Chapter 12. California's Nursery and Cannabis Industries

Part 2. California's Cannabis Industry

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Abstract

In November 2016, two decades after legalizing medicinal cannabis, California voted to legalize and regulate "adult-use" (recreational) cannabis. Implementation is being gradually rolled out throughout 2018, but, due to lack of data and a vibrant illegal market, implications of the new regulations and taxes are unusually difficult to model. We first assess the current industry situation, from cultivation through retail. We next project the likely economic situation in 2019, with regulation and taxation in place. The legal California cannabis industry benefits from improved access to management and capital and new demand. However, legal cannabis also faces considerable taxes and compliance costs. We estimate that about 80 percent of California-grown cannabis continue to leave the state. Less than half (about 1.3 million pounds) of the in-state retail sales will be in the legal regulated and taxed segment, with total retail revenue of $6.7 billion, including about $1.8 billion in taxes.

Authors' Bios

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Introduction

Cannabis production, processing, sale, purchase, and possession by California residents with a doctor's recommendation has been allowed under California law for more than 20 years. Under the Compassionate Use Act of 1996, medicinal cannabis purchase and possession has been legal for patients over 18, and for younger consumers accompanied by a parent or legal caretaker. Adult-use cannabis purchase and possession has been legal for those over the age of 21 (under state law, but not federal law) since November 2016, when California voters approved Proposition 64, the Adult Use of Marijuana Act (AUMA). Nonetheless, in 2018, big changes are underway for California's cannabis industry.

In June 2017, the California State Legislature enacted the Medicinal and Adult Use Cannabis Regulation and Safety Act (MAUCRSA), which specified the framework for taxing and regulating cannabis in California. The first set of regulations for cultivation, manufacturing, testing, distribution, and retail sale of both medicinal and adult-use cannabis went into effect on January 1, 2018. Regulations implementing MAUCRSA will be more fully implemented beginning July 1, 2018. Full enforcement of the new regulations will be phased in somewhat later.

Economists have an important role of helping policymakers, the public, and market participants understand the economic effects of the rapidly evolving legal and regulatory environment for cannabis in California. However, there are several serious challenges that impede efforts to measure and explain the economics of the cannabis industry in California. First, there are no official price or quantity data. Although medicinal cannabis has been legal to purchase and possess for two decades by those with medical recommendations, the State of California collected no official statistics on the commodity. Most California production and use has been outside the legal channels for medical production, processing, sale, and use. Thus, a large industry developed in California that avoided compliance with auxiliary government regulations such as those administered by environmental, labor, public health, or tax authorities.

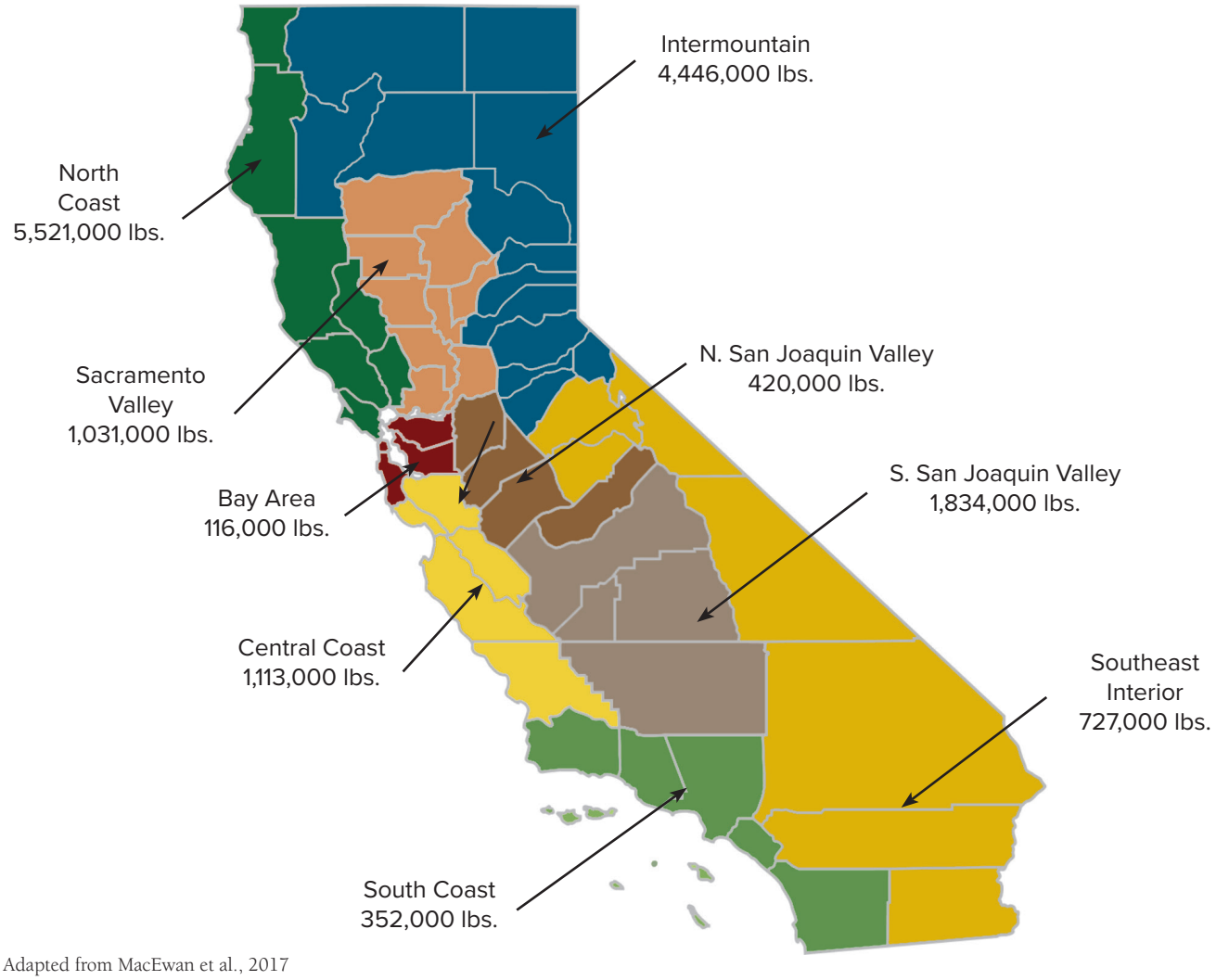
Cannabis sale, purchase, and possession remains prohibited under federal law, with potentially severe penalties. This status of cannabis under federal law continues to mean that cannabis is not a normal farm product in the context of inter-state trade, finance, and banking.

