2019 Recreational Marijuana Supply and Demand Legislative Report

Oregon Liquor Control Commission

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Contents

Executive Summary

There has been and continues to be significant speculation about the amount of marijuana produced and consumed within Oregon's regulated recreational market. The same holds true for legal and illegal cannabis consumption in other states, including those with medical marijuana and adult-use programs. This report seeks to clarify and quantify Oregon's legal marijuana market by using baseline data and applying conventional economic analysis.

The Oregon Liquor Control Commission (OLCC) is required by law to report to the legislature the amount of marijuana produced by Recreational Producers and bought by consumers in Oregon from Recreational Retailers. This report does not include information on the Oregon Medical Marijuana Program (OMMP), personal home grow, or the illegal market.

The Oregon recreational marijuana industry has created a booming consumer market of low prices and increasing demand. The number of applications for licenses to produce recreational marijuana has also continued to exceed expectations. Decreasing consumer prices are a direct result of supply that exceeds demand and have increased market pressure on licensed operators throughout the supply chain. This report provides a snapshot of the Oregon recreational marijuana program, including the supply of marijuana, product flow, inventory on hand, consumer demand, and possible policy options.

Oregonians passed Measure 91 in November of 2014, legalizing adult-use recreational marijuana in Oregon. OLCC is the agency in charge of licensing Recreational Producers, Processors, Wholesalers, and Retailers. Measure 91 established, and subsequent legislation maintained, the philosophy of a free market within the regulated recreational system in order to prioritize early transition away from the illegal market by both producers and consumers. The barriers to entry are lower here than in other states: Oregon does not have a residency requirement for investment or ownership, licensing fees are low, and there are no limits to the amount of licenses one individual or a business can acquire.

Key Findings

o Supply exceeds demand within Oregon's recreational marijuana market.

o Between July 2017 and June 2018, demand represented 50% of supply; the other 50% remained accounted for in recreational licensees' inventory and contained within the recreational system.

o OLCC Recreational Producers harvested more than 2,000 metric tons of wet, untrimmed marijuana in 2018; if all currently pending Producer applications were approved, estimated production would increase to nearly 4,000 metric tons of wet weight.

o As of January 1, 2019, the recreational market has 6.5 years' worth of theoretical supply in licensees' inventory accounted for and contained within Oregon's Cannabis Tracking System.

o An estimated 55% of total statewide marijuana consumption among Oregonians aged 21 or older is procured from OLCC Recreational Retailers. Based on existing levels of production, all consumption of marijuana among Oregon adults could be supplied by the OLCC market.

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This report finds that supply in the recreational market is twice the level of current demand. The unpurchased supply remains tracked and contained within the legal, regulated market. This disequilibrium between supply and demand has contributed to growing levels of licensees' inventory. As of January 1, 2019, the recreational market has an estimated 6.5 years' worth of theoretical supply on hand. Even under assumptions of growth in demand caused by more Oregonians consuming more marijuana supply will almost certainly continue to exceed demand at current levels of production.

This report evaluates production and sales within the time period of July 2017 through June 2018, using data from the state's Cannabis Tracking System. Due to the diversity of product mixes sold by Recreational Retailers, this report standardizes all sales to a single unit (milligrams of THC sold) and calculates a "wet weight equivalent" of the amount of marijuana estimated to have been needed to supply that level of demand in the given time period. This "wet weight equivalent" method and the report's findings were validated by external reviewers from the private sector and other state agencies.

Based on the outcome of the data analysis, this report discusses the positive and negative implications of potential policy choices including maintaining the free market status quo and letting the market self-correct towards equilibrium, limiting the maximum producer canopy, increasing license fees, and placing a cap or moratorium on the number of recreational licenses. Due to the nature of the market in which supply already exceeds demand, any policies enacted with the purpose of creating equilibrium in the near-term will inherently have an effect on incumbents within the market.

To obtain a paper copy of this report contact the Oregon Liquor Control Commission's Recreational Marijuana program at marijuana@oregon.gov.

Published online at https://marijuana.oregon.gov under the "Government Resources" header.

Introduction

Per ORS 475B.548, by February 1 of each odd-numbered year the Oregon Liquor Control Commission (OLCC), which licenses and regulates production and sales of recreational marijuana in Oregon, must submit a report to the Legislative Assembly on the following:

> *the approximate amount of marijuana produced by marijuana producers that hold a license issued under ORS 475B.070 and the approximate amount of marijuana items sold by marijuana retailers that hold a license issued under ORS 475B.105, and whether the supply of marijuana in this state is commensurate with the demand for marijuana items in this state.*

The first "supply and demand report" was submitted by the OLCC in 2017, less than 12 months after the first Recreational Producer licenses were issued (April 29, 2016) and less than 6 months after the first Recreational Retailer licenses were issued (October 1, 2016). The 2017 report concluded that the Oregon recreational market was "on the road to maturity" but that it was "too early to know the degree to which there is excessive or insufficient supply to match demand." Now with data on nearly three years' worth of recreational marijuana production and nearly two-and-a-half years' of recreational sales, this 2019 Supply and Demand Report can better analyze the degree of equilibrium of supply and demand within the Oregon recreational marijuana market.

The Oregon recreational marijuana industry has created a booming consumer market in which low prices have contributed to a continued increase in demand. However, the number of applications for licenses to produce recreational marijuana has continued to exceed expectations after eclipsing initial estimates. This has led to a market in which decreasing consumer prices are a direct result of supply that exceeds demand, low wholesale prices, and increased market pressure on licensed operators. This report provides a snapshot of the Oregon recreational marijuana program, including the supply of marijuana, product flow, inventory on hand, consumer demand, and possible policy options.

Background

In Oregon there are four markets for marijuana:

1) **Recreational**. Created by Measure 91 in November 2014, the recreational marijuana market is licensed and regulated by the OLCC. Any adult 21 years of age or older or any Oregon Medical Marijuana patient 18 years of age or older may purchase marijuana from a Recreational Retailer. Recreational Producers cultivate and harvest plants within their licensed premises for sale by Recreational Retailers as "usable marijuana" (dried and cured flower and leaves) or for further processing by Recreational Processors into secondary items such as extracts and concentrates (e.g., butane hash oil (BHO) and "vape cartridges") and tertiary items such as edibles, tinctures, and topically applied products (topicals). Recreational Wholesalers are licensed to store and distribute items within the recreational market. Laboratory licensees perform required testing on marijuana items, including but not limited to tests for residual pesticides and product potency. Items harvested or processed within the recreational market must remain within the OLCC-licensed system and Recreational Retailers may only procure products from other recreational marijuana licensees.

2) **Medical**. Created by Measure 67 in 1998, medical marijuana is regulated by the Oregon Health Authority (OHA). The original medical marijuana law included only direct relationships between medical marijuana patients registered with OHA and medical marijuana caregivers for the cultivation and possession of marijuana for medical use. Subsequent medical marijuana laws expanded the program to include medical growers, processors, and dispensaries, all overseen by OHA. However, nearly all of the medical processors and dispensaries that were registered with OHA at the time Measure 91 passed have subsequently become licensed under the OLCC's recreational marijuana program and transitioned to the recreational market. Those processors and dispensaries that have remained with the Oregon Medical Marijuana Program (OMMP) are primarily located in opt-out jurisdictions, which prohibit recreational licensure. The vast majority of activity within the medical system today consists of patients growing for themselves or receiving medical marijuana from their legally designated grower.

3) **Home Grow**. Passed as part of Measure 91, every adult 21 years of age or older in Oregon is legally permitted to grow marijuana (up to four plants per household). This "home-grown" marijuana may be for personal use or provided as a gift to other individuals in the state for no consideration. Although home extraction (e.g., butane hash oil) is illegal, making at-home concentrates (e.g., ice water hash) or products such as edibles with home-grown (or gifted) marijuana is permitted under Oregon law.

4) **Illegal**. Fully illegal production and sales, neither regulated nor licensed by any entity in Oregon, has a long-standing history in Oregon. Although the establishment of both medical and recreational laws legitimized production and sales within the regulated systems, fully illegal production and sales persist. Moreover, while home grow itself is legal, it can cross into illegality if production exceeds possession limits, if harvested material is sold (rather than gifted), or if marijuana is taken out of the state. Due to the inherent "underground" nature of the illegal market, it is impossible to make definitive estimates of its size.

This report is limited to estimates of supply and demand only within the recreational market. This report makes no attempt to estimate the production, sales, or equilibrium of supply and demand within the State of Oregon as a whole.

Market Trends Since Licensure Began

Licensure
As of January 25, 2019, OLCC has 1,114 Recreational Producers currently licensed and 607 Recreational Retailers. Those numbers alone are double the initial estimates of *total* licensure by 2019.[1] Moreover, there are another 1,117 Producer applications and 336 Retailer applications pending review or approval by the OLCC. Enthusiasm for licensure in the recreational market has not subsided. In fact, when OLCC announced that it would put a pause on processing new

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[1] Initial estimates in 2015, based on population-adjusted licensing volume in Washington and Colorado, were 826 total licenses issued by the 2017-2019 biennium. Estimates by license type were 328 Producer licenses, 188 Wholesale and Laboratory licenses, and 310 Retailer licenses.
https://olis.leg.state.or.us/liz/2015I1/Downloads/CommitteeMeetingDocument/81394#page=19

applications received after June 15, 2018, OLCC received an additional 664 Producer and Retailer applications in the first two weeks of June 2018.

As shown in Figure 1, the cumulative number of applications received has continued to increase at a rate commensurate with approved licenses for Retailers (red) and exceeding the rate of approvals for Producers (blue). The rate of submission of applications shows no signs of abating. On the contrary, the most noticeable recent trend is the spike in June 2018 coinciding with applicants' attempts to submit "under the wire" of OLCC's announced pause.

Figure 1: Cumulative Total of Licenses and Pending Applications by Month[2]
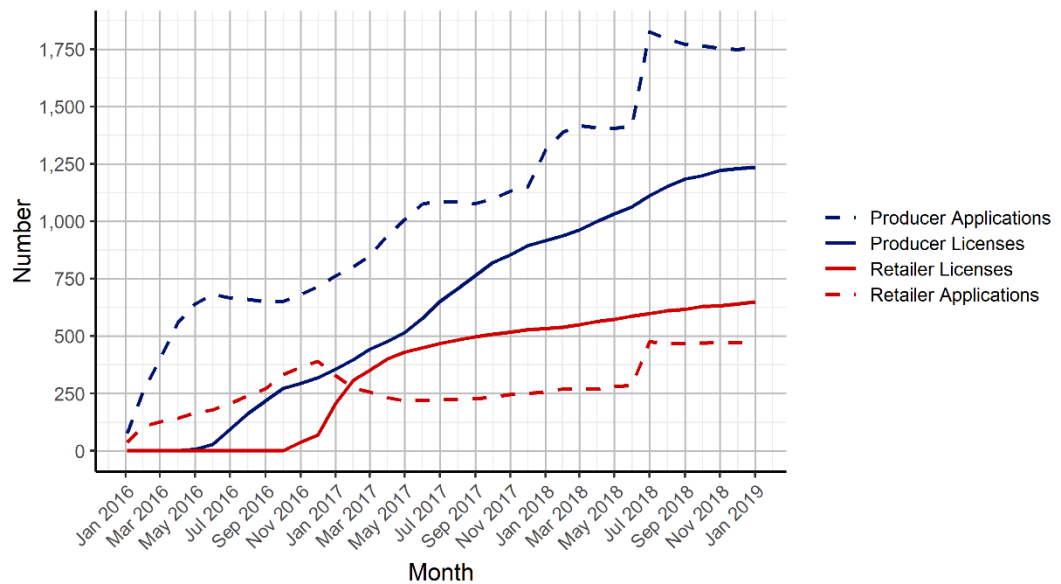
Production

The amount of marijuana produced within the Oregon recreational market has increased as more licensed Recreational Producers have entered the market. The aggregate amount harvested within the recreational market consists of two factors: first, the amount harvested *per licensed producer* and, second, the *number of licensed producers*. Each factor can independently affect the supply of harvested marijuana within the recreational market. For example, if 100 producers each harvested 10 pounds last year but each harvested 20 pounds this year, the supply will have doubled. Similarly, if this year 200 total producers are licensed and each again harvests an average of 10 pounds, supply will have also doubled.

