Effect of taxes and costly regulations on the licensed and unlicensed cannabis markets

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Abstract

Cannabis has become a major commodity in much of North America, and is one of the most highly taxed and regulated agricultural products. Yet there is little research on the economic implications of cannabis taxes and regulations, which limit the availability of cannabis from legal licensed suppliers. Taxes and regulations generally raise the price and reduce the availability of licensed cannabis, which may increase the demand for unlicensed cannabis. In many states, the result is that licensed cannabis is more expensive and less available to consumers than unlicensed cannabis. This paper explores the impacts of several taxation and regulation alternatives that would likely increase the quantity of licensed cannabis relative to cannabis from unlicensed suppliers. Given the lack of cannabis data and confidence about the most important parameter estimates, we document confidence intervals around our simulation outcomes. Our simulated outcomes focus on policy-relevant market shares, government revenues, and welfare aggregates.

Keywords: Cannabis, equilibrium displacement, policy simulation, welfare effects

Introduction

It is now legal for patients with doctor's recommendations to possess medicinal cannabis in most of America, and it is legal for all consumers age 21 and over to possess cannabis in 11 U.S. states and the District of Columbia. State laws generally allow consumers to possess cannabis without penalties, but put legal restrictions on those that sell cannabis by requiring licensing, compliance with mandatory testing, packaging rules, and other safety regulations, and by imposing a series of taxes in several forms and at several stages in the marketing chain (Goldstein and Sumner 2019).

While a legal, licensed and taxed cannabis segment has emerged around the United States in recent years, the illegal and unlicensed segment has not faded away, and in many places it still comprises the majority of cannabis sold (Goldstein, Sumner, and Fafard 2019). Substantial illegal markets are thought to exist alongside the legal markets across North America, including in the early-adopting U.S. states of California, Colorado, Washington, Oregon, and Nevada, and in Canadian provinces. Many licensed sellers and those in enforcement argue for stronger enforcement against those in the unlicensed market segment. Others point out that cannabis sold through the licensed segment has much higher prices and is less readily available in many areas; that many buyers had accessed unlicensed sellers for many years before the new regulations and taxes; and that higher prices and inconvenient access have not been a compelling rationale for buyers to shift segments.

The main question of this paper is how can licensed cannabis be regulated in a way that makes it more attractive for cannabis consumers than unlicensed cannabis, while preserving regulatory benefits such as quality control and taxpayer revenue. This paper investigates several potential regulation and tax alternatives in the context of an empirical simulation model designed explicitly to yield policy relevant information on impacts. We show that simple changes to the stage of the supply chain at which taxes are applied can prevent large increases in the retail price of cannabis while preserving much of the tax revenue. In this paper, we use California data and regulations as a case study but the analysis is broadly applicable.

Economic literature on the legal and illegal cannabis markets

The economic literature on consumer choice between legal and illegal versions of products tends to focus on product categories where taxes are relatively high and regulations relatively costly, and thus where the material cost of producing the consumable portion of the good is relatively small as a portion of overall costs. For instance: illegal drugs, certain alcohol products, and, in the past few decades, tobacco.

Illegal counterfeit alcohol and tobacco are more common in Asia, Africa, and Latin America than in the United States, but illegal alcohol and tobacco markets do exist in the U.S. In a 2016 criminology survey of consumers of legal and illegal (unlicensed) cigarettes in the Bronx, New York, cigarette consumers' decisions were "guided by various concerns, including reliable access to illicit cigarettes, minimal exposure to the police, the ability to purchase cigarettes on credit, reduced risk of being sold low-quality cigarettes (i.e., stale, counterfeit), and the chance to successfully complain in case of poor product quality"; and cigarette consumers "make rational decisions to purchase illicit cigarettes within the constraints they face", and "base their decisions on a set of factors of which the lowest retail price is not a primary concern" (von Lampe et al. 2016).