This chapter deals with two broad questions. First, what is the economic situation of the cannabis industry in California from farm cultivation through processing, marketing, and retailing? We describe the industry in terms of prices, quantities, and revenues in the relevant California markets, and we outline the main regulations. Second, the likely situation of the industry in the near future when the regime of regulation and taxation is fully in place? For the discussion of cultivation and manufacturing, we draw on reports prepared to inform the California regulatory process (MacEwan et al., 2017; Eschker et al., 2018). For a discussion of the wholesale and retail markets, we draw on our research developed at the University of California Agricultural Issues Center (AIC) (Sumner et al., 2018). These three reports were provided to the California state government to provide analysis of economic impacts of major regulations.

In broad terms, the dimensions of cannabis in California are as follows. Production is about 15 to 16 million pounds. Consumption in California is about 3 million pounds; this means that about 80 percent of total cannabis production by weight is shipped to destinations outside the state and thus remains outside the legal and regulated system being implemented.

Within California, we estimate that about half the cannabis consumption by weight (about 10 percent of production) is likely to be sold through state-regulated venues. The wholesale farm price of cannabis varies widely by growing method, potency, other product characteristics, and regulation status. As of late 2017, the wholesale price of medicinal cannabis averaged about $1,600 per pound, with lower prices for cannabis grown outdoors and higher prices for cannabis grown indoors. The price of retail cannabis varies widely by region and location, regulation

Figure 1. Estimated California Cannabis Production by Region, 2017



Source: Adapted from MacEwan et al., 2017

status, and product characteristics. As of late 2017, on a flower-equivalent basis, cannabis outside the regulated system had an average price of about $2,100 to $2,600 per pound, and the price of cannabis in the medicinal retail market was about $3,600 per pound.

The new regulations and taxes are disrupting the cannabis production, processing, and marketing system. These changes are causing some production and marketing costs to decline while imposing substantial new taxes and regulatory costs throughout the supply chain. We anticipate that most of the regulated and taxed cannabis will be grown indoors or in greenhouse (also known in the industry as "mixed-light") environments, using methods that more readily comply with track-and-trace and testing regulations. Similarly, manufacturing will more likely be conducted by operations with the resources and physical capacity to meet testing and packaging requirements.

Licensed cannabis retail outlets will have access to regulated and tested products, more business security, more access to management talent, and more access to legal capital than their unlicensed competitors; but they also face compliance costs. Customers in the taxed and regulated market have a secure legal environment for purchases of tracked-and-traced production that has been thoroughly tested. The cost of these products, however, is likely to be almost double the cost of cannabis products from unregulated and untaxed sources.