The 2017 harvest saw both factors (per producer harvest and number of licensed producers) rise, which greatly increased recreational supply relative to 2016. In contrast, the 2018 harvest had more

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[2] Application and license counts are cumulative and include applications that have been withdrawn or denied and licenses that are revoked, surrendered, or expired. Applications are calculated as the cumulative total number of submitted applications minus the cumulative total number of licenses issued.

producers harvesting less per license, which still yielded a greater aggregate amount harvested compared to 2017.

As with all the following analysis of market data, the source of the data on harvest by month comes from Oregon's Cannabis Tracking System (CTS).[3] OLCC rules require that licensees reconcile physical inventory with their reported CTS inventory each day. This entails reporting all activity that occurred during the business day. Licensees must report plant stocks (new plantings and plant deaths), harvests, waste, transfers, lab testing, and sales. This compliance tool creates a wealth of data that can also be used to study the general dynamics of the industry.

Figure 2 illustrates the increase in harvested supply year-over-year. The graph also demonstrates the heavy concentration Oregon has historically had in outdoor production in which the month of October represents an outdoor grower's entire annual harvest. This contrasts with indoor growers in which supply is generated through repeated, smaller harvests over the course of the year.[4]

Figure 2 also shows that the 2018 harvest rose considerably compared to 2017. As seen in Table 1, total harvested wet weight increased by 17% between 2017 and 2018. Far from an abnormally high "bumper crop," the 2017 yields may be a new baseline due to the ever-increasing numbers of licensed producers. Even if the per producer output declines relative to 2017, the total number of producers may more than compensate in future years. Indeed, if every currently pending Recreational Producer application were licensed at its proposed canopy size, the estimated annual harvest based on 2018 output per square foot would be 8.7 million pounds—an increase of nearly 88% compared to 2018.

Figure 2: Wet Weight Harvested by Month and by Producer Type

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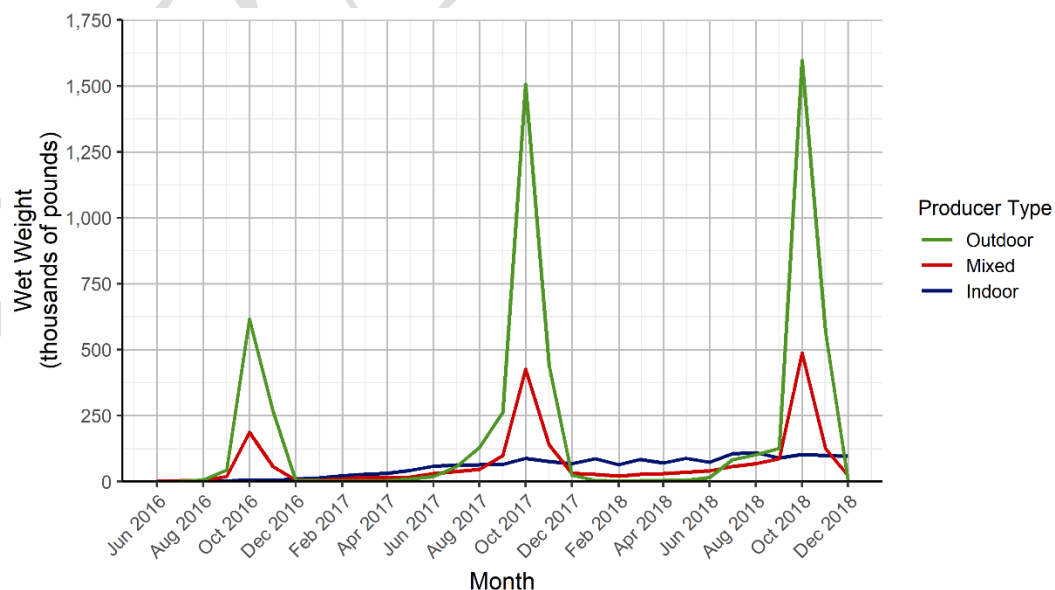
[3] Oregon's CTS system is also known as "Metrc."

[4] OLCC issues licenses for three types of producers based on the manner of cultivating flowering plants. Indoor producers use artificial lighting, Outdoor producers do not, and Mixed producers have a portion of the flowering canopy that uses artificial lighting and a portion that does not. Any producer may use artificial lighting for cultivation of immature (non-flowering) plants.

Table 1: Wet Weight Harvest (pounds) by Producer Type and Year

Year	Indoor	Mixed	Outdoor	Total
2017	613,000	872,000	2,453,000	3,938,000
2018	1,075,000	1,027,000	2,511,000	4,613,000
Prospective	2,122,000	1,638,000	4,894,000	8,653,000

Sales

Increased supply has resulted in consumer prices falling from more than $10 per gram of usable marijuana in October 2016 to less than $5 per gram in December 2018, as seen in **Error! Reference ource not found.**. Despite those falling prices the overall dollars sold year-over-year have continued to increase, rising nearly 16% between December 2017 and December 2018 (see

). This rise is sales, and therefore in marijuana tax revenue, is due to increases in the total quantity of marijuana items sold. For example, Figure 5 shows that both extracts/concentrates and cannabinoid products (e.g., edibles, tinctures, etc.) had their best month of sales in December 2018.

There is a marked seasonality to marijuana sales. This makes it difficult to know at what point (or whether) quantities sold will plateau even with declining prices and when (or whether) this will lead to a decrease in total dollars sold in the recreational market. For example, total sales peaked in August 2017 before declining in the winter months and then again increasing in Spring 2018. The most recent sales peak was in August 2018 and has since declined, but it is unknown whether (and to what degree) sales will increase in Spring 2019. In other words, we do not yet have sufficient data to disentangle predictable, endogenous seasonal effects from exogenous market shocks (both positive and negative).

At this point, however, the available evidence of decreasing prices and increasing sales indicates that the recreational market continues to chip away at the illegal in-state market, resulting in increasing marijuana tax revenues for the state, schools, and local governments.[5]

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[5]

 and Figure 5 also show a spike in sales in January 2017, coinciding with the end of Early Start sales. This marked the point at which OHA medical dispensaries could no longer sell to recreational consumers and began shifting to OLCC licensure. This sudden increase in January 2017 in all likelihood represents the same customers coming to the same stores as they did in December 2016, but those sales instead took place within the recreational rather than the medical market.

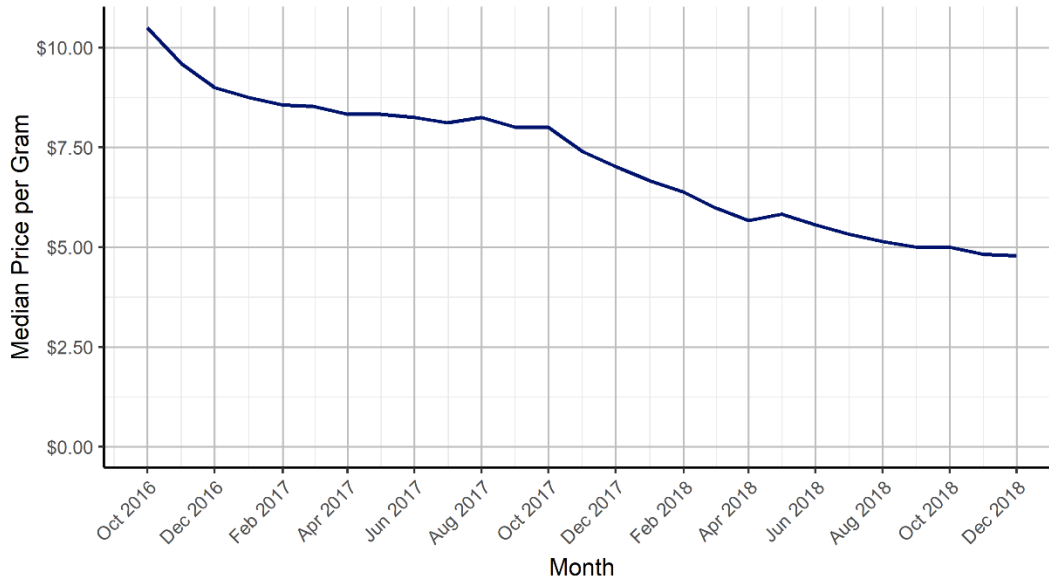*Figure 3: Median Retail Price per Gram of Usable Marijuana by Month*

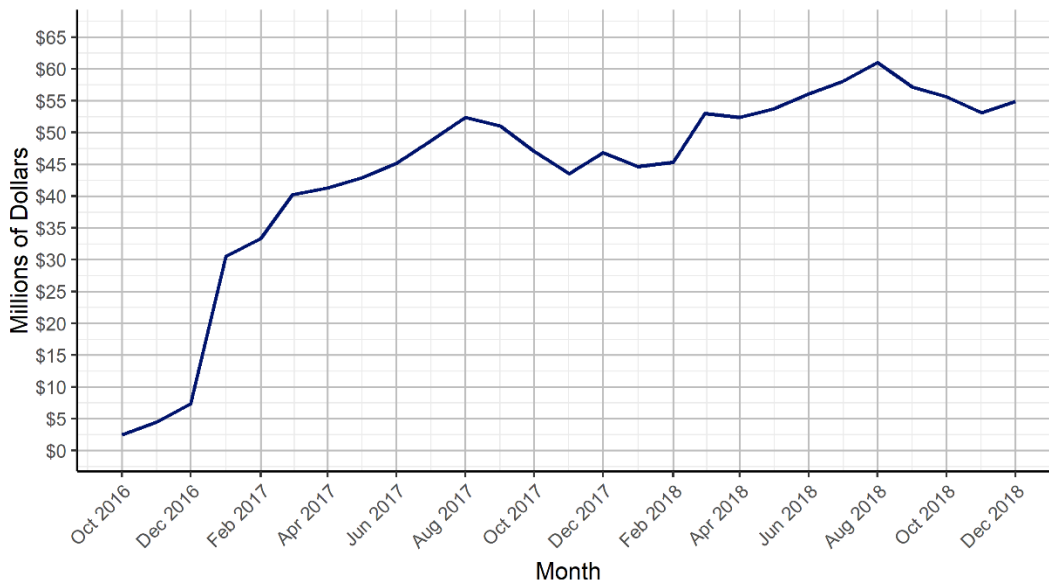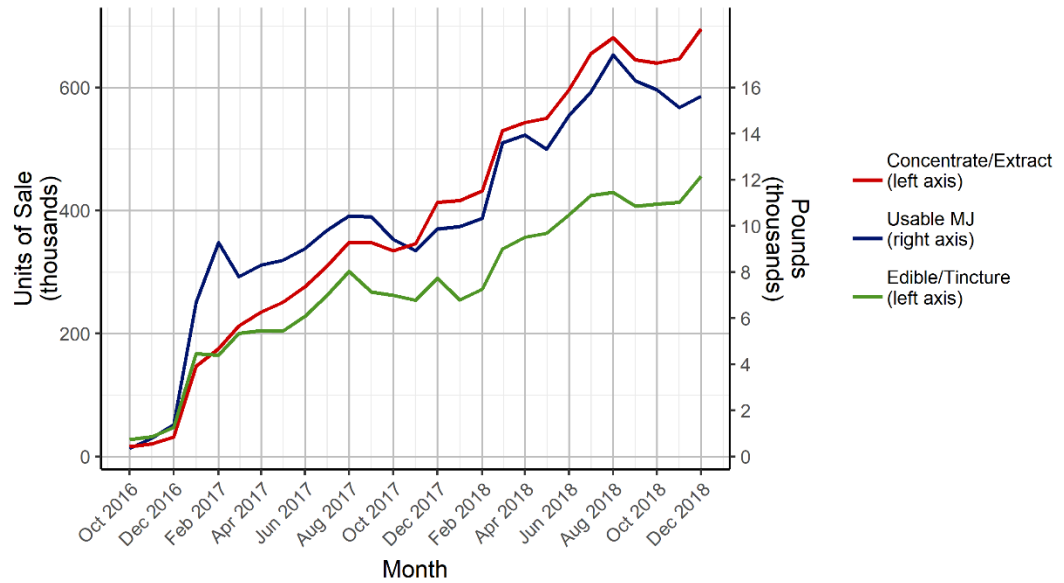*Figure 4: Total Dollars Sold by Month by OLCC Recreational Retailers*

Figure 5: Quantity Sold by Month

Medical dispensaries have almost entirely transitioned to OLCC licensure, which has made Recreational Retailers a significant source from which medical patients purchase and receive marijuana items. Monthly patient sales have held remarkably stable at approximately $5 million per month since January 2017 when "early start" sales ended and dispensaries began transitioning in bulk to the recreational market (Figure 6). While patient sales at Recreational Retailers as a percentage of total sales have declined, this is due to total sales increasing at a faster rate than sales to patients.