A 2019 RAND study based on data from the National Survey on Drug Use and Health (NSDUH) estimated that, several years after Washington's legal adult-use cannabis system was implemented in 2014, 40%–60% of cannabis consumed in Washington State was illegal (unlicensed) cannabis. The RAND researchers elicited consumers' "self-reported information about amount spent on marijuana at the time of the last purchase," adjusted for assumed underreporting, and estimated quantity of cannabis consumed by dividing self-reported amount spent by an assumed average price per gram of marijuana, "evaluated at the typical purchase size of about one-half of an ounce from NSDUH respondents" (Midgette et al. 2019, p.46).

This follows the methodology used in previous RAND studies of the cannabis industry (Kilmer et al. 2010; 2013; Caulkins et al. 2013a; 2013b; 2015; Light et al. 2014). One drawback of this methodology, acknowledged by Midgette et al. (2019) and others, is that the typical potency of cannabis is widely thought to have gone up over time; so if cannabis consumption were measured in terms of THC content, consumption could increase even if the number of grams did not increase. Consumption of oil-based products such as cannabis wax, shatter, and edibles is even harder to measure or average, as the potency of such products varies even more widely than flower potency varies. More expensive cannabis and legal cannabis tend to have higher THC than cheaper cannabis and illegal cannabis (Orens et al. 2015), but the connection between THC content and potency (how strong consumers perceive cannabis products to be upon consumption) has also been questioned in recent research published in *JAMA Psychiatry* (Bidwell et al. 2020).

Legal cannabis, compared with illegal cannabis, may have certain advantages (not limited to typically higher THC content) that some consumers are willing to pay extra for, such as testing certification (Valdes-Donoso, Sumner, and Goldstein 2020). Little research to date considers the sensory differences between legal and illegal cannabis, or between cheaper or higher-THC cannabis and cheaper or lower-THC cannabis whether the difference between the two can be detected by consumers. Research on wine (e.g, Goldstein et al. 2008) suggests that consumers do not prefer more expensive wine to cheaper wine in blind taste tests.

There is a scant literature on elasticities of demand for cannabis. Because cannabis remains illegal in most of the world, including the United States, most published research has focused on illegal cannabis demand. (Reinarman 2009) compares California and Holland patterns of consuming cannabis through surveys. In Holland, where most people buy through stores, people favor milder cannabis. Lower lifetime use in Amsterdam (with 35% of those surveyed reporting using cannabis at least once in the past) than in San Francisco (62%). Only 5% of Amsterdam and 13% of San Francisco cannabis users said they would use more if cannabis were cheaper, and 63% of those surveyed in Amsterdam and 61% of those surveyed in San Francisco said they would not use less cannabis even if it were "much more expensive," suggesting relatively inelastic demand.

The few specific estimates of own-price elasticity of demand for cannabis that can be found in the economics and public policy literature vary widely. Jacobi and Sovinski, in a paper in the American Economic Review, used data from a broad population of cannabis users in the Australian National Drug Household Survey to estimate own-price elasticity for illegal cannabis to be -0.2 (Jacobi and Sovinsky 2016).[1]

Again on the illegal side, (Davenport and Caulkins 2016) find that cannabis consumption rose dramatically in US from 2002-2013, and prevalence of monthly users consuming daily or

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[1] Younger consumers, who tend to face more severe budget constraints, may be more price-elastic as they are for cigarettes. (van Ours and Williams 2007) estimated own-price elasticity of demand for illegal cannabis from young Australians at -0.31 to -0.70. (Nisbet and Vakil 1972), in an article published in the American Economic Review based on an anonymous mail-in survey of UCLA students, estimated a price elasticity of demand for illegal cannabis ranging from −0.36 to −1.51. We take this study to be of limited current relevance because it is 13 years old.

near-daily rose from 11% to 33%. Davenport and Caulkins refer to cannabis users are "downscale," similar to cigarette smokers: 29% have income below US$20,000 per year (versus 27% of cigarette smokers and 13% of alcohol users), and 19% have no high-school education (versus 20% of cig smokers and 8% of alcohol users). Davenport and Caulkins report that 15% of all users spend one-quarter of their monthly income or more on (illegal) cannabis.