Farm Production of Cannabis in California

Estimates of the quantity of cannabis production in California must be assembled from a variety of sources. MacEwan et al. (2018) used information from satellite imagery, law enforcement reports, local interviews, and many other sources to estimate 2017 production by region. Figure 1 displays their estimates. The data are displayed in what we term "dried cannabis flower equivalent" units, which includes estimates of a small contribution from leaves and trimmings, which are sold at much lower prices (often less than one-tenth of dried flowers.) Of the 15,560 million pounds of production in 2017, MacEwan et al. (2018) estimates that about 11 million pounds comes from Northern California, where cannabis has long been grown in mountains and valleys, often in remote areas. Another three million pounds comes from the San Joaquin Valley and the mountain and desert interior counties. That leaves about 1.5 million pounds in the coastal regions from San Diego up to San Francisco, where the bulk of the California population resides and where most California cannabis consumption occurs.

Table 1 shows the estimated distribution of production in each region by the share of production method—outdoor, indoor, and greenhouse. The final column in Table 1 shows the share of California production in each region based on the production quantities reported in Figure 1. Note that more than 70 percent of California production comes from Northern California. These regions, like most others, have the majority of production outdoors, but the 51 percent grown outdoors in the North Coast region is below the statewide average of 58 percent grown outdoors. The share grown in greenhouses ranges from 54 percent in the South San Joaquin Valley and 43 percent in the North Coast region, to only 8 percent in the Southeast interior and 9 percent in the North San Joaquin Valley. Finally, only 9 percent of California cannabis is grown indoors with the highest shares in the more urban regions of the Bay Area and the South Coast.

These production estimates include the roughly 80 percent of cannabis that is shipped outside California, similar to many other California commodities. There are two major differences for cannabis. First, evidence suggests that relatively little cannabis is exported from the United States (with Canada as the potential exception). Second, unlike other farm products, cannabis is illegal to ship to other U.S. states.

Table 1. Share of Production Measured in Pounds by Method by Region, 2016/17

	Outdoor	Indoor	Mixed Light	Total Share
		Percent		
Intermountain	63	9	27	29
North Coast	51	6	43	35
Sacramento Valley	77	8	15	6.6
Bay Area	26	61	13	0.7
North San Joaquin	74	17	9	2.7
Central Coast	74	6	20	7.2
South San Joaquin	43	3	54	12
Southeast Interior	83	8	8	4.7
South Coast	48	30	22	2.4
Total	**58**	**9**	**33**	**100**

Source: Adapted from MacEwan et al., 2017

Table 2. Production and Costs for Outdoor, Indoor, and Mixed-Light (Greenhouse) for Surveyed Operations in 2016/17

	Outdoor	Indoor	Mixed Light (Greenhouse)
	All Values per Operation		
Canopy Square Feet	15,265	9,375	9,875
Production per Square Feet (lbs).	0.019	0.186	0.105
Total Production (lbs)	291.16	1,747.27	1,038.75
Price per Pound ($/lb)	1,402	2,100	1,575
Flower Revenue ($ thousands)	408	3,669	1,636
Trimmings Revenue ($ thousands)	3	17	10
Total Revenue ($ thousands)	411	3,687	1,646
Reported Expenses ($ thousands)	218	1,730	875
Return to Management and Risk ($ thousands)	**193**	**1,956**	**771**

Note: Based on a cultivator survey described in MacEwan et al., 2017.

Source: Adapted from MacEwan, 2017, with additions.

The other difference is that much of the production remaining in California is also being sold outside the regulated and taxed legal market. Although cannabis is legal to buy and possess (buying cannabis from unlicensed sellers is not a crime), selling cannabis outside the licensed, taxed, and regulated system is subject to criminal penalties. Below, we discuss the division of cannabis sold in California between the licensed and unlicensed systems in more detail.

Table 2 summarizes data from a 2017 survey of cannabis growers. We emphasize that because of the difficulties of contacting some growers and concerns of some growers about providing information, these data may be subject to high margins of error. Moreover, the problems of sampling means that the results cannot be said to be based on a random sample of producers.

Table 2 provides data on averages per farm separately for the three cultivation methods: outdoor, indoor, and greenhouse (mixed light). Compared with other agricultural products, cannabis canopy area per farm is small (a fraction of an acre on average for all methods). Cannabis produced per square foot varies significantly by cultivation method.

Outdoor production typically has one harvest per year and, for the surveyed farms, yields an average of only 0.019 pounds, or 0.3 ounces, of dried flowers per square foot of canopy area. Indoor operations average only about 60 percent of the area of outdoor operations, but produce several harvests per year and, in this sample, yield almost 10 times as much cannabis per square foot as outdoor production. Greenhouse production is much closer to indoor in terms of square feet per operation, and averages about 0.105 pounds of cannabis per square foot. Indoor cultivation is much more intense and has very high annual yields of dried flowers per square foot compared to the outdoor operations in this sample. The canopy area per operation is about 60 percent of the outdoor canopy, thus the indoor cultivators averaged about six times as much cannabis as the average outdoor cultivator. The average greenhouse cultivator produced about 3.6 times as much as the outdoor cultivator in this sample.

