How much will the 25/25/25 tax scheme actually impact the price of cannabis?

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CALCULATIONS

Table of Contents

Executive Summary

This paper describes a model of how taxes will affect prices in the legal Washington cannabis market. As with many other goods, tangible production and processing costs will not dominate the final product cost. Most of the final price will instead come from markups and taxes.

This creates substantial uncertainty in estimates of the final price and, to a lesser extent, uncertainty about the proportion of that price the state will collect in taxes; the tax rates are set by law, but the markups are the results of market processes that cannot be predicted well in advance. Even at a fixed *ad valorem* rate, the tax revenue per gram depends on the price at each stage and, hence, on the markup levels.

We looked across a range of legal products and market segments at markups for processors and retailers. (See Appendix A to this report.) The markups vary enormously, depending on, among other things, the extent of branding, advertising, and the market power of sellers – characteristics that remain uncertain for the legal marijuana market. Furthermore, even within a particular well-defined product segment, such as beer, markups can vary substantially across brands.

This paper reports quantitative results for a particular assumed set of markups, but the primary deliverable is the model, not those numerical results. That is, we invite the WSLCB to adjust the markup and other model parameters as better information becomes available and to explore the consequences. The model is designed to be useable by someone with common Excel skills.

The model is built around three distinctions that may influence the size of markups that can be sustained: (1) useable marijuana vs. infused products, (2) standard brands vs. heavily marketed "prestige" brands, and (3) retail stores that compete on price vs. those that provide a high level of customer service. The second option in each pair will tend to command higher markups, and so higher taxes per gram of marijuana consumed.[1]

The weighted average tax per gram will tend to be greater if the market gravitates toward consumers buying heavily marketed marijuana-infused products from high-end stores, and smaller if marijuana purchases are dominated by standard brands of useable marijuana bought from retailers who compete on price.

In either case, though, the tax burden—meaning tax as a share of final price to consumer—will probably be between 30-40%, perhaps in the high 30's for goods sold in service-oriented (high markup) retail stores and mid 30's for goods sold in stores that compete on price. That is, the proportion of the final cost to consumers that comes from taxes is much more stable over a range of markup parameters than is the projection of the final price level and, hence, the tax revenue per unit sold and consumed.

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[1] We are using WA-502's technical definition of marijuana. So for a marijuana-infused product such as a brownie, we are speaking of the tax per gram of marijuana the production process used in order to make that brownie, not the weight of the brownie.

Basic Model

A simple model of tax revenues would chain together vertically the three market layers (producer, processor, and retailer), their taxes, an assumed cost of production (growing), and ad hoc assumptions about percentage markups at each level. This is similar in spirit to the Colorado tax calculator available at http://coloradofutures.colostate.edu/calculator/.

In the Washington State context, if one thought, for example, that producers would sell for $2 per gram (i.e., $2,000 per kilogram) and markups would be 100% for both processors and retailers, then taxes would account for a little over one-third (36.7%) of the $16.99 per gram retail price, as shown in Exhibit 1. Note for this model, the $2 per gram producer price implies a price to retailers of $6.25, which is broadly consistent with current access points paying about $5 per gram.

Exhibit 1: Price Structure with (Over-Simplified) Vertical Structure and Production Costs of $2 per Gram

Parameter		Net Revenue for Business	Tax Revenue	Market Level	Price
Producers' selling price	$ 2.00	$ 2.00		Farmgate price pre-tax	$ 2.00
Excise tax on producer	25%		$ 0.50		
				Price to processor	$ 2.50
Processor markup	100%	$ 2.50			
				Processor price pre-tax	$ 5.00
Excise tax on processor	25%		$ 1.25		
				Price to retailer	$ 6.25
Retailer markup	100%	$ 6.25			
				Retailer price pre-tax	$ 12.50
Excise tax on retailer	25%		$ 3.13		
				Advertised Price	$ 15.63
Sales tax	8.75%		$ 1.37		
	Total	$ 10.75	$ 6.24	Price to Consumer	$ 16.99
		Tax Burden	36.7%		

A similar spreadsheet could be constructed for vertically integrated producer-processors, but that is not shown because the overall approach is problematic for at least three reasons.

First, there is no universal percentage markup that one can just plunk down into these calculations. A review of retail markups across 53 sectors find an enormous range of average markups, from 14% for gas stations with convenience stores to 139% for optical goods (e.g., glasses). There is also variation byproduct within any given industry segment; grocery stores enjoy much higher markups on prepared and ready-to-eat foods (bakery items and the like) than they do on packaged and canned goods. So, while a double-your-

money (100% markup) rule of thumb pricing may be familiar, it is terribly important to make a serious effort to understand what markups are in comparable sectors.

For example, if we replace the arbitrary assumptions of 100% markups with the processor markups typical of a dairy (34%) and retail markup typical of beer, wine and liquor stores (31%), then the numbers would look very different. The projected retail price would then be less than half as high ($7.46 vs. $16.99), and, likewise, the tax revenue would be substantially less per gram sold, ($3.31 vs. $6.24) but a higher proportion of the final price (44.4% rather than 36.7%).

Second, the architecture of this simple model implies that the markups are rigidly indifferent, in percentage terms, to changes in costs further up the production chain, which can lead to perverse results. For example, if additional regulations, unionization of agricultural workers, or some other shock drove up production costs from $2 per gram to $3 per gram, then every number in the spreadsheet would be inflated by 50%, as follows:

Exhibit 2: Price Structure with (Over-Simplified) Vertical Structure and Production Costs Increased to $3 per Gram

Parameter		Net Revenue for Business	Tax Revenue	Market Level	Price
Producers' selling price	$ 3.00	$ 3.00		Farmgate price pre-tax	$ 3.00
Excise tax on producer	25%		$ 0.75		
				Price to processor	$ 3.75
Processor markup	100%	$ 3.75			
				Processor price pre-tax	$ 7.50
Excise tax on processor	25%		$ 1.88		
				Price to retailer	$ 9.38
Retailer markup	100%	$ 9.38			
				Retailer price pre-tax	$ 18.75
Excise tax on retailer	25%		$ 4.69		
				Advertised Price	$ 23.44
Sales tax	8.75%		$ 2.05		
	Total	$ 16.13	$ 9.36	Price to Consumer	$ 25.49
		Tax Burden	36.7%		

Comparing Exhibits 1 and 2 reveals an implausible implication of the simple vertically chained model. According to the simple model, retail sellers should rejoice if legal cannabis becomes more costly to grow, because they would then make $9.38 for every gram sold, not just $6.25. In reality, the legal market must compete with the black market, medical marijuana, and grow-your-own, as well as facing price-sensitive consumers who could use less marijuana if prices approached $25 per gram (which is more than double a common "access point" price today). So when production costs go up, retailers' margins are more likely to shrink rather than rise.

Third, the model does not account for more nuanced aspects of industry structure, such as specialized processors (e.g., oil extractors who sell to bakeries or other processors), or differences between useable marijuana (meaning dried flowers sold loose or pre-rolled in joints) and marijuana-infused products (edibles and other more processed forms of cannabis). So next we consider a more sophisticated model.


