser populations and regions with higher crime rates have recently legalized, their experiences may give new insights into the impacts of legalization on the effects on crime and the criminal justice system more broadly. Moreover, research on traffic injuries and other health risks depends on in large part on testing, which remains quite limited in many parts of the country. Finally, whether or not it impacts educational or learning depends on whether legalization increases teen drug use, for which there remains little evidence. However, the lack of an increase in teen use so far is no guarantee this will hold in the future as prices continue to fall or societal acceptance increases.

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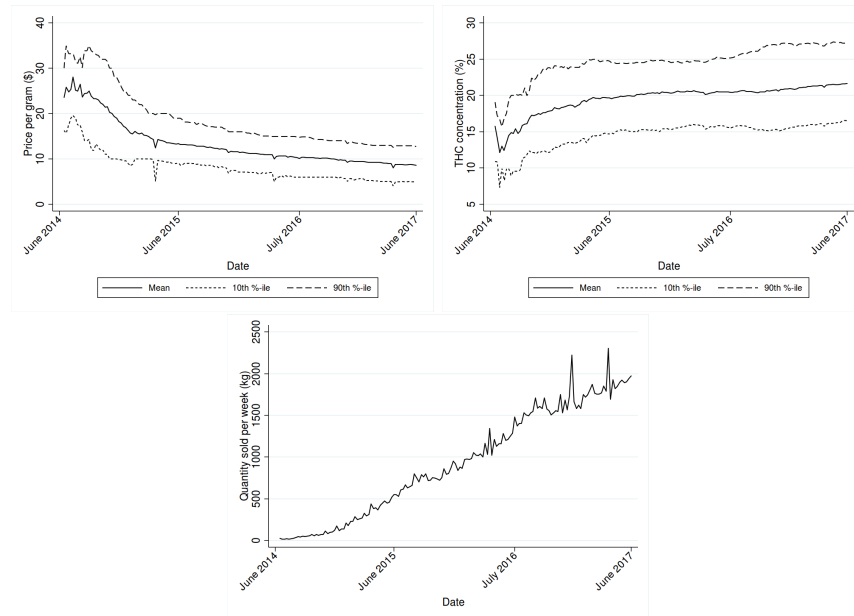
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6 Tables and Figures

Figure 1: The evolution of Washington’s recreational cannabis market over time



Notes: Figure reprinted from Hansen et al. (2020) with permission. Data is aggregated to the weekly level; for example a point in the top-left graph represents the mean (or 10th percentile, or 90th percentile) price per gram for “usable marijuana” sold in that particular week. Here, “usable marijuana” means the dried and cured flower bud of the *Cannabis* plant.

Table 1: Cannabis Legal Status by Country

Jurisdiction	Recreational	Medical
Antigua and Barbuda	Decriminalized	Illegal
Argentina	Decriminalized	Legal, Open Market
Australia	Legal in one territory, No Market. Decriminalized elsewhere.	Legal, Open Market
Austria	Decriminalized	Legal, Open Market
Barbados	Illegal	Legal, Open Market
Belgium	Decriminalized	Legal, Open Market
Belize	Decriminalized	Illegal
Bermuda	Decriminalized	Legal, Open Market
Bolivia	Decriminalized	Illegal
Brazil	Illegal	Legal, Open Market
Canada	Legal, Open Market	Legal, Open Market
Chile	Decriminalized	Legal, Open Market
Colombia	Decriminalized	Legal, Open Market
Costa Rica	Decriminalized	Illegal
Croatia	Decriminalized	Legal, Open Market
Cyprus	Illegal	Legal, Open Market
Czech Republic	Decriminalized	Legal, Open Market
Denmark	Illegal	Legal, Open Market
Dominica	Decriminalized	Illegal
Ecuador	Decriminalized	Legal, Open Market
Estonia	Decriminalized	Illegal
Finland	Decriminalized	Legal, Open Market
Georgia	Legal, no market	Legal, No Market
Germany	Illegal	Legal, Open Market
Greece	Illegal	Legal, Open Market
Israel	Decriminalized	Legal, Open Market
Italy	Decriminalized	Legal, Open Market
Jamaica	Decriminalized	Legal, Open Market
Lebanon	Illegal	Legal, No Market
Lithuania	Illegal,	Legal, Open Market
Luxembourg	Decriminalized,	Legal, Open Market
Malta	Decriminalized	Legal, Open Market
Mexico	Decriminalized	Legal, Open Market
Moldova	Decriminalized	Illegal
Netherlands	Decriminalized	Legal, Open Market
New Zealand	Illegal	Legal, Open Market
Nicaragua	Decriminalized	Legal, Open Market
North Macedonia	Illegal	Legal, Open Market
Norway	Illegal	Legal, Open Market
Paraguay	Decriminalized	Illegal
Peru	Decriminalized	Legal, Open Market
Poland	Illegal	Legal, Open Market
Portugal	Decriminalized	Legal, Open Market
Romania	Decriminalized	Illegal
Saint Kitts and Nevis	Decriminalized	Illegal
Saint Vincent and the Grenadines	Decriminalized	Legal, Open Market
San Marino	Illegal	Legal, Open Market
Slovenia	Decriminalized	Illegal
South Africa	Legal, No Market	Legal, No Market
South Korea	Illegal	Illegal
Spain	Legal, No Market	Illegal
Switzerland	Decriminalized	Legal, Open Market
Thailand	Illegal	Legal, Open Market
Trinidad and Tobago	Decriminalized	Illegal
United Kingdom	Decriminalized	Legal, Open Market
United States	Legal in 15 States & D.C., Market Open in 11 states	Legal in 36 States and D.C., Market open in 34 states & D.C.
United States Territories	3 Legal Territories, No Market	4 Legal Territories, 1 Open Market
Uruguay	Legal, Open Market for residents	Legal, Open Market
Vanuatu	Illegal	Legal, Open Market
Zambia	Illegal	Legal, No Market
Zimbabwe	Illegal	Legal, Open Market