Figure 6: Dollars Sold by Month and by Customer Type
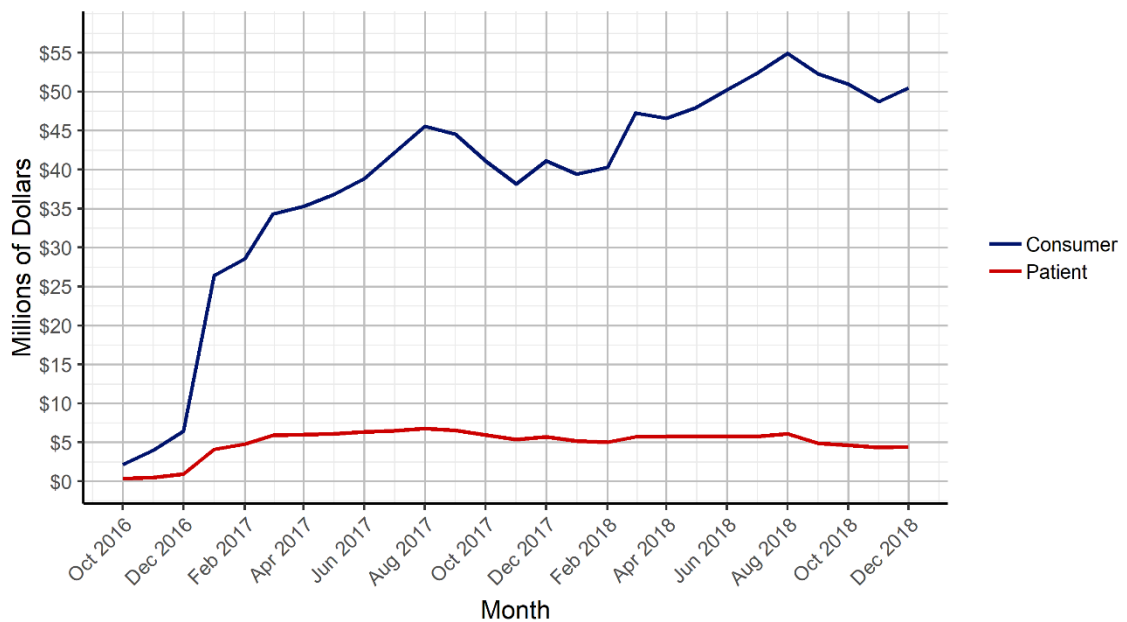
One major trend in Oregon, as well as other states with legalized recreational markets, is the increasing customer shift away from usable marijuana (flower, leaves, and non-infused pre-rolls) towards other product types, particularly extracts and concentrates. While usable marijuana sales peaked in August 2017 (approximately $34 million in sales), extract and concentrate sales increased another 40% between August 2017 and August 2018 ($12.5 million to $17.5 million).

Figure 7: Dollars Sold by Month and by Product Type
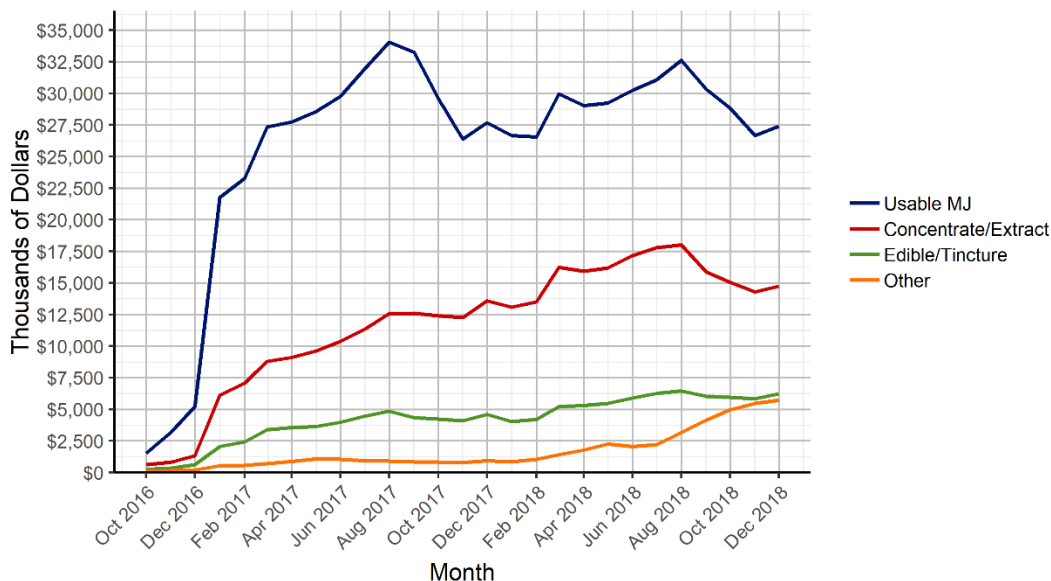
Aside from being an interesting market dynamic on its own, this trend introduces further complexity into estimating supply and demand. Demand-side product mixes play a central role in how much supply is needed to satisfy a certain level of demand. For example, satisfying 1 gram of demand for usable marijuana requires far less upstream supply than 1 gram of extract or concentrate. Moreover, even within these broad categories, there is a heterogeneous mix of what "extract," "concentrate," and "edible" means and the supply required to manufacture them. This complexity, and the implication for this report's supply and demand estimates, are discussed in further detail later in this report.

Inventory

Decreasing consumer prices are a direct consequence of greater supply and lower wholesale prices within the recreational market. Basic principles of supply and demand dictate that if supply exceeds demand within a market, all else equal, prices will decline for that product. Wholesale prices, or the price paid between licensees, demonstrates this trend (Figure 8). As the amount harvested has increased, the wholesale price has decreased. Indoor- vs. Outdoor-produced usable marijuana has a clear distinction in terms of price level, but for both the overall wholesale price trend is the same.[6]

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[6] Indoor marijuana is produced in smaller quantities for higher "top shelf" prices. Lower-priced outdoor marijuana is more typically used for input material for extract/concentrate processing.

Figure 8: Median Wholesale Price by Month and by Producer Type
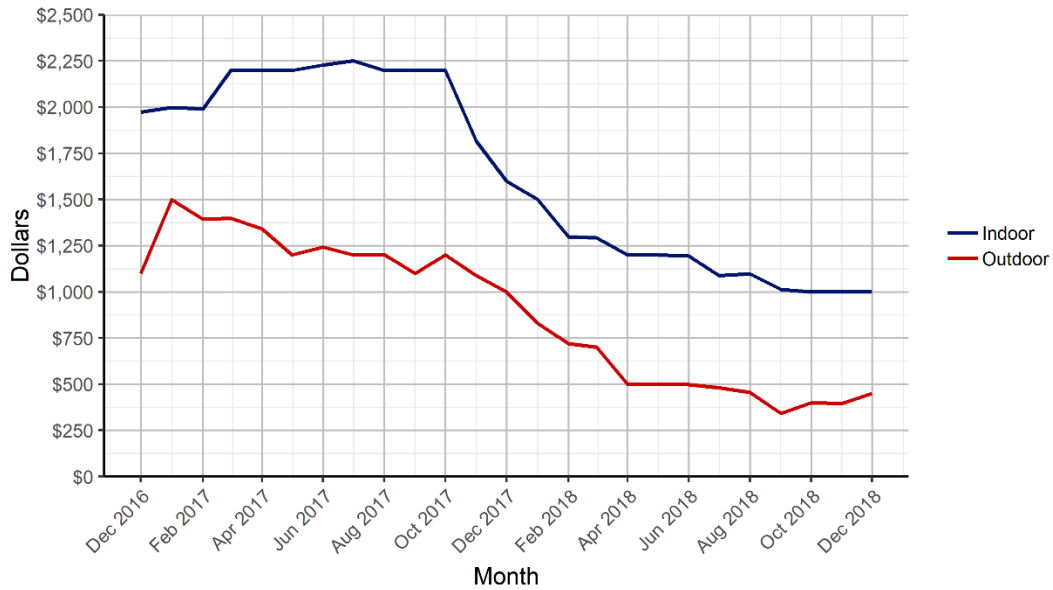
Beyond declining wholesale prices, actual levels of inventory on hand by license type month-to-month are a more direct indication of increasing supply (

Figure 9 to Figure 11). Although some degree of supply storage and wind down of inventory over the course of the year would be expected due to the large proportion of annual harvest that takes place in a single month, the actual level of inventory remains well-above what is needed to satisfy demand through the supply chain. For example, inventory levels of usable marijuana at Recreational Producer locations in October 2018 continued to exceed what was on hand in October 2017. This is the case despite a large ramp up of extract, concentrate, edible, and tinctures manufacturing.

Processors appear to be taking advantage of low prices on input material to "stock up" for projected future sales; extracts and concentrates are more shelf-stable than either usable marijuana or edibles and tinctures. This ramp up in processor manufacturing in 2018 will likely result in a net decrease of processor demand for input material harvested during the 2018 outdoor season. In other words, although usable marijuana levels have declined precipitously throughout the course of 2018 after a post-harvest spike, the level remains higher year-over-year and the sell down rate is likely to be lower in 2019, resulting in a continuously increasing stock of supply.