Richer Model

This section presents a richer model of the structure of the cannabis industry and associated implications for taxes. The legal marijuana industry may become quite complex, and one could easily create a model that is as unhelpfully complex as the previous one was distressingly simple. We strive here for a happy middle ground, presenting the simplest possible model that acknowledges the following possibilities:

- Some growing will be vertically integrated with processors (and thereby avoid the first level excise tax), while other "independent" growers sell to processors and pay the tax.

- Some processors will sell not to retailers but to other processors (e.g., one that specialize in oil extraction selling to bakeries).

- Production of marijuana-infused products, such as edibles, must be distinguished from production of conventional useable marijuana because it may command higher markups.

- There will be low-frills retailers who compete on price as well as higher-margin retailers who offer amenities such as more sales staff assistance, more attractive stores and locations, etc. This is akin to the difference between K-mart and Nordstrom's, and we will refer to the categories as "price-conscious" and "high-touch" retailers, respectively.

Figure 1 presents a schematic representation of this industry structure.

Figure 1: Schematic Diagram of Industry Structure Captured in Model
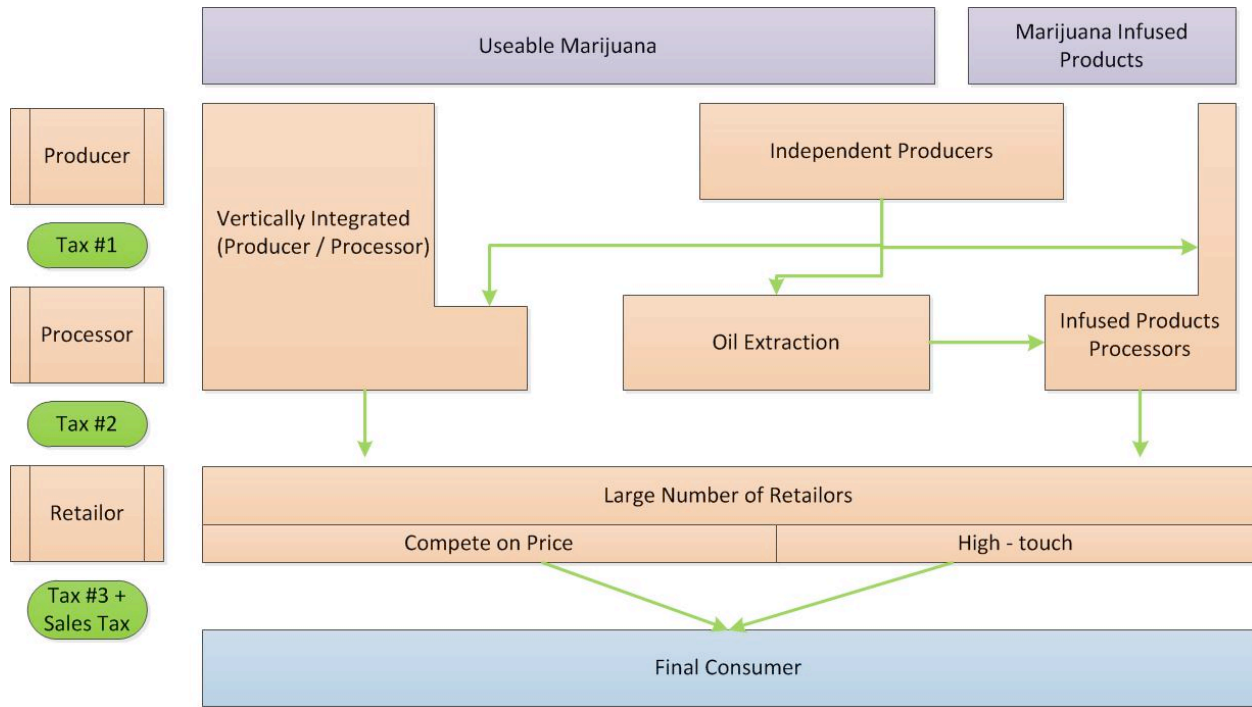
Note that the boxes in Figure 1 correspond to activities, not companies. One licensee might process and sell both useable marijuana and marijuana-infused products, but we divide those activities into separate boxes because the processor markups on marijuana-infused products may be higher than on useable marijuana.

The five salmon-colored boxes in the middle layers of Figure 1 actually correspond to *six* types of activity:

1. Growing (production) without processing ("independent growers")

2. Growing (production) by a processor (vertical integration which avoids the first 25% tax)

3. Processing of useable marijuana (e.g., joints and loose marijuana that users will smoke or vaporize)

4. Processing of intermediate goods sold to other processors (e.g., firms that specialize in extracting oils for sale to processors of infused products)

5. Processing of marijuana infused products

6. Retailing

These six activities map onto only five boxes because activity #2 (growing by vertically-integrated processors) is not a separate box. Rather, it is represented by the "bumps" on the "vertically integrated producer/processor" and "infused products processing" boxes, extending up into the producer layer. To avoid cluttering the diagram,

vertically integrated production by processors of intermediate goods ("oil extractors") is not shown, although the spreadsheets below do allow for that possibility.

The width of the boxes in Figure 1 is meant to be suggestive of their likely relative magnitude. For example, we would guess that much, perhaps even most, useable marijuana will be produced and processed by vertically integrated entities. Avoiding the first-level tax might directly save something like $0.75 per gram (25% of a farmgate price of around $3,000 per kilogram), and that savings is magnified by reducing the processor and retail prices and so taxes at those levels. Note: an integrated producer-processor selling just 2,000 grams (2 kilograms) would more than recoup the $1,000 annual license fee.[2] Hence, independent producers will face a marked competitive disadvantage relative to integrated producer-processors.

Indeed, although today growers almost always do their own drying and trimming, the producer tax could change that, so that independent growers sell raw product that is dried and trimmed by processors. Shifting the cost of trimming to after the 25% producer tax would produce important savings since trimming labor accounts for about one-quarter of the total cost of growing, curing, and trimming with artificial lights and one-half the total for growing outdoors.

Integrated producer-processors might nonetheless outsource some production. Suppose, for example, an integrated producer-processor developed a successful brand which that enjoyed demand that exceeded its in-house production capacity. We might expect them to buy from independent producers, at least until they have time to ramp up their in-house production (and assuming outsourced production would not compromise its quality standards), since a $0.75 per gram tax is not large compared to the opportunity cost of leaving demand unmet.

By contrast, we imagine that a significant number of processors of infused products will be essentially bakers, brewers, or candy makers, with no special skill at, or interest in, growing cannabis. Some will presumably vertically integrate back into production to save the 25% excise tax on that part of their raw materials cost, but others may focus on activities for which they have comparative advantage, and outsource raw materials production to independent growers.

At the very top of the figure we suggest that the majority of the cannabis consumption will be of useable products. We are not aware of systematic data on mode of consumption for the U.S., but a recent survey in Europe asking respondents' main form of cannabis use found that fewer than 3% cited either food or beverage in any of the countries surveyed.[3]

Consumption of oils and extracts may be and/or may become the larger share of consumption of other-than-usable-marijuana, but we do not address that explicitly since as

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[2] There is also a one-time $250 application fee, but that doesn't change the point that even modest sales volume is sufficient to recoup the license and application costs.