The prices in 2016/17 were much higher per pound for indoor and greenhouse cannabis. Revenue per farm averaged about $411,000 for outdoor cultivators, compared to $3,687,000 for indoor and $1,646,000 for greenhouse cultivators. Reported direct expenses are only about half of revenue indicating very high returns to management and risk. These high residual earnings reflect the substantial risk of cannabis operation in the illegal market before regulations. Informal reports of regular losses of cash and crop due to criminal activity or business disputes, a lack of

legal recourse, and significant potential for arrest and loss of crop and cash as a result of law enforcement suggest that long-term average returns may be significantly less than indicated in Table 2.

In April 2018, reflecting shifts in the market with more legalization and regulation, wholesale prices are reported to be less than $900 per pound for outdoor cannabis and less than $1,600 per pound for indoor cannabis, with greenhouse again in the middle (Cannabis Benchmarks, 2018). Using an average price in the illegal segment of about $1,000 per pound, we estimate that cannabis shipped out of California has a farm value of about $13 billion per year, which is roughly the farm revenue of milk and almonds together. The farm value of cannabis sold in California is now in the range of $3 billion for an annual total of about $16 billion.

Taxes and regulations being implemented in 2018 affect the cannabis cultivation industry both directly and through market relationships. State taxes are specified as $148 per pound of dried flower and $44 per pound of leaves and trim. MacEwan et al. (2018) estimate that leaves and trim will comprise only about 10 percent weight sold.

In addition to these taxes, the state requires a track-and-trace system starting at the farm, as well as surveillance to implement the system and provide security. The California Department of Food and Agriculture (CDFA) is responsible for licensing cannabis growers and issuing several license types based on cultivation method, size, and whether the cannabis is to enter the medicinal or adult-use segment. The cannabis itself may be identical in these license categories. Proposed license fees rise with the area of canopy and are higher for greenhouse and indoor methods to reflect higher production and prices per square foot of canopy. Producers may obtain several licenses. As of the end of April 2018, there were about 2,800 temporary cultivation licenses of all types (which are available with no fee, but which require a complex application and eligibility), with many entities possessing more than one license.

State regulations are expected to add about $50 per pound to cultivation costs. Local governments, mainly counties and cities, are also implementing taxes and regulations on cultivators. These vary by medicinal versus adult-use cannabis and by cultivation method—outdoor, indoor, or greenhouse. Although local taxes and regulations are still in flux and much harder to gauge, local taxes are estimated to add another $128 per pound to the costs of supplying cannabis from the farm (MacEwan et al., 2018). One complication is that growers will tend to avoid high-tax, high-regulation areas. Some taxes are on a per-square-foot basis and thus favor growing systems with high-yields of cannabis per square foot. The overall tax rate per pound thus depends in part on how production methods evolve.

The evolution of a licensed, taxed, and regulated cultivation industry will favor those firms adept at attracting relatively sophisticated management and adequate capital to meet the new regulatory setting. This new setting includes not only cannabis-specific taxes and regulations, but an array of labor, health and safety, environmental, and other regulations and taxes about which many incumbent cannabis growers have not been knowledgeable or compliant. We expect many growers who were well suited to the long-standing unlicensed and unregulated system to be less suited to the new system than many new entrants. Many of these incumbents may therefore choose to remain unlicensed. Since the size of illegal market is likely to remain very large relative to the regulated market, these producers can remain in the cannabis business without attempting to navigate a system in which they may have little comparative advantage.

Manufactured Cannabis in California

Most retail cannabis is sold as dried flowers for smoking, but a significant minority of the retail market is manufactured cannabis products derived from cannabis flowers, leaves, and trim. Manufactured products are made using cannabis materials that are extracted using a variety of methods, including pressurized solvent-based extraction, distillation, pressing, tumbling, and dry sifting. The retail products using these concentrated extractions are roughly divided into three product categories:

(1) Concentrates, e.g,. Butane Hash Oil (BHO) and CO2 oil, typically sold at retail in cartridges for use in vape pens (small portable vaporizers), or as disposable vape pens; or rosin, which has a gum-like consistency. Oil typically has 60–75 percent THC content by volume.

(2) Edibles, e.g., cannabis-infused foods and beverages, and tinctures (drops taken by mouth). These are generally manufactured using cannabis concentrates as ingredients.

(3) Topicals, e.g., creams, lotions, oils, or balms applied to the skin. These are also generally manufactured using cannabis concentrates as ingredients.