Figure 9: Inventory by Month and by License Type, Usable Marijuana[7]
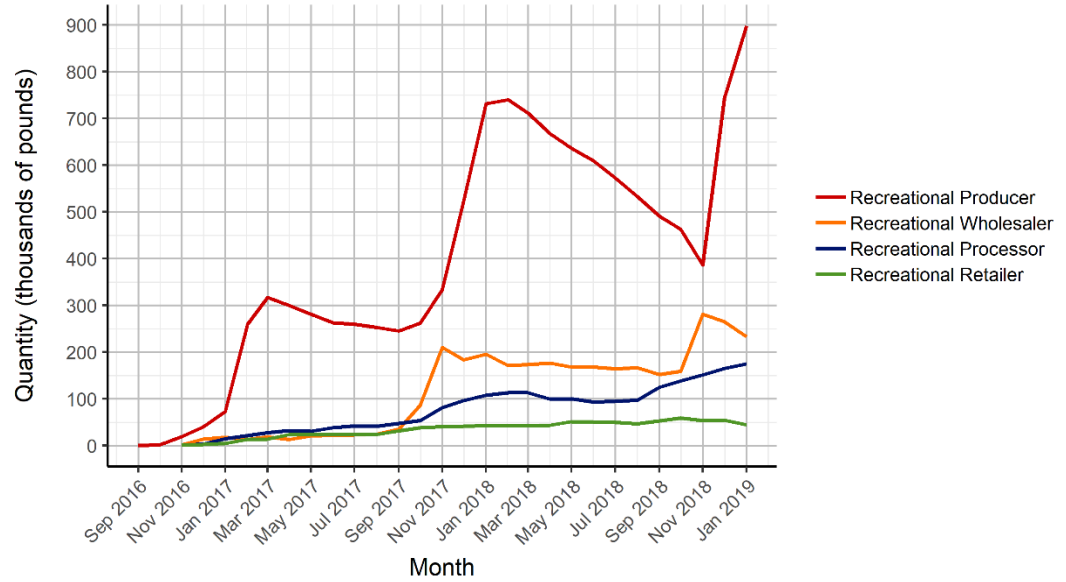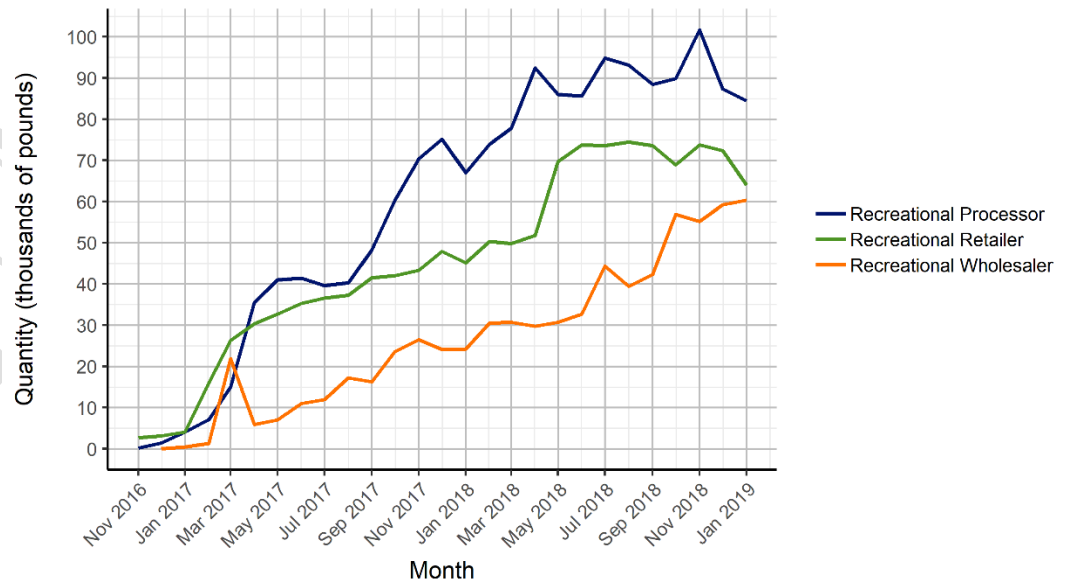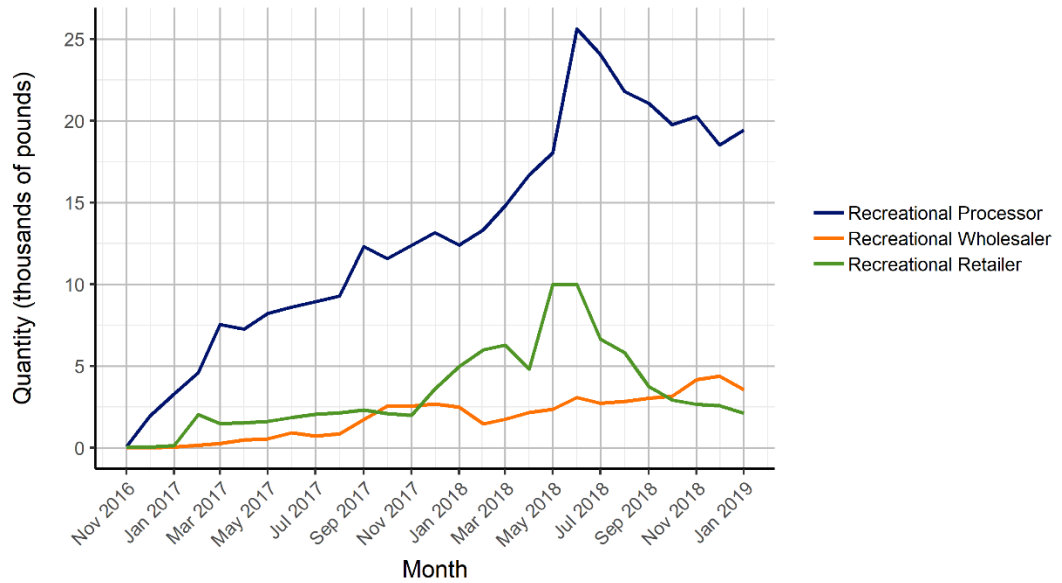

Figure 10: Inventory by Month and by License Type, Edibles/Tinctures

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[7] Although outdoor harvests occur almost exclusively in October, the time it takes to dry, trim, and cure creates a lag between harvest and when the product is reflected as "usable marijuana" in producer inventory levels.

*Figure 11: Inventory by Month and by License Type, Extracts/Concentrates*

Raw inventory weight provides a useful insight into levels of supply. Scaling to a demand-equivalent estimate even more fully illustrates the trend of increasing supply. Using the estimation method described later in this report, the inventory levels by month are converted to an amount of THC and compared to the July 2017 to June 2018 levels of demand.[8] This results in a standardized trend of supply in terms of the number of years it would take to sell through the entirety of the inventory in the OLCC market with no further production. Based on this estimate, as of January 1, 2019, the theoretical level of supply in the OLCC system is 6.5 years.

Almost certainly some amount of the existing inventory in the recreational system will never be sold. It may become too stale to be sold or is of insufficient quality to compete in the current market environment. In fact, anecdotally some of it may already be waste that has not yet been disposed of. Although the current inventory levels would not literally sustain current demand for 6.5 years, the estimate does provide an illustration of the effects of year-over-year production that exceeds consumer demand.

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[8] The method of "wet weight equivalent" estimation used in this report converts THC sold to an estimate of wet weight harvested. The method used in Figure 12 to estimate supply of THC is the inverse—it takes weight based on the product's place within the supply chain and converts to THC, using the same parameters described in the Technical Appendix.

Figure 12: Inventory of Supply of THC by Month
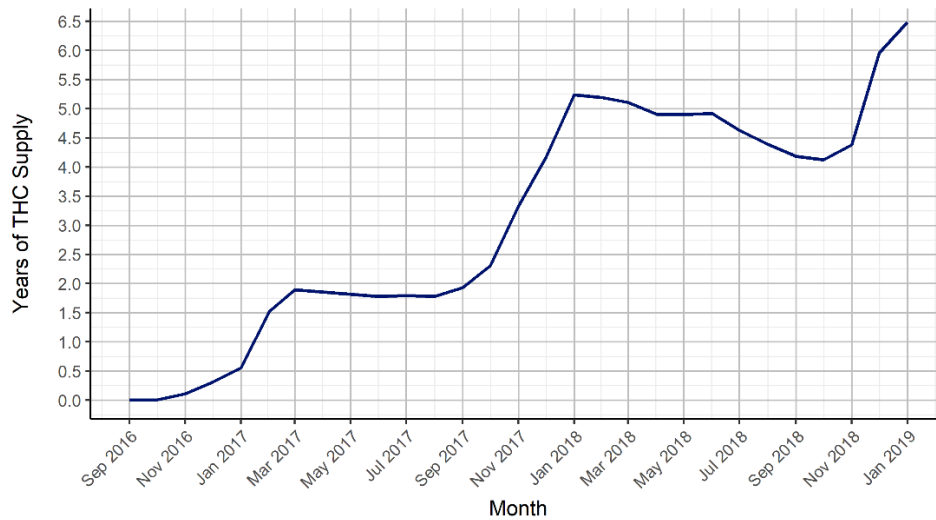
While inventory levels continue to grow, the stock is growing within the licensed recreational system. The law of supply and demand dictates that increased supply above equilibrium results in lower prices, all else equal. Inventory levels, wholesale prices, and consumer prices all tell a consistent story—supply is higher than demand within the legal, recreational supply chain resulting in lower prices.

Licensees are obligated to reconcile inventory daily in the state's Cannabis Tracking System, which is only one component of OLCC's "three-legged stool" of compliance. The other two "legs" (security requirements, such as required cameras and video retention, and physical site inspections) add an additional layer of surety to the integrity of the closed-loop recreational system. Although cases of illegal diversion out of the OLCC recreational system have occurred (with both administrative and legal sanctions occurring as a result), by and large the vast majority of product that licensees have declared as being in their inventory has been identified as on-site during physical site inspections.

Growing supply and declining prices create market pressures that may over time increase the likelihood of licensees turning to illegal diversion and arbitrage opportunities out-of-state in order to keep businesses afloat. However, under the current market dynamics, a license in good standing in Oregon is viewed as an asset that can attract capital investment (in-state, out-of-state, and international) for future expansion under a (potential) future federal regulatory structure that permits interstate trade. This incentivizes operating within the legal structures of Oregon's market even if it comes with greater price pressures and short-term losses. In this way, businesses in Oregon's recreational marijuana market are in some ways analogous to technology start-ups. Specifically, investors and business owners are willing to take the risk of losses today for potential large gains tomorrow. However, this calculus depends on "tomorrow" not being excessively far in the future and the license remaining in good standing.

In other words, supply exceeding demand in and of itself is not an indicator of illegal activity that warrants drastic policy action, but may instead be an indication of speculative bets and pending market corrections. While policy decisions may be needed to push supply down closer to demand, this does not necessarily mean that wholesale change to licensure or the market itself is required.

Model for Estimating Supply and Demand

Estimates of inventory on hand within the market can identify stock of supply in a given month, but it cannot directly answer the question of whether the flow of supply through the market is in equilibrium with demand.

First, inventory levels are influenced not only by production within the market but, at least in the case of the recreational marijuana market, are also affected by continued transitions from the medical marijuana system. Medical marijuana growers continue to surrender their medical registrations and become recreationally licensed, which continues to create a steady flow into the recreational system. This complicates an analysis of supply and demand because it creates one-time increases in net recreational inventory that may not reflect long-term production trends.[9]

Second, supply alone is only one half of the equation; demand estimates are also needed to evaluate not only whether supply and demand are in equilibrium during a discrete time period, but also the ways in which changing demand dynamics may either push demand closer to or further from supply.

To more reliably estimate both sides of the equation over a fixed period of time and hold various factors constant, this report evaluates production and sales within the time period of July 2017 and June 2018, using data from the state's Cannabis Tracking System. Due to the diversity of product mixes sold by Recreational Retailers, this report standardizes all sales to a single unit (milligrams of THC sold) and calculates a "wet weight equivalent" of the amount of marijuana estimated to have been needed to supply that level of demand in the given time period.

Units of THC and Wet Weight Equivalent

By and large, the demand for recreational marijuana can be traced to a demand for THC (tetrahydrocannabinol), which is the intoxicating component of marijuana. Marijuana within the OLCC recreational market is overwhelmingly grown to maximize concentration of THC and is the primary driver of consumer demand for recreational marijuana products. Anecdotally there is increasing demand for CBD (cannabidiol), the non-intoxicating component of marijuana that is also attracting considerable interest in cannabis research for its potential medical benefits. This trend may impact future supply and demand trends. However, with more legal outlets of supply for CBD as compared to THC, the recreational marijuana market will likely continue to predominantly serve the THC portion of the cannabis market.[10]

Due to the wide-ranging and ever-shifting mix of product types, the most straightforward method of estimating demand is to convert purchases to a standardized unit of THC. This is possible in large part due to the testing requirements for recreational marijuana products. All final products transferred to a Recreational Retailer for sale to a consumer must be tested for potency (both THC and CBD). Due to the chain of custody linking items in the Cannabis Tracking System and the required daily inventory reconciliation (which includes all lab testing information as well as all sales data), every item sold can be linked to its specific THC potency value in milligrams. For example, if

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[9] For example, a medical grower may "stock up" inventory over a period of time in anticipation of gaining access to a more robust processor and retailer market.

[10] With federal de-scheduling of high-CBD hemp in the 2018 federal Farm Bill and avenues for its entry into the OLCC market, it is likely that any rise in demand for CBD will be met through the hemp market and that the recreational marijuana market will continue to be a center of production of high-THC marijuana.

a 1 gram vape cartridge with 650 mg of THC (65% potency) is sold, that would be equivalent to 3.25 grams of usable marijuana at a potency rate of 20%. By calculating how much usable marijuana was used to manufacture a gram of extract, this report is able to evaluate the increase or decrease in demand, and the commensurate change in supply needed, that would result from consumers substituting away from usable marijuana and towards extracts or other product types.