[3] Margriet van Laar, Tom Frijns, Franz Trautmann and Linda Lombi (2013). Cannabis market: user types, availability and consumption estimates. Chapter 3 in Further Insights into aspects of the illicit EU drug markets, Editors: Franz Trautmann (Trimbos Institute), Beau Kilmer (RAND) and Paul Turnbull (ICPR), pp.73-182.

of now such sales are not planned under I-502. If and when they are included, it may be useful to revamp this model. It seems plausible that in the future, much of the oil may be extracted from leaves and trim produced as a byproduct of making useable marijuana. That would represent an additional revenue stream for those who in this model are seen as producers of usable marijuana, with little in the way of additional costs.

One division that may at first seem controversial is the implication at the bottom of the figure that the majority of retail selling will be from establishments that cater to price-conscious consumers (K-mart style outlets), with only a minority of the market catering to consumers who will pay extra for a "high-touch" shopping experience (Nordstrom-style retailing). However, nation-wide, cannabis consumption is dominated by people toward the bottom of the distribution of educational attainment, which on average means by the less affluent. In terms of days-of-use reported on household surveys, college graduates account for less than 15% of consumption, whereas those with a high school education or less account for 60% of consumption, as suggested by Figure 2.

We used the SAMHDA R-DAS on-line tool to investigate demographics of Washington State's past-month users and found similar results as shown in Figure 3 below. The variation between the state and national proportions is small and could be entirely due to sampling variability, given the small sample sizes for an individual state. Hence, the educational demographics of marijuana users in Washington State do not appear to differ significantly from national trends.

Figure 2: Most Reported Marijuana Use Involves Consumers with a High School Education or Less; Household Survey Reported Consumption by Educational Attainment Resembles that for Cigarettes, while Alcohol Consumption is more Upmarket

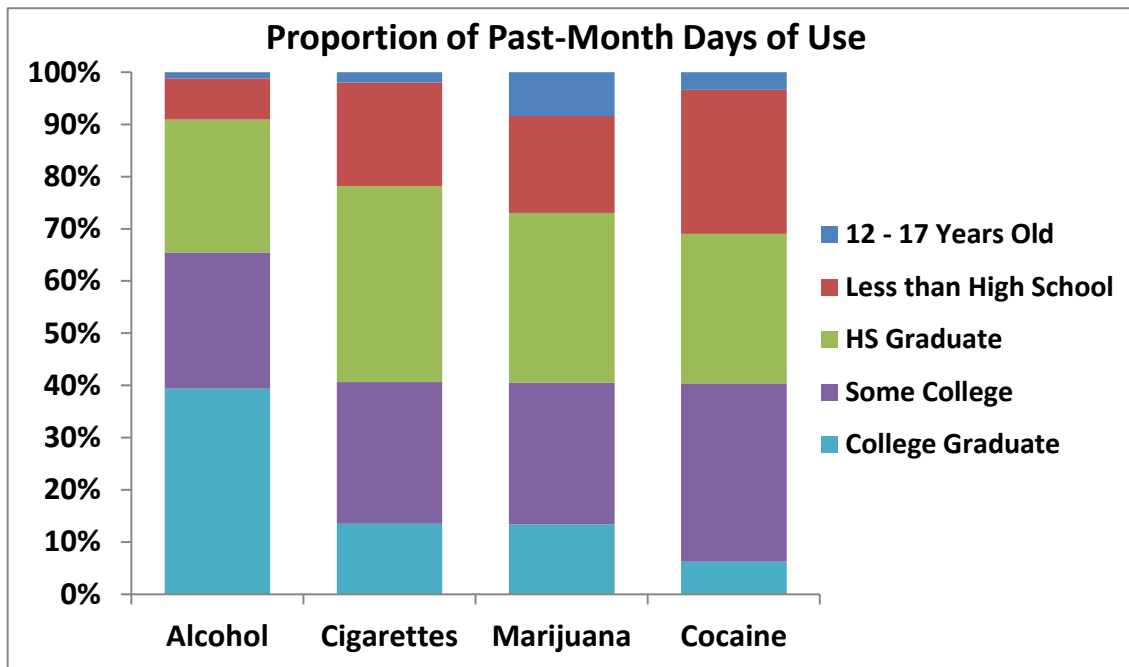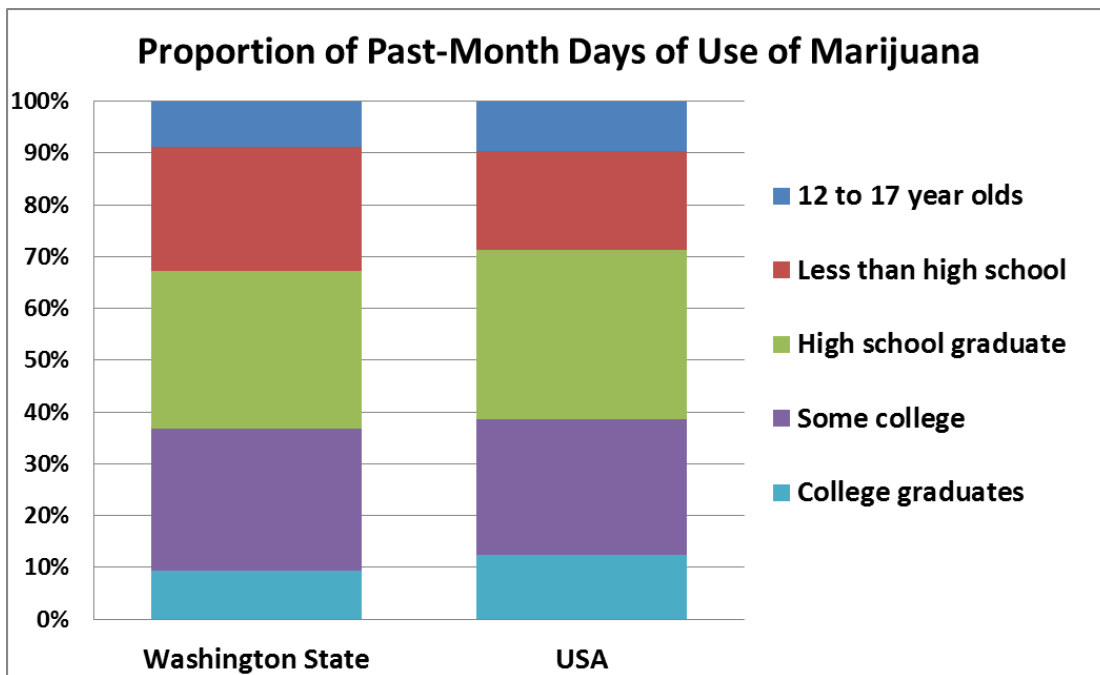Figure 3: Washington State and US Past-Month Consumption by Educational Attainment[4]

[4] http://www.icpsr.umich.edu/icpsrweb/SAMHDA/studies/32101/datasets/1/sda/table,
http://www.icpsr.umich.edu/icpsrweb/SAMHDA/studies/32101/datasets/0001/sda/table

We recognize that not all will find this evidence persuasive. The advocacy community that promotes marijuana policy reform is disproportionately well-educated, so there is a widespread impression that most of the market is too. For this parameter, and all others in the model, the associated spreadsheets make it easy for the WSLCB or other users to enter their own preferred parameter values, a matter to which we turn next.