Eschker et al. (2018) estimated that manufactured products, including concentrates, edibles, and topicals, comprised about 30 percent of California's legal medicinal cannabis segment (by revenue) in 2017, and will have a similar share of the fully regulated market that includes adult-use cannabis. Using the AIC estimate of a medicinal retail market of about $2.5 billion in 2017, this would generate a retail value of about $750 million. Eschker et al. (2018) estimate an average ratio of wholesale to retail prices for manufactured products of 0.4 during 2017. That ratio implies that retail sales value of $750 means a wholesale revenue of about $300 million for manufactured products in the medicinal cannabis market.

Sales volumes within manufactured cannabis products in the medicinal segment is about 75 percent concentrates, 22 percent edibles, and 3 percent topicals. Manufactured products in the unregulated segment are almost all concentrates. Moreover the share of manufactured products sold through the medicinal dispensaries has been much larger than the medicinal share of the dried flowers sold in California. Eschker et al. (2018) assume, with a high degree of uncertainty, that there were approximately 1,000 legal medicinal manufacturing businesses operating in California in 2017, and about 2,000 manufacturers in the unregulated segment. These businesses were generally very small, averaging only about one full-time-equivalent employee per firm.

Starting 2018, manufactured cannabis products are regulated by CDPH. Separate license types are required for extracts using nonvolatile solvents and extracts using volatile solvents. As of the end of April 2018, there are about 720 manufacturing licensees of all types. These temporary licenses are available with no fee, but which require a complex application and eligibility.

CDPH also enforces rules covering food safety, the security of licensed manufacturing premises, compliance with the track-and-trace system, packaging and labeling, and other areas of regulatory oversight. Eschker et al. (2018) estimate costs of the licenses plus state regulations. Applying AIC market size assumptions, we estimate that these costs add about $95 per pound to costs of cannabis in terms of dried-flower equivalents.

Economics of California Cannabis Wholesale and Retail Activities

The medicinal cannabis segment operated for about 20 years with no significant state regulation and a small and highly variable degree of regulation under local jurisdictions. In many municipalities, no cannabis retail storefronts were allowed, but delivery services made cannabis available to customers with medicinal recommendations. Medicinal cannabis buyers were required to obtain a medical document (not a prescription) signed by a California physician indicating that cannabis was recommended. In practice, such recommendations could be obtained via a very quick in-person visit. A patient would self-report medical symptoms indicating cannabis, and to show that he or she (or his or her parent or legal caretaker) was a California resident aged 18 or over. The typical fee for an in-person appointment was about $50.

In recent years, some doctors began offering these recommendations via websites with video-chat functionality. No video chat was required—only completion of an on-line form, proof that the patient was a California resident of legal age, and access to payment by credit card. Fees for online appointments were somewhat lower and permission was available within minutes. It is instructive to note that despite the ease of meeting the medicinal requirements, most cannabis remained outside this California-legal retail segment.

Table 3 shows our estimates of the situation of the retail cannabis market within California in 2017. We estimate that about 700,000 pounds of cannabis on a dried-flower-equivalent basis were sold in California through medicinal cannabis retail firms known as dispensaries. Another 2.1 million pounds were sold through the unregulated (illegal) segment. Based on the AIC survey and a number of industry sources, we estimate that the retail price of medicinal cannabis averaged about $3,600 per pound for total retail revenue of about $2.5 billion in 2017. The unregulated segment had a price that was about 66 percent of the medicinal price, or about $2,360 per pound, for estimated revenue of about $5 billion. Thus, we estimate full retail cannabis sales were about $7.5 billion in 2017.

Assessments of 2017 cannabis consumption in California are complicated by the mixed legal and illegal situation. Adult possession of cannabis was legal according to state law. At the same time, sales of cannabis remained illegal unless the retailer had a local license and the buyer had a medical permission. Sumner et al. (2018) base their estimates on a large number of sources, including surveys of illegal cannabis use, data from consumption surveys and government records in Colorado and Washington, and industry surveys.

Table 3. Estimated California Retail Cannabis Quantities, Prices, and Revenues, 2017

Segment	Share	Flower Equivalent	Retail Price	Retail Revenue
	Percent	Thousand Pounds	$/Pound	$ Billion
Medical Cannabis	25	700	3,600	$2.5
Unregulated Cannabis	75	2,100	2,360 (~66% of medical price)	$5.0
Total Cannabis Market	**100**	**2,800**	**2,667 (~average)**	**$7.5**

Sources: UC Agricultural Issues Center retail cannabis price survey; Board of Equalization tax data; AIC market review of public estimates of cannabis prices and quantities.

Table 4. Average California Retail Prices Across Medical Cannabis Dispensaries, November 2017

	Average Low Price	Average High Price
	$/Package	
One-eight Ounce Dried Flower Package	31	51
Full Ounce Dried Flower Package	177	305
0.5 gram c\Cartridge	30	43

Source: UC AIC cannabis price survey.