Similarly, based on the myriad paths harvested material could take through the supply chain, this report converts the aggregate THC amount sold to a *wet weight equivalent* of the marijuana that went into the final product. Marijuana is cultivated and harvested like many agricultural crops. However, unlike many other agricultural commodities the actual marketable portion of the crop is extremely small relative to the initial weight of the harvested portion. In the case of marijuana, the dried and cured flower and leaves are the saleable product, which can represent as little as 10% (or less) of the initial harvested weight due to evaporation of water weight and waste of stems and stalks.

The potential paths marijuana may take between harvest and final sale are significantly more diverse than many other agricultural products. At a high level, the general product flow is as follows:

- Marijuana plants are harvested wet; drying and curing may account for as much as 90% loss of weight.
- Usable marijuana sold to consumers directly as flower (buds) and leaves (shake/trim) are tested for pesticides, water activity, moisture content, and potency and transferred to Recreational Retailers for sale.
- Marijuana to be used for further processing into secondary items is sent to Recreational Processors. Depending on the method and desired product, marijuana sent to processors may range from wet, untrimmed marijuana that is processed within 24 hours of harvest to material that has been fully dried and cured.
- Extracts and Concentrates processed from raw marijuana "feedstock" for direct sale to consumers are tested for pesticides, solvents (if applicable), and potency and transferred to Recreational Retailers for sale.
- Extracts and Concentrates for further processing into tertiary items (e.g., edibles, topicals, etc.) are tested for pesticides and solvents (if applicable) prior to being processed in-house or sent to another Recreational Processor for conversion into a final product. This final product is then tested for potency and transferred to a Recreational Retailer for sale.
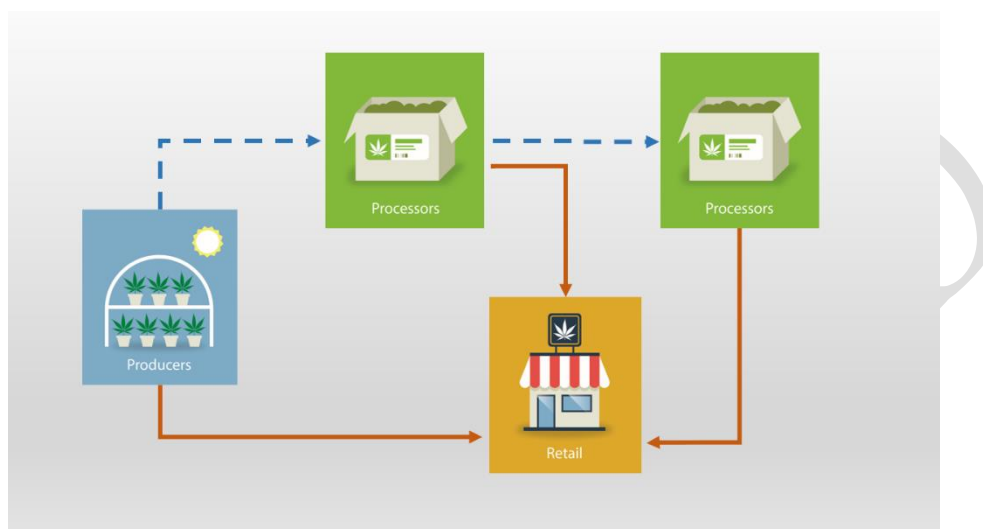
By reconstructing each step of the supply chain from the item as sold back to its originating input material, this methodology is able to convert the THC value of the final product to the initial wet weight of its source material.[11] The difference between the *actual wet weight harvested* between July 2017 and June 2018 and the estimated *wet weight equivalent of THC sold* over the same period is the degree of equilibrium between supply and demand within the OLCC recreational marijuana market.

Supply and Demand Findings

It is OLCC's estimate that demand in the recreational marijuana market was 50% of supply produced by OLCC-licensed producers between July 2017 and June 2018 (see technical appendix for full analysis and a more comprehensive description of the methodology used). In that time period 15.5 million grams of THC were purchased from OLCC Recreational Retailers, which is a wet weight equivalent of 2.1 million pounds of marijuana. Over the same time period approximately 4.2 million pounds of wet weight marijuana was actually harvested. This is the estimate under our "fixed demand" method in which consumption is taken as constant based on purchases between July 2017 and June 2018.

Although these estimates are derived from point estimates of factors such as product mix of demand, wet-to-dry ratios of marijuana, and input/output ratios of marijuana "feedstock" to secondary products, no reasonable set of assumptions result in demand matching supply under current conditions. For example, even if extracts and concentrates became 100% of the recreational

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[11] The reason for converting back to wet weight, rather than converting wet weight to THC-equivalent, is that both actual wet weight harvested and actual THC sold are fixed and known. If this report were to instead convert wet weight harvested forward to anticipated THC demand it would be introducing additional (and unnecessary) assumptions into the estimate. Specifically, if in 12 months' time the market share of extracts and concentrates were to increase by 40% it would drastically change the wet weight equivalent required to satisfy that demand. Supply takes time to work its way through the market for sale to a consumer in its final form. Projecting forward the supply harvested in a given month would require projecting forward under assumptions of anticipated product mixes. However, by casting backwards from known share for a given product mix to wet weight equivalent supply, this market share is held constant and gives a reliable estimate for the actual supply for the actual demand over the study period.

market share of THC purchased (from its current market share of 23%), demand would increase to only 71% of supply.

The only reasonable mechanism for demand within the OLCC recreational market to approach or meet supply is for the demand to rise through one of three (non-mutually exclusive) channels: an increase in marijuana consumers within the state, a greater level of consumption by marijuana users, or a rise in market share of the recreational market relative to other in-state marijuana markets (i.e., medical, home grow, and illegal). We estimate this potential growth through a "projected demand" method in which we analyze by how much potential consumption within the OLCC market would need to increase in order to match market supply.

Due to the historically "underground" nature of marijuana production and consumption, data on use rates and use levels is based on surveys that may be heavily skewed by respondents choosing not to answer truthfully. However, particularly as norms around production and use have changed in Oregon, there is a lower risk that current survey data on use patterns among Oregon adults is significantly biased.

Federal data related to number of consumers and levels of consumption suggests that approximately 20% of Oregon adults 21 years or older have consumed marijuana at least once in the last year and, of those who have consumed, the average level of annual consumption is 224.6 grams of flower-equivalent marijuana. At a median usable marijuana potency level of 19.5%, this is an annual mean THC consumption of approximately 44 grams. Like many markets, including for alcohol, total consumption is overwhelmingly driven by the heaviest users through the "80/20 rule." Generally, 20% of users represent 80% of total consumption. Based on a comparison of these estimated levels of consumption to actual sales of THC within the OLCC market, we estimate that the OLCC market was the source of approximately 55% of total THC consumed in Oregon (see Technical Appendix for details of estimates and calculations).

If any one of these three numbers were to increase, all else equal, the total demand within the OLCC market would increase and become closer to recreational supply. All three increasing at the same time would have an even larger effect. For example, if the number of marijuana consumers and the level of consumption were both to increase by 10% (to 22.9% and 48 grams of THC, respectively) and the OLCC market share were to increase by 25% (from 55.1% to approximately 69%), the total demand for THC in the OLCC market would increase by 50%.[12]

Even taking into account greater consumption within the OLCC market, supply would continue to far exceed demand. Under our estimate of "projected demand"—if total statewide consumption were to remain constant but OLCC sold two-thirds of statewide THC—recreational marijuana consumption would still only be 61% of recreational marijuana supply. In fact, it would require an

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[12] It is also possible that market share gains have a geometric rather than linear relationship. In this case, a tipping point may exist at which point a marginal consumer transitioning to the OLCC market represents a proportionately larger share of total consumption. Although we can estimate OLCC market share of the aggregate amount of THC purchased, we have no mechanism to estimate whether heavy users (those 20% of users representing 80% of consumption) are more or less likely to be OLCC consumers as opposed to medical, home grow, or illegal market participants. If these users are more likely to consume outside of the OLCC market, an increasing market share at some point would begin to lead to more of those heavy users purchasing within the OLCC market and increasing OLCC market demand at a greater rate.

increase of total statewide THC consumption by 25% *and* increasing the OLCC market share of that consumption from 55% to 75% to result in recreational demand that meets 98% of the recreational supply.

Table 2: Estimates of Supply and Demand

	Fixed Demand	Projected Demand
Median Demand Relative to Known Supply	49.7%	61.1%
Median Wet Weight Equivalent Demand	2,134,000	2,626,000

The data makes clear that the recreational marijuana market's supply far exceeds demand within the market. In fact, based on current production and statewide consumption levels this report's estimates demonstrate that the OLCC market could meet annual demand for total *statewide* THC consumption, even those currently procuring through non-recreational market sources.

Although this report has taken supply as fixed based on a single 12-month period, supply is projected to increase precipitously based on the pipeline of pending applications. The current level of annual production within the OLCC system is sufficient to meet statewide demand and demand is unlikely to increase commensurate with this potential rise in supply. Absent a significant decline in the amount of marijuana produced—through either a market contraction or policy changes to the licensed recreational system—the recreational market is on a path towards even greater disequilibrium.

Policy Considerations

Oregon's current market dynamic of supply exceeding demand strongly contrasts with Colorado, where there are more robust supply-side constraints enforced as part of licensure. Although Colorado does not have a hard cap on numbers of licenses, regulators strictly enforce producer canopy allotments by forcing individual producers down in allotted canopy if they cannot demonstrate sufficient market for the amount of marijuana they produce. Colorado's recent report on supply and demand notes that its policies have resulted in supply being much closer to equilibrium with demand than estimates for Oregon (301.7 metric tons consumed in Colorado versus 340.7 produced, approximately 88% of supply in Colorado compared to 50% in Oregon). Notably, however, Colorado's near-equilibrium between supply and demand has not prevented its market from experiencing an average wholesale market price decline of 38% for bud (marijuana flower) between January 2018 and January 2019.[13] This indicates that market equilibrium may not in and of itself stabilize market prices or decrease market pressures on existing licensees.

The Oregon recreational marijuana system was intentionally established, in both the original ballot measure and the legislative implementation, as a freer market than the states that had adopted legalization prior to Oregon (Washington and Colorado). The 2016 legislation that lifted Oregon residency requirements for those with financial or ownership interests in OLCC licensees further cemented this structure. In large part, this approach to implementation of the recreational marijuana market was made to resolve a specific set of public policy issues that neither Washington nor

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[13] Colorado Department of Revenue. "Current & Prior Average Market Rates (AMR) for Retail Marijuana Excise Tax." https://www.colorado.gov/pacific/sites/default/files/AMR_PriorRates_Jan2019.pdf.

Colorado had faced, namely a longstanding tradition of marijuana cultivation even prior to the implementation of Oregon's medical marijuana law in 1998.

When the recreational marijuana system was established it was done with the philosophy that market competition would resolve issues of excessive supply. Producers (and other licensees) whose costs were not covered by market prices would exit the market, as happens in markets for crops such as hops or corn. This would naturally diminish supply and the market for recreational marijuana, like other markets, would self-correct.

What is unknown at this time is whether the Oregon recreational market is sufficiently similar to other markets to naturally self-correct towards equilibrium. If the marijuana market is viewed as equivalent to a market such as hops, overproduction may not in and of itself be a public policy concern. Declining prices may cause losses for private individuals or businesses but these types of losses in other markets are generally not viewed as requiring state intervention to correct levels of supply. If, however, the nature of the marijuana market—for example, the ban on interstate commerce—creates unique concerns, policy changes at the state level would be more warranted.

The range of policy options in relation to supply exceeding demand exist along a spectrum, ranging from no changes in the market structure (i.e., letting supply self-correct towards equilibrium) to changes at the margins (e.g., reducing licensed grow canopies and/or raising license fees) to sweeping change in the form of a license cap or moratorium. Both the perceived nature of the problem and the costs and benefits of policy choices inform where along the spectrum decision-making should occur.