Model Parameters

Figure 4 is a more detailed version of Figure 1, which identifies the key parameters that must be established to run the model. Table 1 then provides the full list of these parameters and our base case values for them.

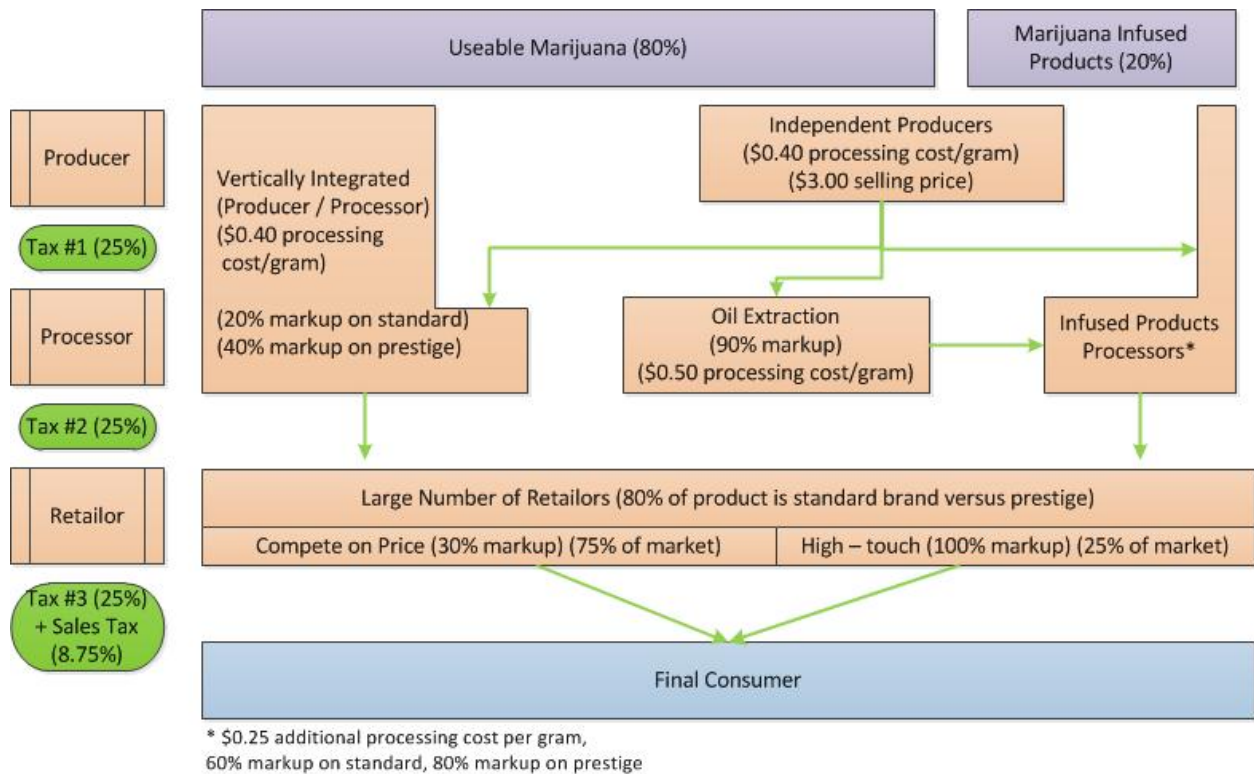Figure 4: Key Parameters of Industry Pricing and Taxes Model

* $0.25 additional processing cost per gram,
60% markup on standard, 80% markup on prestige

Table 1: Parameters Used in the Tax & Price Model

Production and Processing Costs

$ 3.00	Producers' selling price	
	Processing costs per:	
$ 0.40	gram of Useable MJ	
$ 0.25	Additional processing cost per gram of MJ in an infused produ	
$ 0.50	Additional cost of extracting oil, per gram processed	

Production & Materials Flow Parameters

Proportion of production accounted for by vertically integrated
   processors for MJ used in production of

80%	Useable MJ	
0%	Oils	
30%	Infused Products	
25%	Proportion of MJ-content in infused products that is bought	
	from oil extractors	

Markups

50%	Oil Extractor's Markup (%)	

Processor Markup by Type of Product and Brand

	Useable Marijuana	Infused Products
Standard Brand	20%	60%
Prestige Brand	40%	80%

Retailer Markup by retailer type

Price	30%	
Touch	100%	

Market Share Parameters

80%	MJ Sold as Useable MJ vs. Infused Product	
80%	% of product sold as Std vs. Prestige brands	
75%	Proportion of retailers competing on Price vs. Touch	

Tax Rates

25%	Excise tax on producer	
25%	Processor excise tax rate	
25%	Retail excise tax rate	
8.75%	Sales tax rate	

We conducted sensitivity analysis with respect to these parameters and determined that the processor and retailer markups are among the most important, so they merit their own discussion, which we present in detail as Appendix A. In brief, for our base case we applied markups that seem plausible given what is observed in other industries and for other products that might be viewed as broadly comparable, and then computed what that implied for firm's net revenues, to ensure that the parameters are plausible.

For example, we assume a 30% markup for no-frills retail stores that compete on price, which is similar to the current values for beer, wine, and liquor stores (31%), grocery stores (35%), and fruit and vegetable markets (41%), but slightly lower on the grounds that marijuana has a high value to weight and volume ratio (so requires less floor space); the markup for cigarettes, for example, appears to be considerably lower, although it is possible stores use them as a loss leader.

Would a rate of 30% be sufficient to cover a store's operating expenses? Probably. Today the retail value of the national marijuana market is about $30B, and Washington has about 3.1% of the nation's past-month consumers.[5] If, after legalization, legal sales are even half as large (i.e., if the legal industry seizes roughly half of the market), and the state licenses 300 retail outlets, then the average sales per outlet would be $30B * 3.1% * (1/2) / 300, or close to $1.6 million per year. With a markup of 30% the cost of goods sold absorbs slightly over 75% of gross revenue, which would leave roughly $400,000 per year to cover other operating costs and normal profits. Is that enough?

That would seem to be sufficient given the Washington Liquor Control Board's own experience with retail liquor stores. In the last full year of operation (2011), the 328 stores generated gross liquor sales of $888 million with operating costs of below $100 million,[6] implying operating costs were about $300,000 per store. So it would appear that a 30% markup will generate enough revenue per outlet to operate a store.

In our base case, we presume that most (75%) retail stores compete aggressively on price, and they mark up by 30%, but the remainder of the market consists of high-touch or boutique vendors who achieve much higher markups (100%) by providing much more intensive customer service. Many of today's medical dispensaries may fall more into this model, with service staff willing to discuss the perceived merits or limitations of this or that variety, rather than just serving as a cashier.