Note: Current to the best of the authors' knowledge as of June 15, 2021. For recreational cannabis, "legal, open market" means that there is a licensed retail location to purchase marijuana "Legal, no market" means that while consumption for recreational use is legal, no licensed retail locations exist. For medical cannabis, "open market" means that medical dispensaries or pharmacies are open with a range of cannabis products. "No market" means that consumption for medicinal purposes is legal, but no licensed dispensaries exist. As of June 15, 2021, the U.S. states of Virginia, South Dakota (subject to court ruling), and New Mexico were slated to open legal recreational markets on July 1, 2021.

Table 2: Recreational Cannabis Taxes by Jurisdiction

Jurisdiction	Retail Excise	
	Tax Rate	Additional Taxes
Canada	-	Wholesale tax is the higher of 10% or \$1 per gram. The following products are instead taxed at \$0.01 per milligram of the total THC in the cannabis product: cannabis oils, topicals, extracts, and edibles. There are additional adjustments for some provinces.
Uruguay	-	“Variable fee” system
U.S. States:		
Alaska	-	Cultivation tax of \$50/oz on dried flowers (unless immature/abnormal; then \$25/oz), \$15/oz on for other plant material, \$1 for clones. 5% optional local sales tax.
Arizona	16%	
California	15%	Note: for all arms-length transactions between processor and retailer, the retail excise tax is actually imposed on the wholesale price + a fixed markup that is reassessed every 6 months. The markup rate increased from 60% to 80% on 1/1/2020. Cultivation tax of \$9.65/oz on dried flowers, \$2.87/oz on dried leaves, \$1.35/oz on fresh plant material (these have been inflation-adjusted over time). Optional locality taxes.
Colorado	15%	Additional 15% tax applied at wholesale based on average market rate in the state. Optional locality taxes.
Illinois	10%	10% tax applies for products with THC <35%, 20% tax on edibles, 25% tax for products with THC ≥ 35% (mostly concentrates). 7% cultivator tax on first sale. Optional locality taxes up to 3%.
Maine	10%	Additional cultivation tax of \$335/pound on dried flowers, \$94/pound on for other plant material, \$1.50 on immature plants and seedlings, and \$0.30 for seeds.
Massachusetts	10.75%	Localities may impose additional 3% excise tax.
Michigan	10%	
Nevada	10%	Additional 15% tax applied at wholesale on “fair market value.”
Oregon	17%	Localities may impose additional 3% excise tax.
Washington	37%	

This table includes every jurisdiction where recreational cannabis is sold as of June 15, 2021. States also levy their state and local retail sales taxes (when they have them) on cannabis sold at retail except in Colorado. Washington initially set a tax rate of 25% both at retail and for transfers within the supply chain. In July 2015, Washington switched to a single 37% tax at retail. Colorado initially had a 10% retail excise tax (+2.9% state sales tax) until July 2017 and Massachusetts initially had a 3.75% retail excise tax rate, but it was increased before recreational cannabis sales began in that state.