If changes to the market structure are desired to push supply down closer to current market demand, nearly all actions would require legislation or an expansion of OLCC authority. Based on the original Measure 91 ballot initiative and subsequent legislation, the OLCC has authority over two narrow avenues for supply limits related to licensed canopy areas (decreasing maximum tier sizes and modifying the ratio between outdoor and indoor canopies). However, this authority is much more limited in scope than in Colorado. For example, whereas Colorado can limit individual licensees' production by restricting their individual canopy, the OLCC can only modify the aggregate canopy size allowance for producer tiers as a whole.

Below is a discussion of potential policy decisions and considerations.

Maintain Status Quo

A market in which supply and demand are not in equilibrium does not typically prompt a policy response from state or federal authorities. Although it may cause private losses to individuals or businesses, "creative destruction" is generally viewed as an inherent risk of entrepreneurial activity and investment. For example, data from the US Bureau of Labor Statistics shows that 20% of all private businesses fail within two years of establishment and nearly 40% fail within the first four years.[14]

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[14] Bureau of Labor Statistics. "Survival rates of establishments, by year started and number of years since starting, 1994–2015, in percent." https://www.bls.gov/bdm/entrepreneurship/bdm_chart3.htm. Data specific to Oregon available at https://www.bls.gov/bdm/or_age_total_table7.txt.

The Oregon marijuana market was established with such creative destruction in mind. Low barriers to entry were created in an effort to incentivize transition to the recreational market, with the expectation that Oregon's long-standing tradition of robust marijuana production would persist. By bringing this production into the legal, recreational market it was for the first time directly measurable and observable.

The recreational market is living up to expectations of booming production and declining consumer prices that cut into the illegal market while also experiencing rising tax revenues. Meanwhile, the Legislature's lifting of Oregon residency requirements in 2016 for owners and investors in OLCC marijuana licensees has provided access to capital for businesses and helped ensure liquidity. This has created a business dynamic similar to tech start-ups—many businesses are able and willing to weather losses today for the prospect of large profits tomorrow. Oregon businesses build a brand and establish legally licensed outposts in other states and the state benefits from an emerging growth industry. This business strategy can only succeed if the company retains a license in good standing in Oregon, thereby also creating an incentive for compliance.

However, the degree to which Oregon's marijuana market will continue to function like other markets is an unknown question. Other products have access to interstate and international trade and therefore more legal avenues to sell off supply. Restrictive federal tax and bank policies also increase marijuana business' costs relative to peer agricultural industries. Finally, marijuana faces significantly higher federal scrutiny and there is a greater interest in ensuring that businesses do not turn to illegal activity to stay afloat.

Canopy Size and Ratios

Under ORS 475B.085 the OLCC is tasked with setting canopy limits for Recreational Producers; originally these canopies were specific to flowering plants but have subsequently been extended to immature (non-flowering) plants as well. The OLCC controls two elements of canopies: the overall size and the ratio between indoor and outdoor producers. ORS 475B.085 states:

> **475B.085 Marijuana plant grow canopies; rules.** (1) Subject to subsection (3) of this section, the Oregon Liquor Control Commission shall adopt rules restricting the size of marijuana plant grow canopies at premises for which a license has been issued under ORS 475B.070. In adopting rules under this subsection, the commission shall:
>
> (a) Limit the size of marijuana plant grow canopies, for premises where marijuana is grown outdoors and for premises where marijuana is grown indoors, in a manner calculated to result in premises that produce the same amount of harvested marijuana leaves and harvested marijuana flowers regardless of whether the marijuana is grown outdoors or indoors. […]
>
> (c) Take into consideration the market demand for marijuana items in this state, the number of marijuana producers applying for a license under ORS 475B.070, the number of marijuana producers that hold a license issued under ORS 475B.070 and whether the availability of marijuana items in this state is commensurate with the market demand.

Current OLCC rules for producer tiers have been unchanged since first being adopted in 2016. The rule development process went through a rigorous feedback and advisory process. It included 15 meetings of Rules Advisory Committees in 2015 related in whole or in part to rules for producers and a public comment period in 2016 prior to final adoption by the Commission. Based on feedback from the public and other stakeholders, the OLCC established a four-to-one outdoor to indoor flowering canopy ratio, a maximum flowering canopy size of 40,000 square feet for an outdoor producer, and a maximum flowering canopy size of 10,000 square feet for an indoor producer. (Mixed producers may have portions of their flowering canopies as indoor and some as outdoor with an outdoor-equivalent maximum of 40,000 square feet.) The producer tiers and license fees are as follows:

Tier	Outdoor Maximum Flowering Canopy	Indoor Maximum Flowering Canopy	License Fee
Tier II	40,000 sq. ft.	10,000 sq. ft.	$5,750
Tier I	20,000 sq. ft.	5,000 sq. ft.	$3,750
Micro Tier II	5,000 sq. ft.	1,250 sq. ft.	$2,000
Micro Tier I	2,500 sq. ft.	625 sq. ft.	$1,000

Based on statute, OLCC by rule could decrease the canopy size for all producer types (e.g., halve all maximum canopies), reduce the outdoor-to-indoor ratio (e.g., halve the maximum outdoor canopy levels and leave indoor canopies at their current levels), or both (e.g., halve the indoor maximum canopy and make the outdoor maximum a quarter of its current maximum).

Although OLCC could unilaterally enact these limits by rule, it would have a drastic effect on existing licensed producers who have invested in security systems and built structures based on both the anticipated size of their licensed canopy and estimates of harvested output per square foot. Moreover, canopy changes on their own, in the absence of moratoriums, cap, or changes to license fees, may not be sufficient to dissuade existing licensees to simply apply for additional producer licenses. Under the status quo an outdoor producer may grow up to 40,000 square feet under a single license. If canopy limits were imposed they may simply shift towards growing 20,000 square feet under two separate licenses, with no net change to the licensed grow area in the state. This would in effect increase the work required to license the same amount of licensed grow space and potentially pull OLCC resources away from other activities required to license and monitor existing licensees (e.g., inspectors doing more required pre-licensing site visits rather than site inspections of licensees, license investigators processing new applications rather than business or premises change requests, etc.).

In combination with other policy actions, however, reductions in canopy sizes or the outdoor to indoor ratio could resolve a supply/demand collective action problem in the recreational marijuana market while allowing existing licensees to retain their place in the Oregon market as a foothold for future expansion. Within the recreational market, like in the case of other agricultural markets, it is in the self-interest of an individual producer to produce as much crop as possible but for competitors to under-produce. This would put the producer in a position of selling more harvest at a higher price (more personal supply, lower market supply, and therefore higher prices). Instead, though, the bulk of producers simultaneously pursue their individual self-interest, leading them to each maximize

supply, which drives market supply up and market prices down. By "resizing" producer canopies to levels the market is better able to sustain, producers may harvest less but potentially see rising prices (or at least see prices that decline more slowly).

License Fee Increase

The rate of license applications in the current market environment is an indication that at their current levels license fees play a small role in the decision-making process of whether to enter the recreational marijuana market. In fact, even when the OLCC announced a pause on processing applications received after June 15, 2018 due to the high number of existing licenses and applications, there was a significant spike in applications submitted in the first two weeks of June. Applicants seem willing to "roll the dice" that they will survive market pressures. Such a mentality speculative entrepreneurship has few downsides for the state as a whole in other licensed markets (e.g., restaurants applying for liquor licenses). However, in a market in which legal supply must stay in-state and illegal out-of-state export can fetch considerably higher prices, a large demand for licenses risks creating even greater pressure on licensees and an incentive for illegal activity.

If license fees are to be increased, the OLCC may not do so unilaterally. While the fee levels are established in OLCC's administrative rules, the agency requires approval to raise the fees and spend the revenues. OLCC's marijuana program is exclusively fee-funded. Fee revenues may only be set at a level to cover program costs and maintain a small operating reserve. If OLCC were granted budgetary authority to collect and spend more fee revenue, the agency would only be able to fund specific positions or agency costs. Without additional authority, OLCC could not charge fees that resulted in excess funds. If the Legislature granted OLCC additional revenue and expenditure authority above direct program costs, excess fees collected could be sent to the existing Oregon Marijuana Account, similar to marijuana taxes. Those funds could then be distributed to schools, cities, and counties.

Although license fee changes could be a tool to diminish demand for licenses and therefore the supply of marijuana within the recreational market while also generating additional revenue for the state, one major risk is that the elasticity of demand for licenses is unknown. In other words, it is unknown the degree to which applicants' decision-making process would be affected by higher license fees and by how much demand for licenses would decrease for a given dollar increase in the fee.

Additionally, there is a business impact to consider in determining whether and how high to increase license fees. Businesses have made decisions based on projected costs, including license fees, and an increase in these costs could exacerbate business pressures being felt in the current market environment. While higher license fees and fewer producers would in the long-term be more likely to stabilize supply and prices, it would be cold comfort to a licensee who faces more immediate cost pressures.

License Cap or Moratorium

Due to the federal regulatory landscape and prohibition against interstate trade of marijuana, each new state that legalizes recreational marijuana must become self-sufficient in supplying its own demand. At the outset of market implementation, the greatest concern has historically related to

initial *shortages* of supply.[15] Over the longer-term, however, the inverse effect of interstate trade prohibition is that states can *only* supply their own demand. Specifically, consumer demand has tended to rise but at a slower rate than supply because of increasing productivity and more licenses being issued. This results in leaving states with excess supply that cannot be exported to other markets.

Two potential mechanisms to limit supply is a cap on the number of permitted licenses (either of all types or of a specific type) or a moratorium for a period of time on any new licenses being issued. A cap on the amount of licenses is considerably simpler to institute prior to a market being launched. If a cap were to be set below the number of current licenses either existing licenses would have to be revoked or the cap would in effect operate more like a moratorium in which no new licenses are issued until the number has decreased to a level below the cap. In practice, however, the principle is the same—supply is limited by controlling the number of operators permitted to produce marijuana.

Although a cap or moratorium could effectively limit growth in supply within the recreational marijuana market, there are several factors that would influence the policies' potential effectiveness.

1) Specific to a cap on licenses, at what level would the cap be set and by whom (e.g., by statute or administrative rule)?
2) Specific to a moratorium, would the moratorium be for a specific period of time or based on market conditions? If the latter, which market conditions and on what frequency (e.g., reevaluated annually? biannually?)
3) For both a cap and moratorium, would existing licenses be "grandfathered" in? Would existing applications be grandfathered?
4) Would business structure changes and buy-outs be considered the same license for purposes of a cap or moratorium, or would business structure changes and/or buy-outs be considered a new license and therefore affected by the cap/moratorium?
5) Would a cap and/or moratorium be applicable to all license types or only specific license types (e.g., only on producers)?

Based on the manner in which a cap or moratorium is implemented, there is significant risk that the policy could at best be ineffective in addressing excess supply and at worst exacerbate existing business and market conditions. A cap or moratorium with grandfathering provisions for both existing licenses and applications would set maximum supply above what the market currently produces and do nothing to stabilize wholesale prices or market pressures. On the other hand, if a cap or moratorium were set at a lower level but did not permit business structure changes or buy-outs it could significantly limit businesses' access to capital and eliminate an avenue many use to weather an environment of decreasing profits. Conversely, a cap or moratorium that did permit business structure changes could have the effect that new entrance into the market could come *only* through buy-outs and acquisitions, which may lead to market consolidation of licenses in the hands of fewer, larger businesses. Finally, a cap or moratorium on all license types (rather than producers only) would risk throttling demand rather than supply and exacerbating the degree of disequilibrium between supply and demand.

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[15] Most recently Canada has experienced "growing pains" of supply shortages; https://www.nytimes.com/2018/11/07/world/canada/canada-marijuana-shortage.html.

Even if a cap or moratorium were implemented in a way that maximized its probability of success, preventing new entry into the legitimate, regulated recreational market risks pushing people into the illegal market. In other words, although a cap or moratorium may limit supply within the recreational market it may not have any net effect on the supply of marijuana in Oregon as a whole.

There is also a practical complication in evaluating the correct level for a cap or moratorium. Predictions of future market conditions are notoriously difficult, particularly when market dynamics and the regulatory landscape is ever-shifting. A cap or moratorium that must be updated based on market conditions will inevitably require guesses about the future state of the marijuana market. Any level of central planning in a market is prone to mistakes and inaccurate guesses. It will be even more difficult to hit the mark in the new and unpredictable recreational marijuana market.