Processor Market Power and Markups

One reason for differentiating the activities in Figure 1 is that different types of processors, products, and brands are likely to enjoy different markups. The markup rule in elementary economics states that a firm's profit-maximizing markup is the reciprocal of one plus the

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[5] SAMHSA estimates that Washington State had about 556,000 past-month marijuana users in 2010-2011 (http://www.samhsa.gov/data/NSDUH/2k11State/NSDUHsae2011/NSDUHsaeWA2011.pdf) relative to a national total of 17,741,000
(http://www.samhsa.gov/data/NSDUH/2k11State/NSDUHsae2011/NSDUHsaeUS2011.pdf).

[6] The state had retail/purchasing/Distribution Center expenses of $91M, from which one should subtract the Distribution Center expenses when thinking about the retail stores, but add a prorated proportion of its $19M in "general" expenses.

inverse of the elasticity of demand faced by the firm (not the elasticity of demand for the product generally).

If the product being sold is an undifferentiated commodity and one seller tries to mark up prices by even a small amount above competitors' prices, then – in an idealized, frictionless market with perfect information – customers will all shop elsewhere. That is, competition will drive prices down to a level such that firms are only recovering their costs (including so-called "normal profits" which represent the opportunity cost of capital invested).

We presume this will more or less be the fate of independent growers who are unable to "brand" or otherwise differentiate their product.

However, if the firm has some market power, then its firm-specific demand will be less than perfectly elastic, and the profit maximizing strategy will be to mark up above cost. The greater the market power, the greater the capacity to mark up price.

One familiar source of market power is being a monopolist. The Washington State licensing process will be relatively open, and there are no patents protecting particular products or processes, so we do not anticipate true monopolies in the Washington State marijuana market.[7]

Other sources of market power, however, include brand recognition, product differentiation, and proprietary processing methods for infused products. Physical location may create monopolistic competition in the retail sector, but proximity to a customer is not likely to be a significant competitive advantage in wholesale transactions because the value of those transactions, and their high value-to-weight ratio, make conventional transportation costs relatively unimportant.[8]

Infused products offer greater potential for product differentiation because they inherit all of the potential for differentiation conferred by the marijuana they contain (e.g., having a higher or lower THC to CBD ratio) but also can be differentiated based on other product attributes. A chocolate chip cookie, a brownie, and a gummy candy edible would all remain distinct products even if the marijuana they contain were all the same in terms of amount of THC, CBD, and other cannabinoids.

For both useable marijuana and infused products, if a particular brand becomes known, trusted, or associated with higher quality in the eyes of the consumer, than the brand's purveyor may be able to raise prices somewhat, without customers flocking to a competing brand. We refer to this as a "premium" as opposed to a "standard" brand.

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[7] A possible exception would be if for a time only one or a few producers will be supplying particular varieties of cannabis. That does not seem like a sustainable competitive advantage in the Michael Porter sense; if one variety is commanding a noticeably higher market price, then other growers will start to grow more of that variety until profit by strain is roughly comparable. Also, this phenomenon might be accommodated within the model by viewing that production as belonging with infused products in terms of markets commanded.

[8] If a processor purchasing 500 pounds can save $0.10 per gram by purchasing from someone halfway across the state, they would do so; the savings (500 pounds * 453.6 grams per pound * $0.10 per gram = $22,680) would justify the additional time and distance traveled.

It is important to note that a premium brand in this context refers to the brand's ability to command a larger than usual markup; it has nothing directly to do with the quality of the product. A brand that is widely advertised may command a larger premium relative to its production cost than another brand that is marketed less aggressively, even if the second product were superior in a blind taste-test or other objective measure. (Some might believe that is the case for mass market vs. some craft-brewed beers.)

We expect that essentially all products will be branded, but that only a minority of brand names will have sufficient market share, recognition, and cachet to command a substantially higher price. This may be more or less the case today with medical marijuana. We downloaded 751 test results for flower products from the Analytical 360 web site (http://analytical360.com/). Almost all identified the type of marijuana by variety,[9] but the most common ("Blue Dream" or a variant thereof) accounted for just 25 of the 751 observations, and its potency was not appreciably greater than that of other brands.

In particular, we assume that processors will be able to achieve the following markups:

Processor Markup by Type of Product and Brand		
	Useable Marijuana	Infused Products
Standard Brand	20%	60%
Prestige Brand	40%	80%

In addition, we set oil extractors' markups relatively high (50%), in part because we do not expect there to be many independent extractors. (Although a counter-argument could be that at least the larger bakeries could presumably do the extraction themselves if the independent extraction companies' prices became too high.)[10]

Retailer Markups

We set the retailer markups at 30% and 100% for the price-conscious (K-mart like) and high-touch (Nordstrom-like) retailers, respectively, based on an array of circumstantial evidence reviewed in Appendix A. These two parameters have a substantial effect on the model results, so we considered a wide range of comparables and other types of evidence. However, that breadth of evidence should not be misconstrued as indicating depth or firmness of evidence. We remain highly uncertain of how large a markup retailers will be able to command.

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[9] All had names, but some of the names appear to have been code names rather than varieties, e.g., T1, T2, …, T9..

[10] Note there is to be no excise tax collected on sales from one processor to another, such as sales of extracted oil to a baker, assuming they are allowed at all, since Section 27(2) specifies that the 2nd level excise tax will be collected on "each wholesale sale … by a licensed marijuana processor to a licensed marijuana retailer."

Production Cost Parameters

We assume in our base case that the producers' selling price will be $3 per gram. That might seem low compared to a current "farmgate" price for medical marijuana closer to $5 per gram, but that farmgate price pertains to dried, trimmed, cured, and packaged product, and so is more comparable to the processors' sales price in this model. With a $3 producer selling price, the model suggests processors' selling prices for useable marijuana would be $4.40 and $5.10 for standard and prestige brands, respectively – *before* including the 25% tax on processors' sales.

Furthermore, Denman and Cooley (2013) estimate ongoing costs (beyond startup) of only $1 per gram for a 10,000 square foot facility using artificial lights, and costs could be considerably lower when growing with natural light.

Likewise RAND's production cost estimates when modeling Proposition 19 were considerably lower, more like $0.75 per gram, if the enforcement risk is truly zero for indoor production (Kilmer et al., 2010a,b). Some of the difference is that Washington State envisions a rigorous and thus fairly onerous regulatory structure, whereas Proposition 19 would have devolved regulation to the local level, and Kilmer et al. (2010a,b) envisioned that as possibly creating a "race to the bottom" with jurisdictions competing with each other to be the most industry-friendly and, hence, derive the economic benefits of hosting production. (Those economic benefits could be quite substantial on a per capita basis in a small municipality or rural county even though they are less compelling at the state level.)

Hence, it seems plausible if not probable that producer prices will decline over time even if they start at $3 per gram.