Some of the other work on the effects of cannabis legalization has come out of advocacy or lobbying efforts. group of university economics professors, led by Jeffrey Miron of Harvard, jointly lobbied for legalization of drugs in a white paper entitled "The Budgetary Implications of Drug Prohibition," which estimates annual government losses due to marijuana prohibition at more than $6 billion (Miron 2010).

Cannabis Industry and the Current Regulatory Framework

Legalization of cannabis began in California in 1996 with the Compassionate Use Act, which allowed cannabis production, processing, sale, purchase, and possession by California residents with a doctor's recommendation. In November 2016, Proposition 64, or the Adult Use of Marijuana Act (AUMA), made adult-use cannabis purchase and possession legal for those over the age of 21.

California produces about 16 million pounds of cannabis (dried flower) annually, of which about 2.8 million pounds are consumed within the state. Of total cannabis consumed in California, in 2019, about 540,000 pounds were produced and distributed by licensed businesses, while the rest is part of the unlicensed, or, illegal, market (Sumner, Goldstein, Matthews and

Sambucci 2020). Because most cannabis produced in California is illegal, official quantities of cannabis production are not available.

Cannabis is grown using three main cultivation methods: outdoor, indoor, and greenhouse (mixed light). Yield and price per pound for cannabis vary by cultivation method, with indoor cannabis having the highest yield and highest prices per pound. For licensed cannabis, in March 2020, average farm prices for cannabis grown outdoors were $850 per pound of dried flower equivalent, $1,200 for cannabis grown in greenhouses, and $1,800 for cannabis grown indoors (Sumner et al. 2020; Cannabis Benchmarks 2020). Growing operations sell cannabis to manufacturers for processing and packaging, and then to wholesale distributors who supply cannabis to retail outlets. We combine manufacturing, packaging, and distribution to retailers into a single wholesale stage in the supply chain. In addition to the services described above, licensed wholesalers are also responsible for collecting the cultivation tax on licensed cannabis, and for mandatory testing that has to be performed by an independent entity.

Cannabis businesses at every stage of the supply chain, beginning with growing operations, must be licensed and pay additional taxes and fees. A cultivation tax of $154 per pound is imposed on licensed growers; wholesalers collect the cultivation tax and arrange and pay for testing before selling cannabis to the retailers. At the retail stage, licensed cannabis is subject to excise tax, as well as local and sales taxes. Licensing fees, taxes, and other regulations, increase the operating costs for businesses entering the licensed marketing channel, and, as a result, increase the price of licensed cannabis far beyond unlicensed cannabis. (Goldstein, Robin S. and Sumner 2019) observed that prices at licensed retailers were on average 25 percent higher than those of unlicensed retailers, although the difference may actually be greater because it is unclear how many of the retailers included excise taxes in the listing price.

Because of licensing requirements, taxes, fees, and other operating restrictions such as lack of access to the federal banking system, and the ability of counties and municipalities to impose local bans on cannabis operations, licensed cannabis market still accounts for a relatively small share of cannabis consumed in California. Most regulations that come into effect contribute to increasing the operating costs for licensed cannabis businesses, and are potentially impeding the licensed segment from gaining market share.

Modeling the Market for Licensed and Unlicensed Cannabis

Economists have modeled vertical linkages through the marketing chain using the framework suggested by (Muth 1964) to simulate effects of taxes, regulations and other market shocks on agricultural markets (Reinarman 2009). Some of the more recent extensions to the equilibrium displacement modeling (EDM) framework include modeling the effects of policy on heterogeneous products, used by James and Alston (2002) to explore the effect of taxes on quality of wine grapes in Australia; and sensitivity analysis incorporating stochastic parameter values, as developed by (Davis and Espinoza 1998) and adapted recently by Lee, Sumner, and Champetier (2019).

Our modeling is consistent with, but makes no particular commitment to, the addictive behavior approach introduced by (Becker and Murphy 1988) and discussed in (Grossman and Chaloupka 1998). This approach assumes that addicts behave rationally and emphasizes the interdependency of past, current, and future consumption of an addictive good. This indicates that consumers incorporate the effects of current consumption on future utility.