Conclusion

Between July 1, 2017 and June 30, 2018, demand for marijuana from OLCC recreational retailers was an estimated 50% of the marijuana harvested by OLCC recreational producers. This estimate does not include other avenues for production or consumption within Oregon (e.g., medical, home grow, or illegal markets). In addition to the one-year supply and demand estimates, inventory stocks continue to build year-over-year for all product types. As of January 1, 2019, the recreational market could satisfy a theoretical 6.5 years' worth of demand without any further production. Despite this market environment of increasing supply and declining wholesale prices, demand for licenses has been steady.

Potential policy considerations include maintaining the status quo licensed structure and allowing the market to self-correct towards equilibrium, increasing license fees, limiting the maximum producer canopy, and placing a cap or moratorium on the number of recreational licenses. Due to the nature of the market in which supply already exceeds demand, any policies enacted with the purpose of creating equilibrium in the near-term will inherently have an effect on incumbents within the market.

Technical Appendix

General Approach

Recreational marijuana licensees have an obligation to report all activities and balance inventories each day in the state-mandated Cannabis Tracking System (CTS). The reporting requirements include documenting all harvests, waste, transfers, lab testing, and sales. This creates a wealth of market information for all licensed activity.

However, counterbalancing the amount of market data available are two other factors: the lack of historical data on the regulated marijuana market and the myriad consumer items into which marijuana can be processed. While data exists for each successive step of the supply chain, the market itself is still in a constant state of flux and does not lend itself to steady state estimates of supply and demand.

This study attempts to capitalize on the advantage of the wealth of data about the market while accounting for the difficulty of steady state estimates by using the Monte Carlo estimation method to vary parameters within reasonable ranges and produce 10,000 simulations of the Oregon recreational marijuana market. In each simulation the same general approach as described in the above report is used. Demand is estimated as the aggregate amount of THC sold by recreational retailers across all product types during the study period. This THC amount is then converted back to its original marijuana wet weight using the formulas described below to estimate a "wet weight equivalent" of demand.

In each Monte Carlo simulation, the specific parameters within the formula are allowed to vary (e.g., wet-to-dry weight ratio, market share of usable marijuana vs. concentrate/extract vs. cannabinoid products, etc.). This affects the individual estimate of wet weight equivalent of demand. Finally, each Monte Carlo estimate of wet weight equivalent of demand is compared to the actual wet weight harvested by OLCC producers during the study period, 4,294,000 pounds, and demand relative to supply is estimated. This produces 10,000 individual wet weight equivalents and estimates of demand relative to supply, allowing for a study of the conditions under which demand equals or exceeds supply.

The formula below relies on median values within the CTS data. The rationale for using medians is that licensee-entered data, like most administrative or user-entered data, is subject to outliers caused by typos and other errors. Using medians rather than means prevents the data from being weighted disproportionately towards outliers and skewing either the supply or demand estimates. However, this is also the benefit of the Monte Carlo method. In addition to the most confident estimate of demand relative to supply using medians of the various parameter values, by simulating 10,000 times we are able to derive a range of plausible estimates of the degree of supply and demand equilibrium in the Oregon recreational market.[16] If none (or extremely few) of these plausible estimates of demand match supply, we can be highly confident that the market is not in equilibrium.

Methods of Demand Estimations

We estimate demand using two methods:

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[16] All parameters in the Monte Carlo model are simulated using triangular distributions. The mode and upper/lower bounds for each parameter are described in Table 4 and Table 5 for the fixed and projected demand models.

1. "Fixed Demand," which estimates demand over the 12 month study period (July 2017 to June 2018), and
2. "Projected Demand," which estimates demand under conditions of variable consumption and OLCC market share.

The general methodology and specific formulas were validated by an external review group that included representatives of the Oregon Office of Economic Analysis, Oregon Medical Marijuana Program, Oregon State Police, ECONorthwest, RAND Drug Policy Research Center, and New Frontier Data. A full draft of this report was reviewed by the same external group and comments were incorporated into this final report.

The "fixed demand" model takes as given the amount of THC consumed within the recreational market and calculates a wet weight equivalent. The "projected demand" model, on the other hand, evaluates the degree to which demand may change if more Oregon adults were to consume marijuana, those who consume were to consume greater amounts, or more existing consumers were to procure THC from the recreational market as opposed to other sources. This "projected demand" model, holding supply as fixed, allows us to analyze the degree to which the market may self-correct towards equilibrium.

Two "layers" of simulations were conducted as part of the "projected demand" model. The first layer estimated the distribution of population use (number of days of marijuana consumption), which was in turn used to estimate the mean amount consumed per user per year. The second layer re-ran this population-use simulation 10,000 times to generate a distribution of mean consumption per user per year.

More specifically, in the first layer simulation, Oregon consumption of marijuana was estimated by running 2,989 simulations to allocate a simulated user set of 1,000 individuals to a specific number of days within a consumption "bucket" (ranging from "never used" to "used 241 to 365 days"). The consumption rate estimates rely on responses to the National Survey on Drug Use and Health (NSDUH) for Oregon survey participants 21 years and older.[17] In combination with this use-frequency data from NSDUH (Figure 14) we conducted a meta-analysis of the amount of marijuana consumed per use day based on frequency of use from 12 studies (Figure 15). Findings from this meta-analysis were then used to define coefficients that generated a smoothed consumption equation. The simulated use days for each population set were then multiplied by the coefficients to derive estimates of mean annual marijuana consumption. The smoothed line equation used to estimate mean grams of consumption per user per day is plotted in Figure 16 below.

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[17] For example, if a population set of 1,000 were assigned to the "bucket" of consuming between 181 and 240 days per year, the simulation would then assign a specific number of consumption days to that population set (e.g., 181 versus 182 days, etc.). The number of runs in the "first layer" simulation (2,989) was selected to align with the NSDUH estimate of Oregon's 21+ adult population over the survey period.

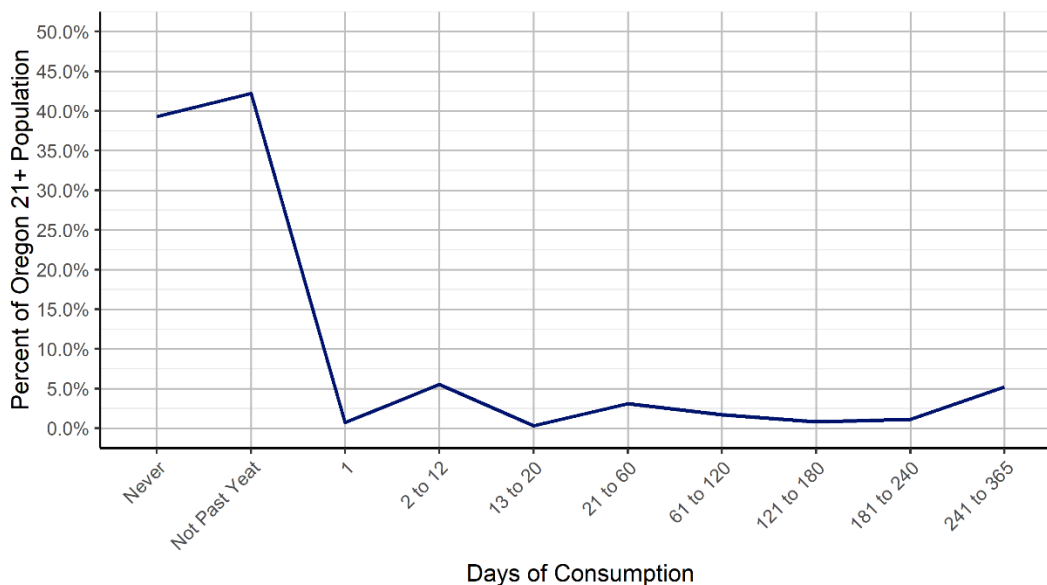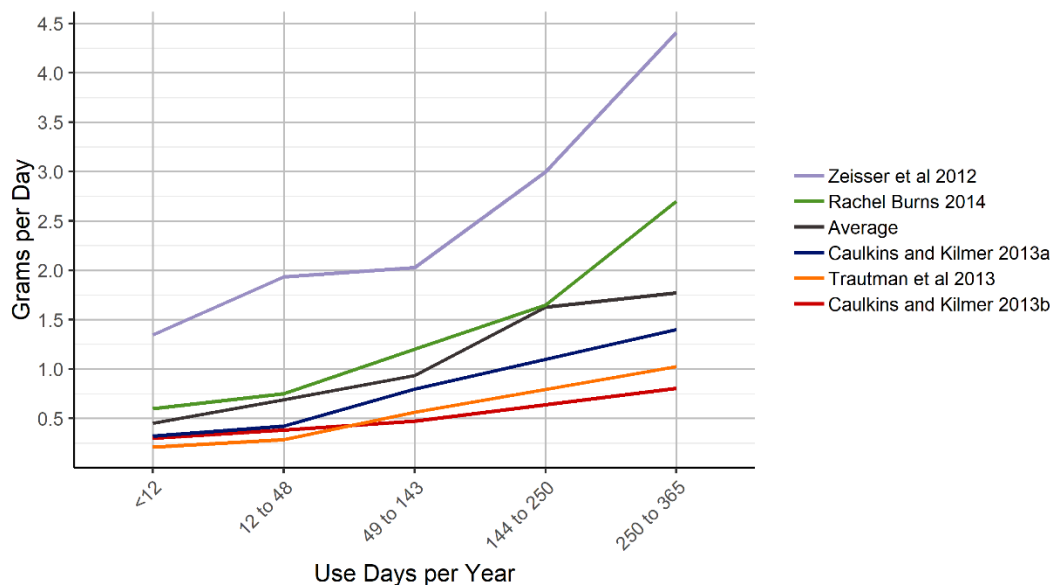*Figure 14: Frequency of Marijuana Consumption by Number of Use Days*

Figure 15: Consumption Per Day by Number of Use Days (meta-analysis) [18]

[18] Burns, R. M., J. Caulkins, S. S. Everingham and B. Kilmer (2013). "Statistics on Cannabis Use Skew Perceptions of Cannabis Use." Frontiers in Psychiatry **4**: 9.

Caulkins, J. P. and B. Kilmer (2013). Estimating the aize of the E.U. cannabis market. Further insight into the aspects of the illicit EU drugs market. F. Trautman, K. B. and T. P. Luxembourg, European Union Monitoring Center for Drugs and Drug Addiction: 503.

Freeman, T. P., C. J. A. Morgan, C. Hindocha, G. Schafer, R. K. Das and H. V. Curran (2014). "Just say 'know': how do cannabinoid concentrations influence users' estimates of cannabis potency and the amount they roll in joints?" Addiction **109**(10): 1686-1694.