We set the processing cost for useable marijuana at $0.40 per gram. This is something of a notional number, since in the current industry structure, producers of useable marijuana often sell directly to retailers. One component of the processing cost will be the cost of testing. For example, if every 2-pound lot required a $75 test, that is $75 / (2 * 453.6) = $0.08 per gram for testing. There may be other regulatory compliance driven costs, but they cannot be estimated at this time.

The other physical materials processing costs are likely to be modest; tobacco is processed for less than $1 per pound. E.g., if time and mileage costs to transport a 50 pound purchase obtained from a producer were $500, that is still only $500 / (50 * 453.6) = $0.02 per gram. Packaging costs should likewise not be high. Even the illegal drug industry only pays about six to ten cents to package a unit of crack (Caulkins et al., 1999), an activity which carries considerable arrest risk for workers, and if the typical marijuana package contains 1/8 ounce of marijuana, that would be just pennies per gram. Furthermore, mechanization in legal industries drives unit packaging costs down to very low levels. Whereas workers in the crack industry package about 100 units per hour, even older model sugar packaging machines are about five hundred times faster, filling 500–1,000 sugar packets per *minute* (Caulkins and Lee, 2012).

We think of the processing costs for extraction and infused-products manufacturing as an increment over and above the cost for processing useable marijuana because most of the activities involved in processing useable marijuana (e.g., the testing) would still need to done by these other processors.

We attempt to build up an extraction cost estimate from the various constituent costs. Processing materials costs are probably not main driver. For example, suppose it costs $250 to fill a 20-pound tank with industrial-quality solvents (e.g., IsoButane), one uses one-quarter to one-fifth of that tank for each 5-liter extraction batch, and a batch consumes 2.5 pounds of marijuana, then that works out to ($250 / 5) / (2.5 * 453.6) = $0.05 per gram of marijuana. By contrast, the cost per gram will be influenced importantly by the firm's production volume and, hence, the volume over which it can amortize the $20,000 - $100,000 fixed cost of acquiring an extraction chamber.[11] So there are some scale economies, and it is not clear either how much demand there will be among processors for extract or how concentrated (excuse the pun) that industry segment will be. Consider a firm that produces a batch each working day of the year. A batch which yields 150 grams that sells for $35 per gram generates sales revenues of $1.3 million per year, a firm size that seems plausible for this nascent industry. So, amortizing the capital cost of a $46,000 chamber over 2 years works out to about ($60,000 / (1134 grams per batch * 250 batches per year * 2 years) = $0.106 per gram consumed.

If labor costs are $50,000 per year, that works out to $0.18 per gram at 250 batches per year. However, it is not clear whether such salaries will be sustainable; current salaries may be more representative of compensation for owner/operators and so mix wages with profits, whereas entrepreneurial profits belong in our accounting within markup, not processing cost.

These identified extraction costs per gram processed (above and beyond the processing cost for useable marijuana) total to roughly $0.35, which we round up to $0.50 per gram processed (and so close to $4 per gram produced) given the relatively high wholesale prices now observed.

The incremental cost of creating infused-products will depend enormously on the nature of that product. Producing simple chocolates and baked goods is not expensive. After all, even the full retail price is not that high. A 40-ounce Whitman's sampler with 72 pieces retails for $30, or $0.41 per morsel. Wholesale costs for plainer brands are of course lower. Twenty-five pound bags of Hershey's kisses can be purchased for $175 over the internet, at 100 morsels per pound that is only $0.07 per morsel. Suppose each piece of marijuana-infused chocolate contained the equivalent of 0.4 grams of marijuana (50 milligrams of THC is equivalent to 0.4 grams of marijuana that is 14% THC). That means the *retail* price of fine chocolates is the equivalent of $1 per gram of marijuana, and the wholesale price for simpler chocolates is just $0.20 per gram of marijuana. Production costs are obviously even lower. Nevertheless, we set the cost per gram at $0.25 since the cost for fresh baked goods would presumably be higher. This is a rather uncertain parameter inasmuch as it is not at all clear what proportion of infused-product purchases will be simple chocolates, and what proportion will be baked goods or other more expensive products.

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[11] Washington Alternative Medicine (WAM) Cooperative described even larger devices, costing $75,000 - $100,000 to build; another source cited a lower cost of $20,000 - $60,000.

Production & Materials Flow Parameters

These parameters have little empirical basis inasmuch as they pertain to a legal industry that does not yet exist; medical marijuana is related, but still differs on several dimensions, and likely also has not yet reached a steady state. The most important of these four is the proportion of marijuana going into useable marijuana that is grown in vertically integrated operations. We expect that to be the usual practice, to avoid the first layer excise tax. Without any particular empirical basis we use 80% as the base case but stress that this, like all parameters, can be adjusted by the WSLCB once better information becomes available.

Given our belief that most marijuana will end up as useable marijuana, not infused products, the results are not terribly sensitive to the corresponding vertical integration parameters for extractors and infused products manufacturers. We guess that the infused product manufacturers would be more specialized in processing and so be less vertically integrated; specifically we set their corresponding parameter at 30%. Likewise and to an ever greater extent we imagine the extractors will be specialized just in extraction and so not grow any of their own marijuana (0%).

The last parameter in this suite is the proportion of marijuana entering infused products that comes by way of extraction firms' (e.g., oils) vs. being purchased as marijuana by the infused product manufacturers. Again, we have no empirical basis for this parameter but guess that it will be less than half and set it to 25%.

Market Share Parameters

For reasons discussed above, we expect most marijuana to be consumed in the form of useable marijuana not infused product; in particular, we set that parameter at 80%.

Likewise, as discussed, we think most marijuana consumers will be from blue-collar demographic groups that will be relatively price sensitive, so expect that the majority of marijuana will be sold as standard, not prestige brands, (80%) and in retail outlets that compete on price (75%), not with those that compete on the service experience.

Tax Rates

The excise tax rates are of course set at 25%. We used a sales tax rate of 8.75%, meaning an average local rate of 2.25% over and above the state rate of 6.5%. (Seattle's rate is 3%, but that is higher than the average for the state.)

Model

Figure 5 is a snapshot of the spreadsheet model. It is moderately complex and it not explained in detail here. However, its broad outlines can be discerned from its basic shape and structure. For example, yellow shaded cells indicate input parameters, and the spreadsheet is divided vertically into 4 blocks corresponding to the four market levels: Cultivation, Oil Extraction & Sale, Final Goods Processing, and Retailing.

Likewise the four columns at the far right correspond to marijuana-infused products (including the oils used in their production), whereas the four columns to their left pertain to useable marijuana.