Some confirmatory evidence for rational consumer behavior in the illegal cannabis market comes from a behavioral experiment at SUNY Buffalo (Collins et al. 2014), where 59 male recreational (then illegal) cannabis users, with a mean age of 22, participated in computer simulation testing demand at prices for “high-grade marijuana” varying across 16 escalating prices from $0 per joint to $160 per joint. Demand was extremely inelastic below $4 per joint and above $40 per joint. Collins et al. observed an S-shaped curve where subjects were the most price-elastic between $4 and $10 per joint. Elasticity of demand and maximum willingness to pay were inversely correlated with frequency of marijuana use, i.e. heavy users were more sensitive to price than light users.

(Becker, Murphy, and Grossman 2006) link the elasticity of demand for an illegal good with the degree and severity of enforcement of laws prohibiting illegal goods. Thus enforcement can impact the size of the illegal market. This paper deals with markets where legal and illegal sub-segments of the overall cannabis market coexist and compete for consumers. In states with legal adult-use cannabis regimes, enforcement is generally against illegal sellers but not against illegal buyers (unless the buyers are under 21). We do not model changes in enforcement (e.g. an increase in decrease in raids of unlicensed facilities) as changing elasticities of demand.

We model cannabis that is available through two distinct market channels: licensed and unlicensed, with substitution in demand but no substitution in production. In our model, cannabis is sold by growers to wholesalers, then by wholesalers to retailers, and retailers supply cannabis products to consumers. In the simplified version of the model, we do not explicitly model the processing and distribution that takes place between farm and retail; instead we subsume the margin between the price farms receive and the price consumers pay into a single intermediary. Cannabis is produced and distributed through two marketing channels: licensed and unlicensed. Throughout the paper, for brevity, we refer to cannabis products as “licensed” and “unlicensed” when describing cannabis products distributed through licensed and unlicensed marketing channels.

The basic structure of the model includes demand for licensed and unlicensed retail cannabis, derived demand for licensed and unlicensed cannabis from growers; supply of cannabis to retailers and consumers, and market clearing conditions. Parameters include the elasticity of total demand for cannabis; the elasticity of substitution in demand between licensed and unlicensed cannabis; the own-and cross-price elasticities of licensed and unlicensed cannabis; the elasticities of supply for licensed and unlicensed cannabis; equilibrium quantities, prices, and shares of licensed and unlicensed cannabis; taxes imposed on licensed cannabis producers and distributors, modeled as price wedges; and exogenous shocks to supply and demand.

We assume licensed and unlicensed cannabis to be imperfect substitutes in consumption, but not in production. Consumers can easily substitute between licensed and unlicensed cannabis products, although some consumers may prefer a particular marketing channel. For example, certain consumers may prefer to buy cannabis from licensed distributors only because of higher perceived quality due to testing and other regulations. In addition, licensed distributors may be perceived as safer or more socially acceptable. On the other hand, consumers may prefer to purchase from unlicensed retailers because of prior relationships, or if they are uncomfortable providing an ID card when shopping at the licensed provider. Other consumers may not care about whether the distributor is licensed, but may simply want to pay the lowest possible prices, thus naturally gravitating towards an unlicensed distributor.

On the supply side, a grower, wholesaler, or retailer may be either licensed or unlicensed. It is not practical for any business to enter the unlicensed market after already having entered the licensed market. Meanwhile, to go from unlicensed to licensed entails significant financial and regulatory barriers. Therefore, we assume no substitution in production between licensed and unlicensed cannabis.

Model of Cannabis Markets, Taxes and other Policies

We begin by characterizing the demand and supply in the markets for licensed and unlicensed cannabis, and then explain in detail the markups, taxes, and fees, that apply to cannabis on the way from farm to consumer. We characterize the demand and supply relationships in the markets for licensed and unlicensed cannabis as follows:

$$QDL = f_L(PDL, VL, PDU) \tag{1}$$

$$QDU = f_U(PDL, PDU, VU) \tag{2}$$

$$QSL = g_L(PSL, ZL) \tag{3}$$

$$QSU = g_U(PSU, ZU) \tag{4}$$

$$QDL = QSL \tag{5}$$

$$QDU = QSU \tag{6}$$

In the equations above, L and U refer to licensed and unlicensed cannabis; QD refers to quantity demanded; QS refers to quantity supplied; PD and PS refer to prices along the demand and supply curves; VL and VU are exogenous demand shifters for licensed and unlicensed cannabis; and ZL and ZU are exogenous supply shifters for licensed and unlicensed cannabis.