Figure 16: Consumption Per Day by Number of Use Days (smoothed estimation)

$$y = -4E\text{-}08x^3 + 2E\text{-}05x^2 + 0.0012x + 0.6057$$
$$R^2 = 0.9287$$
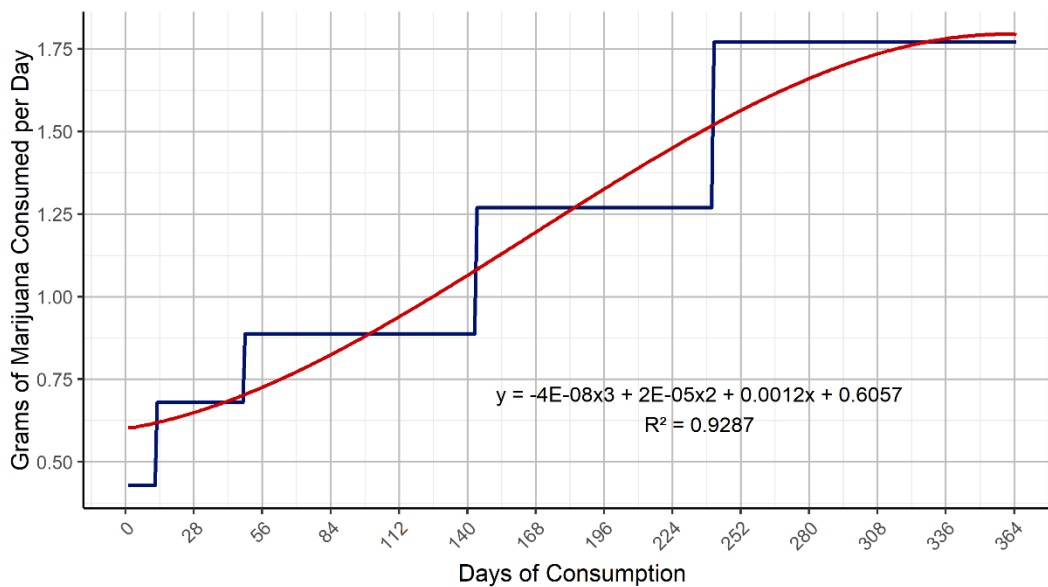
The second layer of the simulation for the "projected demand" model was to re-run this "user set" simulation 10,000 times, varying the probability of assignment to each "bucket" of frequency of use. For each of the 10,000 simulations, the use frequency probabilities were randomly selected within a triangular distribution based on the proportion and standard error from the NSDUH survey. For example, NSDUH's survey results show that 41.9% of Oregonians age 21+ have never used marijuana, with a standard error of +/- 1.64%. The probability for each 2,989 population set of 1,000 Oregonians age 21+ being assigned to the "never used" category was randomly chosen within a triangular distribution of a mode of 41.9% and lower/upper bounds set to the 95% confidence interval (38.7% and 45.1%, respectively).

The two layers of simulations jointly result in 10,000 estimates of consumption probability (those who consumed at least one day during the year), frequency, and amount consumed per user per year. The mean and median consumption rate of the 10,000 "user set" simulations exactly matched NSDUH's survey results.

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Zeisser, C., K. Thompson, T. Stockwell, C. Duff, C. Chow, K. Vallance, A. Ivsins, W. Michelow, D. Marsh and P. Lucas (2012). "A 'standard joint'? The role of quantity in predicting cannabis-related problems." Addiction Research & Theory **20**(1): 82-92.

Table 3: Estimations of Oregon Adult Marijuana Consumption

	Proportion of Oregon Adults age 21+ Consuming At Least Once Per Year	Grams of Marijuana Consumed Statewide per Consumer per Year
Median	20.8%	224.6
Mean	20.8%	224.7
Lower Bound	16.0%	167.4
Upper Bound	26.1%	296.1

The final step of the "projected demand" model uses the consumption rate and consumption level from each of the 10,000 simulations and combines those parameters with the usable marijuana potency percentage (previously simulated in the 10,000 iterations of the "fixed demand" model) to convert annual statewide consumption to grams of THC. The model further varies the percentage of this statewide THC consumption that is purchased within the recreational market as opposed to other sources. The model results in an estimate of THC purchased from OLCC-licensed Recreational Retailers and is compared to supply-side estimates from the "fixed demand" model.

Mechanics of Demand Estimations

Using the general methods described above, the specific formulas that drive the demand estimates throughout this report are as follows:

ω = Wet Weight Equivalent

λ = Wet-to-Dry Weight Ratio

1. The equilibrium between supply and demand in the recreational marijuana market is estimated by dividing the calculated total wet weight equivalent of demand by the actual wet weight harvested over the same time period.

$$\text{Equilibrium of Supply and Demand} = \frac{\omega \text{ of Demand}}{\text{Actual Wet Weight Harvested}}$$

2. Market wet weight equivalent of demand is calculated as the summation of the individual wet weight equivalents of each product category.

$$\omega_{\text{demand}} = \omega_{\text{usable marijuana sold to consumers}}$$
$$+ \,\omega_{\text{extracts and concentrates sold to consumers}}$$
$$+ \,\omega_{\text{cannabinoid products sold to consumers}}$$

3. Each component of the total wet weight equivalent calculation is based on finding the amount of THC sold in the form of each product type, dividing that value by the median THC potency of the product type in order to derive the aggregated full item net weight, multiplying that value by its input/output weight ratio for each step of processing (where relevant) to determine the aggregated weight of input marijuana material, and finally multiplying the usable marijuana net weight by the dry-to-wet weight ratio of marijuana. Usable marijuana and "feedstock" marijuana (the raw input material for processing) are assumed to have different wet-to-dry ratios to take into account fresh processing and other factors that make marijuana input material wetter on average than usable marijuana that is sold directly to consumers.

$$\text{Total } \omega_{\text{usable marijuana sold to consumers}} =$$
$$\lambda \times \frac{(\text{Total mg THC sold to consumers}) \times (\text{THC market share of usable marijuana})}{\text{Median \% THC of usable marijuana sold}}$$

$$\text{Total } \omega_{\text{extracts and concentrates sold to consumers}} =$$
$$\lambda \times \left[\frac{\left[\frac{(\text{Total mg THC sold to consumers}) \times (\text{THC market share of concentrates and extracts})}{\text{Median \% THC of extracts and concentrates sold at retail}} \right]}{\text{Median ratio feedstock marijuana input to extracts and concentrates output}} \right]$$

$$\text{Total } \omega_{\text{cannabinoid products sold to consumers}} =$$
$$\lambda \times \left[\frac{\left[\frac{\left[\frac{(\text{Total mg THC sold to consumers}) \times (\text{THC market share of cannabinoid products})}{\text{Median \% THC of cannabinoid products sold at retail}} \right]}{\text{Median ratio extract and concentrate input to cannabinoid output}} \right]}{\text{Median ratio feedstock marijuana input to extracts and concentrates output}} \right]$$

4. In the "projected demand" model the "Total mg THC Sold to Consumers" in the above formulas is a calculated value based on the number of Oregon adults consuming marijuana, the level at which they consume marijuana, and the percentage of statewide consumption that is procured from within the recreational market.

Total mg THC sold to consumers in retail market
= Oregon population
× Percentage of Oregon adults consuming marijuana in the past 12 months
× Average amount of THC consumed annually
× OLCC market share

The parameter values as used in the above formulas and the upper/lower bounds in the Monte Carlo estimations are as follows:

Table 4: "Fixed Demand" Model Parameters

	Point estimate	Lower Bound	Upper Bound	Notes
Total wet weight harvested by OLCC producers (July 2017 to June 2018)	4,294,000 (pounds)			
Total THC purchased in OLCC market (July 2017 to June 2018)	15,518,237,200 (mg); 34,211.86 (pounds)			
Usable marijuana market share (as % of total mg THC sold at retail)	74.8%	59.9%	78.6%	Upper bound represents +5% of the median and lower bound represents -20% of the median. This is intended to simulate the greater likelihood of customer substitution away from usable marijuana and towards other product types.
Extract/Concentrate market share (as % of total mg THC sold at retail)	23.1%	95%	100%	Lower/upper bounds represent percentage of *remaining* market share after usable marijuana calculated (to avoid >100% market share).
Cannabinoid Products THC market share (as % of total mg THC sold at retail)	2.0%	**	**	In Monte Carlo, lower/upper bounds estimated by subtracting simulated usable marijuana share and extract/concentrate share from 100%.
Potency of usable marijuana sold at retail (%)	19.5%	10.3%	28.7%	Lower/upper bounds calculated within 95% confidence range of

				median with standard deviation of 4.69%.
Potency of extract/concentrate (as %)	65.8%	43.3%	88.3%	Lower/upper bounds calculated within 95% confidence range of median with standard deviation of 11.46%.
"Other" items (derived from extract/concentrate) potency (as %)	0.18%	0.0036%	1.18%	Lower bound calculated using 1 mg of THC divided by median unit weight of cannabinoid items (28 grams); upper bound calculated within 95% confidence range of median with standard deviation of 0.51%.
Wet-to-dry ratio of usable marijuana	10	4.69	15.31	Lower/upper bounds calculated within 95% confidence range of median with standard deviation of 2.71.
Feedstock-to-wet weight usable marijuana ratio	8	64.0%	100.0%	Lower/upper bounds represent percentage of wet/dry ratio for usable marijuana.
Usable marijuana to Extract/Concentrate weight conversion ratio	0.137	0.109	0.164	Lower/upper bounds represent +/- 20% of median.
"Other" items (derived from extract/concentrate) input/output ratio	578.03	462.43	693.64	Lower/upper bounds represent +/- 20% of median.

Table 5: "Projected Demand" Model Parameters

|	Point estimate	Lower Bound	Upper Bound	Notes
# of 21+ adults	3,130,000			
Adult consumption rate (%)	20.8%	16.0%	26.1%	Lower/upper bounds represent minimum and maximum of Monte Carlo consumption model.
Grams of THC consumed annually per consumer	43.43	20.02	74.81	Lower/upper bounds represent minimum and maximum of Monte Carlo consumption model.
OLCC share of Oregon marijuana market	55.1%	55.1%	100.0%	Point estimate based on actual THC sold in OLCC market as a proportion of median estimate of statewide THC consumption from Monte Carlo consumption model.

Results of Demand Estimations

Ten thousand Monte Carlo simulations of demand produce a median estimate of approximately 50% demand relative to supply in the "fixed demand" model and 61% in the "projected demand" model. Under current conditions of demand in the "fixed demand" model there are only 14 Monte Carlo simulation out of 10,000 in which demand matches or exceeds supply. This is a strong indication that regardless of assumptions or parameters there are no reasonable conditions under which the Oregon recreational market is currently in equilibrium. Even taking into account potential growth of consumption rates, levels of consumption, and greater OLCC market share, only 5.3% of Monte Carlo simulations (530 out of 10,000) produce equilibrium.

Table 6: Wet Weight Equivalent of Demand Estimates by Model

	Fixed Demand	Projected Demand
Median demand relative to known supply	49.7%	61.1%
Maximum demand relative to known supply	112.6%	179.5%
Minimum demand relative to known supply	19.6%	20.3%
Percent of simulations where demand equals or exceeds supply	0.01%	5.30%
Median Wet Weight Equivalent Demand	2,134,000	2,626,000
Maximum Estimated Demand	4,729,000	7,541,000
Minimum Estimated Demand	823,600	851,400

Figure 17: Distribution of Wet Weight Equivalent of Demand Results by Model
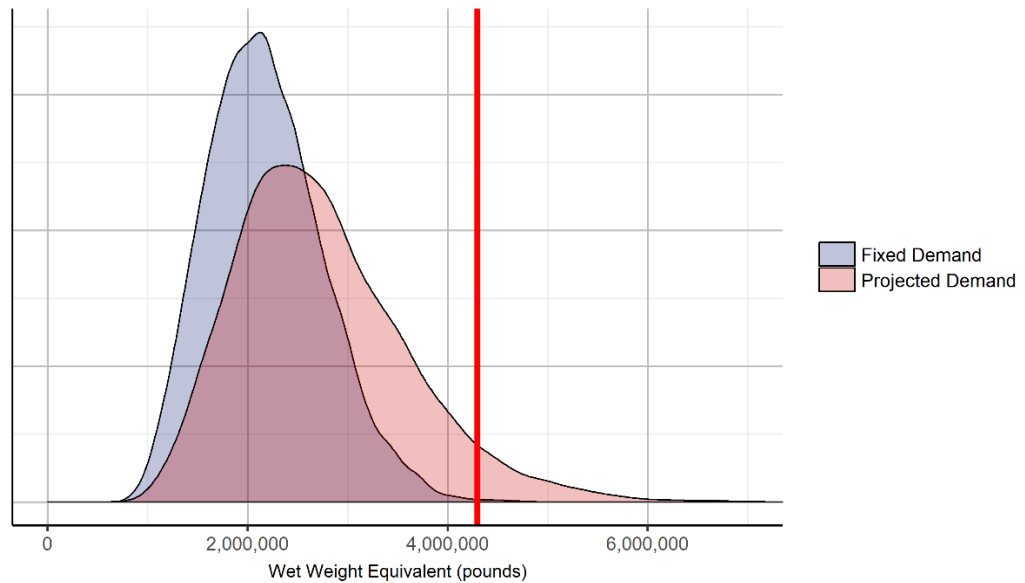
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