As one moves down the distribution chain, products are more finely distinguished. At the processor level, both useable marijuana and marijuana-infused products are broken down into standard vs. prestige brands. At the retailer level there is a further distinction between goods sold in price-conscious outlets vs. high-touch outlets. So, for example, at the bottom of the spreadsheet the far right column corresponds to prestige brand marijuana-infused goods sold at high-touch retailers. That is the highest price category at $30.82 per gram. By contrast, the leftmost of the eight product columns – the one for standard brand useable-marijuana sold through price-conscious retail outlets – has the lowest price at $9.41 per gram; it also has the largest market share, at 48% of the market.
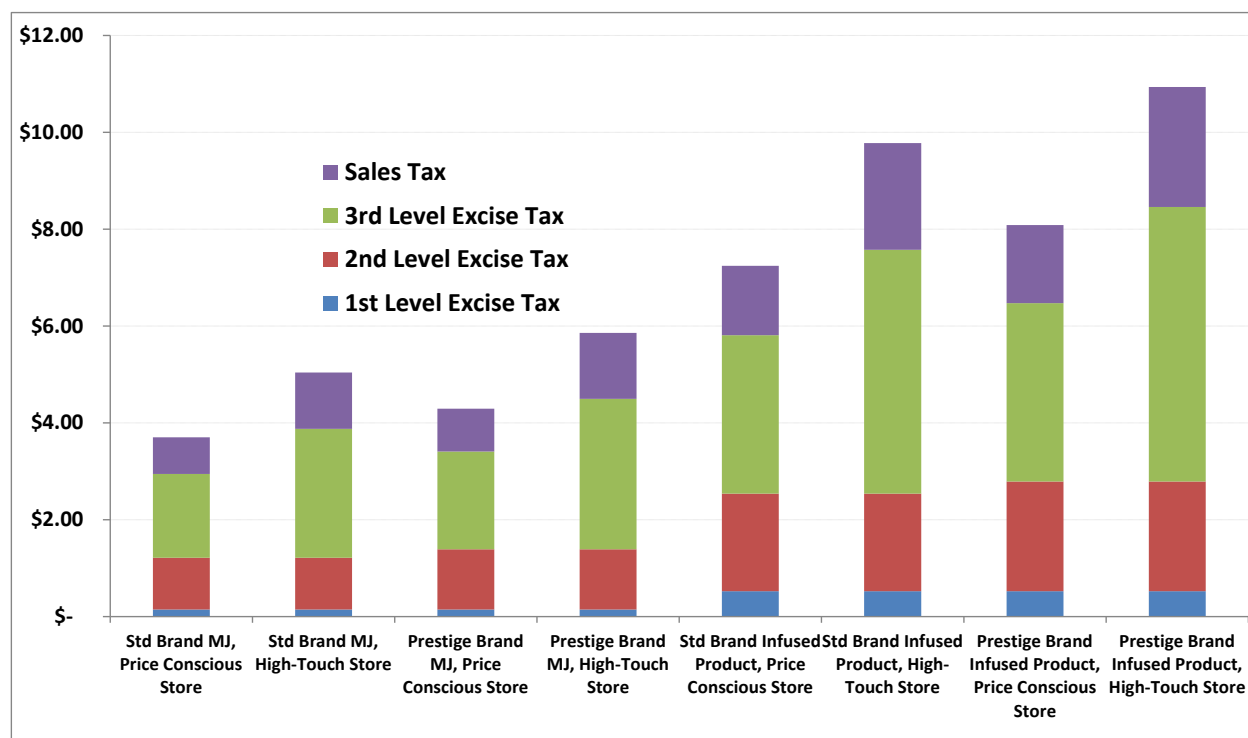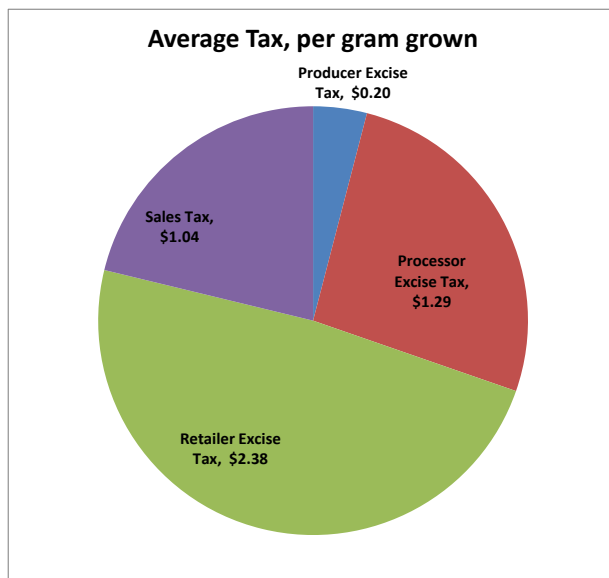
Figure 5: Snapshot of Model

Market Level	Parameters			Useable MJ			Infused Products			
								Type of Product/Intermediate Product		
	25%	Proportion of MJ in infused products that is bought from oil extractors						MJ infused	MJ for Oil	
Cultivation	80%	MJ Sold as Useable MJ vs. Infused Product	Share of all MJ going to that type of processor	80%				15%	5%	
			Proportion of that production accounted for by vertically integrated processors	80%				30%	0%	
			Divide MJ Production between Vertically Integrated & Independents	Useable MJ				MJ infused	MJ for Oil	Cost of marijuana
	$ 3.00	Producers' selling price	Production Integrated with Processor:	64.0%				4.5%	0.0%	$ 3.00
	25%	Excise tax on producer	Independent Producers	16.0%				10.5%	5.0%	$ 3.75
		26.5% Proportion of production subject to 1st excise tax								
	$ 0.20	Resulting producer tax revenue per gram grown	Weighted average cost of marijuana used by that processor	$ 3.15				$ 3.53	$ 3.75	

Oil Extraction & Sale	$ 0.50	Cost of extracting oil, per gram processed (above and beyond that for useable MJ)								
	50%	Oil Extractor's Markup (%)	Selling Price of oils to infused products companies						$ 6.98	

Final Goods Processors		Processing costs per:	Type of Product Useable Marijuana				Infused Products			
Final Goods Processors	$ 0.40	gram of Useable MJ	Weighted average cost of all materials (MJ & oils)	$ 3.15			$ 4.39			
	$ 0.25	Additional processing cost per gram of MJ in an infused pro	Processor's total cost of product & processing	$ 3.55			$ 5.04			
			Type of Brand	Standard		Prestige	Standard		Prestige	
			Processor Markups by Type of Brand & Product	20%		40%	60%		80%	
			Processor price pre-tax (add markup to processors' cost)	$ 4.26		$ 4.97	$ 8.06		$ 9.07	
	25%	Processor excise tax rate	Excise tax on processor	$ 1.07		$ 1.24	$ 2.02		$ 2.27	
			Price to retailer (Processor price + Excise Tax)	$ 5.33		$ 6.21	$ 10.08		$ 11.33	
	80%	% of product sold as Std vs. Prestige brands								
	$ 1.29	Processor tax paid per gram grown	Proportion of all MJ going into that type of product	64.0%		16.00%	16.0%		4.00%	