Equations (1) and (2) refer to consumer demand for cannabis in dried flower-equivalent terms from licensed and unlicensed retail channels. Equations (3) and (4) refer to supply of licensed and unlicensed cannabis, also in dried flower-equivalent terms. As discussed above, we assume substitution in demand but not in supply, so consumer demand for licensed cannabis is a function of prices for both licensed and unlicensed cannabis, whereas supply of licensed cannabis does not depend on the price of unlicensed cannabis. Equations (5) and (6) are market-clearing conditions.

We use the conventional representation of taxes as either ad-valorem or specific price wedges between supply and demand curves. Unlicensed cannabis products face no taxes or regulatory fees, and the process of tracking the price of unlicensed cannabis from farm to consumer is relatively straightforward. First, farms supply unlicensed cannabis products to an intermediary for processing and wholesale distribution. Since there are no taxes or fees, there is no wedge between the price received by the growers and the price paid by the wholesalers.

$$PDU^W = PSU^F \tag{7}$$

In Equation (7), PSU^F represented the prices at which the growers of unlicensed cannabis supply the products, and PDU^W represents the price at which the intermediaries (or wholesalers) or unlicensed cannabis purchased the product.

Next, cannabis is sold to retail outlets. The markup added by the wholesalers reflects the added value of any processing, packaging, or marketing that takes place between buying the cannabis from farmers and supplying it to retail outlets.

$$PSU^W = PDU^W(1 + m_U^W) \tag{8}$$

$$PDU^R = PSU^W \tag{9}$$

In Equation (8), PSU^R is the price at which wholesalers sell cannabis to the retail outlets. This price is equal to the price that wholesalers pay to cannabis farmers, marked up by wholesale markup m_U^W which reflects the value added by processing at this stage of the distribution process.

Equation (9) shows that there is no price wedge between the price wholesalers receive for their product and the price retailers pay to the wholesalers.

Retail outlets sell unlicensed cannabis to consumers at a marked-up price which reflects any added value and operating costs at this stage of the distribution process.

$$PSU^R = PDU^R(1 + m_U^R) \tag{10}$$

$$PDU^C = PSU^R \tag{11}$$

In Equation (10), m_U^R is the retail markup, PDU^R is the price at which retailers purchased the product from wholesalers, and PSU^R is the price at which retailers are selling the product to the consumers. Equation (11) shows that there is no wedge between the price retailers receive from the consumers and PDU^C, the price consumers pay for unlicensed cannabis.

The total difference between farm price and the price consumers pay for unlicensed cannabis is then equal to:

$$PDU^C = PSU^F(1 + w^U) \tag{12}$$

Where:

$$(1 + w^U) = (1 + m_U^W)(1 + m_U^R) \tag{13}$$

In Equations (12) and (13), w^U represents the total markup from the price unlicensed farmers receive to the price consumers pay for cannabis purchased through unlicensed retail outlets.

Licensed cannabis faces several complicated taxes at the farm and retail stages. First, additive cultivation tax is applied per pound of cannabis sold by farmers.

$$PDL^W = PSL^F + T^F = PSL^F(1 + t^F) \tag{14}$$

Equation (14) describes the price wholesalers pay to licensed growers. Above, PDL^W is the price wholesalers pay to the growers; PSL^F is the price licensed growers receive; T^F is the amount of cultivation tax assessed per pound of cannabis sold. To simplify the log-transformation of the model we transform the specific cultivation tax T^F to an ad valorem equivalent t^F by dividing the dollar amount of cultivation tax per pound by the average price received by licensed growers, PSL^F.