Distribution of consumption by demographic group is available from federal surveys of drug use. These surveys are often adjusted for under reporting, but one common result is that most of the consumption, about 80 percent, is by the 20 percent of those who are heavy users. This estimate is useful in assessing average prices, purchase quantities, and impacts of taxation and regulation.

An AIC retail price survey in November 2017 collected "high" prices (highest listed on the on-line menu) and "low" prices (lowest listed on the on-line menu) at more than 2,600 medicinal cannabis retailers in California that had on-line price lists—both storefront and delivery only—across all regions of the state. AIC surveyed high and low prices for three product categories: a package of one-eighth ounce of dried flowers, a package of one full ounce of dried flowers, and a 500-milligram oil cartridge.

Table 4 presents a summary of these price data. The average of the low one-eighth ounce prices is about $31, or about 60 percent of the average of the high prices of $51. For full ounces the range is similar. In both cases, the higher prices tend to be flowers listed with higher-than-average THC concentrations and/or named strains that claim special qualities. Notice that in Table 4, the equivalent price per ounce for the one-eighth-ounce packages is much higher than the average price per ounce listed for the one-ounce sized packages. The low cost per ounce of eight one-eighth-ounce packages is $248 compared to the low price of a one-ounce package of $177. The high cost of such a purchase of eight small package is $408 per ounce compared to the average high price per ounce of $305.

Based on U.S. government surveys, heavy cannabis users consume more than one ounce per month. Hence, these buyers have a strong incentive to buy larger package sizes.

Cartridge prices have a somewhat smaller range, but are in the same general price range as a one-eighth ounce package of dried flowers. For the cartridges, high prices were generally for relatively more concentrated (75 percent THC) cannabis oil, whereas low prices were generally for relatively less concentrated (60 percent–67 percent THC) cannabis oil.

For estimates of market prices and quantities, we convert manufactured product sales into "dried flower equivalent" units of one pound dried cannabis flower with 20 percent THC. The 30 percent share (by revenue) of manufactured products of the retail market is thus incorporated into other overall cannabis estimates in this chapter.

The wholesale and retail functions for cannabis and the required product testing is being regulated by the Bureau of Cannabis Control (Bureau), a newly formed agency of the California Department of Consumer Affairs. The Bureau formulated a set of regulations to implement the requirements of MAUCRSA and in 2018 is overseeing the phase-in of rules.

As of the end of April 2018, the Bureau had issued almost 2,000 temporary licenses of all types, including 25 licenses for testing laboratories, which must be independent of any other cannabis businesses. It had also issued about 50 cannabis event-organizer licenses, which allows organizing events where cannabis is sold, but requires any such sales to be done by companies with a retail license. About 930 temporary retailer licenses had been issued, including those authorized for only delivery with no store-front premises. These retail licenses include both medicinal and adult-use as separate licenses and most license holders have both. In addition, the Bureau had issued more than 750 distributor licenses (adding those for medicinal and

Table 5. Summary of Taxes and Regulatory Costs for California Cannabis Markets

Value	Medicinal Segment	Adult Use segment	Illegal Segment
	$/Pound (Dried Flower Equivalent)		
State Cultivation Taxes	148	148	0
Local Cultivation Taxes	128	128	0
Cultivation Regulatory Compliance Costs	50	50	0
Manufacturing Taxes and Compliance Costs	95	95	0
Testing Compliance Costs, Including Cost of Rejected Product	257	257	0
Distribution and Retail Compliance Costs	151	151	0
	Percent		
Excise Tax Rate	15	15	0
Sales Tax Rate	2.1	8.3	0
Local Percentage Taxes and Fees	7.8	8.2	0
Local Percentage Taxes on Testing Revenue	4.9	4.9	0

Sources: Relevant California laws and proposed regulations, estimates from state agencies and AIC estimates

adult-use), including about 150 for companies that only transport cannabis and cannot do other wholesaling functions to be described below. Finally, about 140 microbusiness licenses have been issued. These allow the licensee to operate as a cultivator with less than 10,000 square feet under canopy; a manufacturer that does not use solvent-based extraction; a distributor; and a retailer. The micro-business must conduct three of these four activities.

An important area of regulation covers implementation of the track-and-trace system, which starts with cultivation and continues through retail sales. A number of security measures require cameras, video archival, record keeping, security guards, specified security in delivery, and secure destruction and disposal of any cannabis that is unsold or not allowed to be sold. Secure childproof packaging is another relatively costly requirement. Even more costly is the requirement that each batch of cannabis (with maximum batch size of 50 pounds) must be tested for a long list of microbial and chemical contaminants as well as for THC levels, moisture, and for some manufactured products, uniformity. The distributors are required to hold the cannabis products during testing and are responsible for submitting excise and cultivation taxes to the State of California authorities.