Retailers			Type of Product Useable Marijuana					Infused Products				
			Type of Brand	Standard		Prestige		Standard		Prestige		
	Retailer Markup by retailer type		Type of Retailer	Price	Touch	Price	Touch	Price	Touch	Price	Touch	
	Price	30%	Price to retailer (copied from above)	$ 5.33	$ 5.33	$ 6.21	$6.21	$ 10.08	$ 10.08	$ 11.33	$11.33	
	Touch	100%	Retailer markup (from table at left)	30%	100%	30%	100%	30%	100%	30%	100%	
			Retailer price pre-tax	$ 6.92	$ 10.65	$ 8.08	$ 12.43	$ 13.10	$ 20.15	$ 14.73	$ 22.67	
	25%	Retail excise tax rate	Excise tax on retailer	$ 1.73	$ 2.66	$ 2.02	$ 3.11	$ 3.27	$ 5.04	$ 3.68	$ 5.67	
	8.75%	Sales tax rate	Sales tax	$ 0.76	$ 1.16	$ 0.88	$ 1.36	$ 1.43	$ 2.20	$ 1.61	$ 2.48	
			Price to Consumer	$ 9.41	$ 14.48	$ 10.98	$ 16.89	$ 17.80	$ 27.39	$ 20.03	$ 30.82	
	75%	Proportion of retailers competing on Price vs. Touch	Share of Market	48.0%	16.0%	12.0%	4.0%	12.0%	4.0%	3.0%	1.0%	

Tax Summary	Tax Summary, per gram grown		Tax Summary (per gram sold, by product, brand, & store type)								
	$ 0.20	Producer Excise Tax	1st Level Excise Tax	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.53	$ 0.53	$ 0.53	$ 0.53
	$ 1.29	Processor Excise Tax	2nd Level Excise Tax	$ 1.07	$ 1.07	$ 1.24	$ 1.24	$ 2.02	$ 2.02	$ 2.27	$ 2.27
	$ 2.38	Retailer Excise Tax	3rd Level Excise Tax	$ 1.73	$ 2.66	$ 2.02	$ 3.11	$ 3.27	$ 5.04	$ 3.68	$ 5.67
	$ 1.04	Sales Tax	Sales Tax	$ 0.76	$ 1.16	$ 0.88	$ 1.36	$ 1.43	$ 2.20	$ 1.61	$ 2.48
	$ 4.92	Total	Total	$ 3.70	$ 5.04	$ 4.29	$ 5.86	$ 7.25	$ 9.78	$ 8.09	$ 10.94
			Tax Burden (Taxes' Proportion of Price to Consumer)	39.3%	34.8%	39.1%	34.7%	40.7%	35.7%	40.4%	35.5%

Model Results

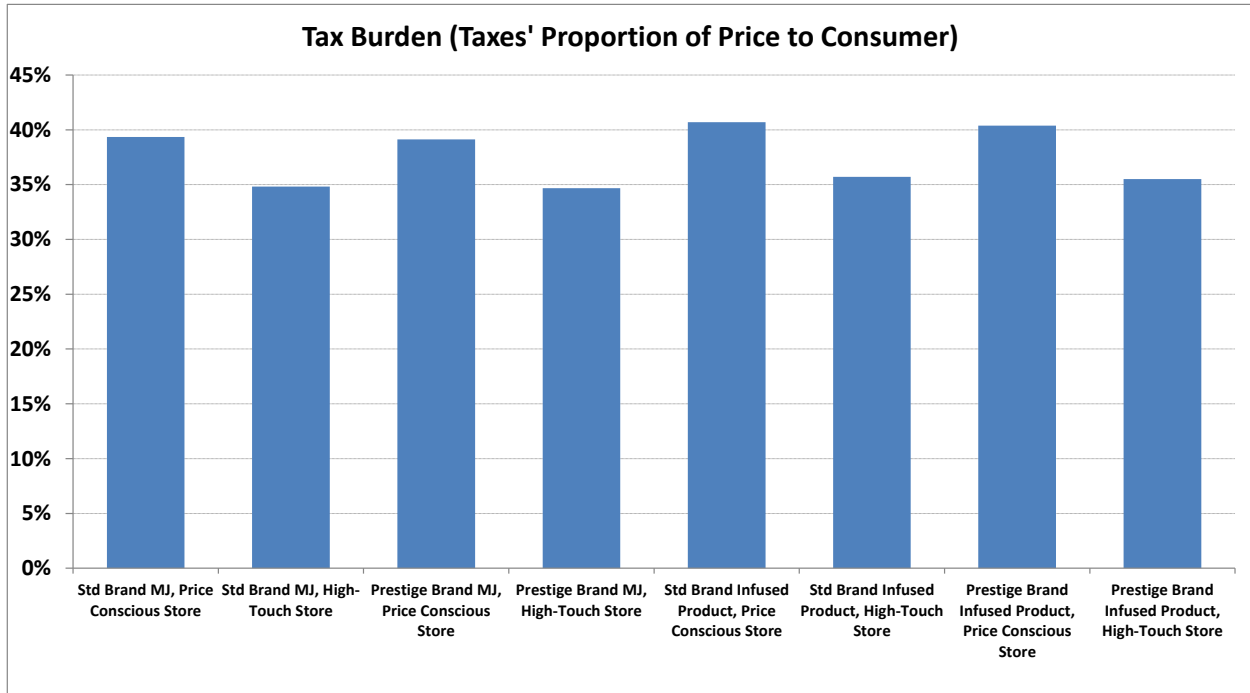The pie chart below shows how the total average tax per gram grown of $4.92 breaks down across the three levels of excise taxes and the sales tax (assuming a sales tax of 8.75%, the 6.5% state tax plus an average local tax of 2.5%). That tax burden varies somewhat by type of product, as well as with brand and type of retail establishment, so the subsequent bar chart gives the breakdown for each product-brand-store type.

Figure 6: Tax Revenue by Type of Tax

Average Tax, per gram grown

Producer Excise Tax, $0.20

Sales Tax, $1.04

Processor Excise Tax, $1.29

Retailer Excise Tax, $2.38

- Sales Tax
- 3rd Level Excise Tax
- 2nd Level Excise Tax
- 1st Level Excise Tax

Obviously the total tax per gram increases as one moves from left to right, but that is mostly because the sales price likewise increases from left to right. The tax burden in percentage terms varies less by type of product, brand, and store as seen in the figure below.

The tax burden (meaning tax as a share of final price to consumer) will probably be between 30-40%, perhaps in the high 30's for goods sold in service-oriented (high markup) retail stores and mid 30's for goods sold in stores that compete on price. That proportion is more stable over a range of parameter values than is the final price level and, hence, the tax revenue per unit sold and consumed.

Tax Burden (Taxes' Proportion of Price to Consumer)

Category	Tax Burden
Std Brand MJ, Price Conscious Store	~39%
Std Brand MJ, High-Touch Store	~35%
Prestige Brand MJ, Price Conscious Store	~39%
Prestige Brand MJ, High-Touch Store	~35%
Std Brand Infused Product, Price Conscious Store	~41%
Std Brand Infused Product, High-Touch Store	~36%
Prestige Brand Infused Product, Price Conscious Store	~40%
Prestige Brand Infused Product, High-Touch Store	~35%

For example, because marijuana-infused products are projected to sell for substantially more per gram of marijuana contained, they would account for a disproportionate larger share of total tax revenues. For example, if they represented 20% of marijuana consumption, they might account for 30%-35% of tax revenues. So the total tax revenue per unit of consumption will be higher if the market leans more toward infused products and away from useable marijuana, and vice versa.