Cannabis is processed and sold to licensed retail outlets without additional taxes or fees at the wholesale stage, however the markup applied by the wholesalers reflects additional operating costs associated with the licensed cannabis supply chain, such as the costs of mandatory testing.

$$PSL^W = PDL^W(1 + m_L^W) \tag{15}$$

$$PDL^R = PSL^W \tag{16}$$

In Equations (15) and (16), PSL^W is the price wholesalers receive from retail outlets; m_L^W is the wholesale markup that reflects added value and operating costs at this stage of the distribution process; and PDL^R is the price retailers pay for licensed cannabis. Retailers further mark up the price they then charge for the product.

$$PSL^R = PDL^R(1 + m_L^R) \tag{17}$$

Equation (17) describes the difference between the price retailers pay for licensed cannabis (also referred to as wholesale price), and the price retailers receive from selling to consumers. Markup m_L^R reflects the added value at the retail stage, as well as relevant operating costs . Additional taxes are imposed at the time of the sale to consumers, creating a wedge between the price retailers receive and the price consumers pay.

$$PDL^C = (PSL^R + PDL^R(1 + m_L^T) \times t_e + PSL^R \times t_l)(1 + t_{ss} + t_{cs}) \tag{18}$$

The wedge between wholesale and retail prices includes the wholesale-to-retail markup, excise tax, sales and local taxes. First, excise tax t_e is applied to the wholesale price PDL^R plus a multiple m_L^T that the state calls a "markup" (but is distinct from the actual markup as we discuss it elsewhere). Local municipal tax t_l is applied to a cannabis price exclusive of the excise tax (PSL^R). State sales taxes—which include California state tax t_{ss} and county sales tax t_{cs}—are applied to a cannabis price that already includes cultivation, excise, and local municipal taxes.

Combining equations (14) through (18) allows us to characterize the total price wedge between the farm supply price and the retail price paid by consumers for licensed cannabis:

$$PDL^C = PSL^F(1 + w^L) \tag{19}$$

Where

$$1 + w^L = (1 + t^F)(1 + m_L^W)(1 + m_L^R)(1 + (1 + m_L^T)/(1 + m_L^R) \times t_e + t_l)(1 + t_{ss} + t_{cs}) \tag{20}$$

Log-Linear Representation of Cannabis Markets, Taxes and Other Policies for Simulations

Totally differentiating equations (1) to (18) and converting to elasticity form yields the linear elasticity model below. We make use of the equilibrium conditions and apply definitions in equations (12), (13), (19), and (20) that combine the price wedges from each stage in the supply chain into a single price wedge between farm and retail prices. The resulting model is described in equations (21) to (26).

In the equations below, we use a proportional change operator $E(x) = dx/x = dlnx$. For example, $EQDL$ represents a proportional change in QDL, or quantity of licensed cannabis purchased by consumers.

$$EQDL = \eta_{LL}(EPDL^C - EVL) + \eta_{LU}(EPDU^C) \tag{21}$$

$$EQDU = \eta_{UL}(EPDL^C) + \eta_{UU}(EPDU^C - EVU) \tag{22}$$

$$EQSL = \varepsilon_L EPSL^F - \varepsilon_L EZL \tag{23}$$

$$EQSU = \varepsilon_U EPSU^F - \varepsilon_U EZU \tag{24}$$

$$EPDU^C = EPSU^F + E(1 + w^U) \tag{25}$$

$$EPDL^C = EPSL^F + E(1 + w^L) \tag{26}$$

Reorganized and in matrix form:

$$\begin{bmatrix} 1 & 0 & -\eta_{LL} & -\eta_{LU} & 0 & 0 \\ 0 & 1 & -\eta_{UL} & -\eta_{UL} & 0 & 0 \\ 1 & 0 & 0 & 0 & -\varepsilon_L & 0 \\ 0 & 1 & 0 & 0 & 0 & -\varepsilon_U \\ 0 & 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 0 & -1 & 0 \end{bmatrix} \begin{bmatrix} EQL \\ EQU \\ EPDL^C \\ EPDU^C \\ EPSL^F \\ EPSU^F \end{bmatrix} = \begin{bmatrix} -\eta_{LL} EVL \\ -\eta_{UU} EVU \\ -\varepsilon_L EZL \\ -\varepsilon_U EZU \\ E(1 + w^U) \\ E(1 + w^L) \end{bmatrix} \tag{27}$$