Sumner et al. (2018) find that tests themselves are likely to cost more than $50 per pound. However, the largest cost derives from loss of product that fails the required tests. Given zero tolerance for contaminants such as pesticides and microbials and the difficulty for growers to meet the very tight standard, Sumner et al. (2018) expect about 12 percent of product to fail the tests and be destroyed as a result. This rate, which is in line with other industry estimates, assumes that companies pre-test some of the cannabis (which is also a significant expense), and recondition and retest some of the batches that fail for reasons that do not rule out remediation. Nonetheless, a 12 percent failure rate would cost an average of $200 per pound of the products that pass and are eligible to be sold in the regulated cannabis market.

Table 5 provides a summary of taxes, fees, and regulatory costs including those at the cultivation, manufacturing, wholesale and retail stages. The retail taxes for cannabis are added in several steps from both state and local jurisdictions. The excise tax, as mandated by MAUCSRA, is 15 percent of the estimated retail revenue, which is calculated as 1.6 times the full wholesale cost (including full costs of the products that have passed the required testing). That is, the excise tax is based on data on wholesale costs, and assumes a 60 percent markup from

wholesale to retail. The state and local sales tax applies in full to adult-use cannabis based on the full retail prices, as with other products in California.

The state sales tax is 7.25 percent and the average county sales tax is about 1.05 percent for a total of 8.3 percent. The sales tax does not apply to medicinal cannabis sales if the buyer has a county-issued medical card in addition to the required medical recommendation. Counties are permitted to charge up to $100 for the county-issued ID card. Heavy cannabis users would likely still find such an exemption worthwhile. For example, assuming the cost of the recommendation and card is about $150 per year, then a buyer purchasing more than $150/0.083 = $1,800 per year would benefit from paying this cost. Given average retail prices of more than $250 per pound, buyers of more than about 8 ounces per year would significantly benefit from this investment. Some medicinal buyers, such as those between 18 and 21 who are not eligible to access the adult-use market, will pay the sales tax. Overall, we assume that about 25 percent of medicinal cannabis will have sales tax assessed.

Local taxes vary widely across the state. A survey of local taxes and fees that were implemented, scheduled, or likely in early 2018 indicated an average of 8.2 percent for adult-use cannabis and 7.8 percent for medicinal cannabis (Sumner et al., 2018). We recognize that retailers will tend to avoid high-tax places for retail operations; especially given that delivery operations are not legally limited to delivering within a particular jurisdiction, we assume that many customers will be willing to travel across (or order across) jurisdictions for a lower price. There are also local taxes that average 4.9 percent on testing lab revenue. This tax is very small as a share of the cost of cannabis, amounting to about $2.50 per pound (compared, for example, to the excise tax that is likely to add about $600 per pound to retail cost).

In order to gauge the impacts of taxes, regulations, and legalization on cannabis purchases overall, as well as in the medicinal, adult-use, and illegal segments, we developed a set of equilibrium displacement model simulations based on assumptions about the initial situation; supply and demand shifts; and supply and demand elasticities, including, importantly, substitution for buyers across segments.

Before turning to results, let us very briefly outline the main underlying assumptions. We start with a situation where adult-use cannabis is legal and sales are about 700,000 pounds, while medicinal sales are about 600,000 pounds and illegal sales are 1,300,000 pounds. The supply elasticity of cannabis in each segment is 5.0, which reflects that fact that cannabis requires few specialized resources and will be a very small share of the space available in greenhouses, warehouses, or outdoor plots (Matthews and Sumner, 2017). The demand elasticity for cannabis overall is taken to be quite inelastic. We use -0.2 from Jacobi and Sovinsky (2016), but this parameter is of little importance in the main results.

The important demand parameters are the own-price and cross-price elasticities among the segments. These elasticities are not based on econometric estimates, because we found no useful data on variations in prices and quantities. The experiences of Colorado and Washington have guided our specifications, but did not provide data for econometric demand estimates.

We frame the demand for cannabis in each segment as a part of a separable group with high elasticities of substitution of 5.0 between medicinal and adult-use segments and 2.0 between the illegal segment and the two regulated segments. The conditional expenditure elasticities are all 1.0. The income share is very small for Californians as a whole. The implied own demand elasticities are about –2.5 in the medicinal segment, –2.25 in the adult-use segment and about –1.3 in the illegal segment, given the larger share of illegal cannabis that each of the other two segments. Cross elasticities are about 1.5 between the two regulated segments and below unity between the illegal segment and the two regulated segments.

We assume that adult-use legalization and regulations will shift the marginal cost and demand functions. Our assumptions are as follows. Legalization and regulations cause marginal costs of the two regulated segments to decline by 12 percent because of access to better management, more secure capital, and less threat of crime and law enforcement actions. Costs rise by 10 percent in the illegal segment to reflect reduced access to qualified managers and increased state-level enforcement against non-compliant cannabis businesses. These proportional

Table 6. Simulated Equilibrium California Cannabis Prices, Quantities, Revenues, and Taxes after Full Implementation of Taxation and Regulation

Variable	Medicinal Segment	Adult-Use Segment	All Legal Cannabis	Illegal Segment	Total Cannabis
			$/Pound		
Average Retail Full Price to Buyers	4,841	5,104		2,659	
			Thousand Pounds		
Quantity	616	724	1,339	1,535	2,874
			$ Millions		
Revenue Without Tax	2,216	2,609	4,825	4,081	8,906
Total Tax Revenue	764	1,084	1,849	0	1,849
Total Revenue	**2,981**	**3,693**	**6,674**	**4,081**	**10,755**

Source: AIC simulations and calculations.

cost shifts apply throughout the supply chain from cultivation through retail.

On the demand side, the regulatory restriction that cannabis retailers must close at 10pm each evening, which reduces access relative to the illegal segment, is assumed to reduce demand for regulated cannabis by 2 percent. Off-setting this demand shift is a shift up in willingness to pay in the regulated segments by 6 percent and a shift down in willingness to pay in the illegal segment due to testing and product security. The notion that safety testing and government assurances of testing and safety can increase willingness to pay is widely incorporated in analysis of demand for other agricultural products (Pouliot and Sumner, 2008; Saitone, Sexton, and Sumner, 2016; and Gray et al., 2005). The final demand shift is a 30 percent shift out in demand for adult-use cannabis which occurs with legalization and easy access through retail markets. This demand shift reflects demand from tourists, publicity, and advertising.

The model applies the tax and regulatory shocks as specified in Table 5 to the prior supply and demand equilibrium. These shocks are accompanied by the supply and marginal cost shifts induced by legalization and regulation. As with common model applications that compares two equilibrium situations, we do not examine the path from one situation to the other. In the case of cannabis legalization and regulation, we expect and (in early 2018) have already begun to observe the considerable flux that accompanies uncertainty and the progressive, asynchronous nature of implementation and enforcement of some regulations and taxes. In a sense, a new legal industry and a new framework of regulations are being created. The government is phasing in the licensing and regulations over a full year, and thus we will not observe the new situation until 2019 at the earliest. Of course, the market will not be static, and we do not expect a static equilibrium to persist even when all regulations are fully implemented.

Table 6 provides information about the new situation based on the taxes, regulations, and assumptions outlined. We stress that these results are more than usually tentative (Hyde, 2016). We project prices (including all taxes) in the medical and adult-use segments to be about $5,000 per pound, while the price in the illegal segment will be just over half that. One uncertainty relates to the potential for the farm cost of legal cannabis to decline more than we assume, but we also note that costs must incorporate the added cost of meeting all the regulations that are not specific to cannabis, and that farm cost makes up at most a third of retail price.

Notice that we project that the two legal segments, together, will comprise about 46 percent of total cannabis quantity purchased in California. The retail price differences are enough to more than offset the demand shifts and marginal cost shifts. Our assumptions about lower costs in the two regulated segments and large shifts up in willingness to pay for tested cannabis and security regulation allow the regulated segment to maintain

its size despite severe price differences with the illegal segment. Within the regulated segment, the lower tax in the medicinal segment is enough to allow that segment to retain many relatively heavy users and decline by only 12 percent.

Because of higher prices, taxes, and costs, aggregate revenue in the regulated segments together exceeds that in the illegal segment. Revenue net of all taxes is almost $5 billion, or about 54 percent of the total cannabis revenue. We estimate that all tax revenue approaches $2 billion per year. Overall, the tax-inclusive revenue in the two regulated segments is about $6.7 billion, compared to about $4.1 billion in the illegal segment, for a total cannabis revenue of about $10.8 billion when the $1.85 billion in taxes is included.

Conclusions

About 80 percent of cannabis grown in California remains illegal under both state and Federal law because it is grown to be shipped out of California. Total farm revenue is likely to be about $16 billion, including $3 billion within California—about half of which is illegal—and $13 billion of illegal cannabis shipped out of California. As with other farm products, the retail revenues are much larger.

We conducted a careful review of regulations and taxes that are in the process of being implemented in California. In order to project where the market is likely to be once taxes and regulations are fully implemented in 2019, we made a long list of assumptions about supply and demand elasticities and shifts. All of these assumptions are open to question. Some, such as demand substitution across segments, magnitude of demand, and marginal cost shifts, are based on little evidence. Nonetheless, we hope that our estimates may be useful for those interested in where the cannabis industry in heading in California. We expect that the illegal segments will remain in place, but that the regulated segments will capture a sizeable part of the overall market and generate billions of dollars in revenue, including almost $2 billion in tax revenue for the state and local jurisdictions.

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