Above, we use the equilibrium conditions in equations (5) and (6) and refer to quantities of licensed and unlicensed cannabis as EQL and EQU. We can then obtain the values of endogenous variables EQL, EQU, $EPDL^C$, $EPDU^C$, $EPSL^F$, and $EPSU^F$, as functions of own-price demand elasticities η_{LL} and η_{UU}; cross-price demand elasticities η_{LU} and η_{UL}; supply elasticities ε_L and ε_U; demand shifters VL and VU; and changes in other exogenous variables such as markups $m_U^R, m_L^W, m_L^R, m_U^R$, and m_L^T, as well as tax rates t_f, t_{ss}, t_{cs}, and t_l.

The results from the simulation model also allow to calculate changes in measures of economic welfare.

$$\Delta CSL = -PDL^C \times QL \times EPDL^C(1 + 0.5EQL) \tag{28}$$

$$\Delta CSU = -PDU^{C} \times QU \times EPDU^{C}(1 + 0.5EQU) \tag{29}$$

Changes in consumer welfare for consumers of licensed and unlicensed cannabis are calculated using changes in prices and quantities consumed of each type of product.

$$\Delta PSL = PSL^{F} \times QL \times EPSL^{F}(1 + 0.5EQL) \tag{30}$$

$$\Delta PSU = PSU^{F} \times QL \times EPSU^{F}(1 + 0.5EQU) \tag{31}$$

The changes in net surplus also include changes in tax revenue, which depends on the change in quantity and price of licensed cannabis, as well as the changes in taxes applied to those prices and quantities.

$$\Delta TR = QL \times PDL^{C} \times [t_0 - t_1(1 + EPDL^{C})(1 + EQL)] \tag{32}$$

In Equation (32), t_0 is effective baseline tax rate calculated as a percentage of consumer price, and t_1 is the corresponding effective tax rate as a result of changes in both exogenous and endogenous variables. Detailed calculations of t_0 and t_1 can be found in the Appendix.
Total welfare change is the sum of consumer and producer surplus for both licensed and unlicensed cannabis, as well as the change in tax revenue.

Since the unlicensed market is illegal, and we are evaluating policy changes that aim to decrease the share of the unlicensed segment, we do not include welfare measures for consumers and producers of unlicensed cannabis in our calculations of net surplus. The net welfare measure for licensed cannabis is therefore the sum of consumer surplus, producer surplus, and tax revenue.

$$\Delta NS = \Delta CSL + \Delta PSL + \Delta TR \tag{33}$$

Parameterization for Simulations

Table 1 contains the full set of baseline parameter values used in the simulation model, including initial prices and quantities, markups and taxes, and elasticities. Reliable data and parameter values to calibrate the model and specify the demand and supply equations are difficult to develop for cannabis. Little or no useful econometric estimation has been published. Moreover, even basic data on quantities (and, to a lesser degree, prices) is not available from usual sources, such as agricultural crop reports.

We use our best estimates of key supply and demand parameters for licensed and unlicensed cannabis, and substitutability between cannabis from the two market channels taken from interviews with industry sources and by analogy with other farm products that share some characteristics with cannabis. We use information from other products and our own experience with the industry to specify the models.

The farm supply elasticity of cannabis in each segment is 5.0, which reflects that fact that cannabis requires few specialized resources and will be a very small share of the space available in greenhouses, warehouses, or outdoor plots (Matthews et al. 2017). Additionally, supply of unlicensed cannabis can easily be diverted from shipments out of state to the local market. In the short run, the supply may be less elastic than in the long run since adjustments to production do take time, especially for licensed cannabis, which is subject to regulatory hurdles and does not have out of state shipments. To account for less elastic supply in the short run, we include estimates with elasticity of supply equal to 1.0.

The demand elasticity for cannabis overall is taken to be quite inelastic. Previous studies include (Nisbet and Vakil 1972), with estimated price elasticity of demand for cannabis ranging from –0.36 to –1.51; (Lakhdar, Vaillant, and Wolff 2016) estimated cannabis price elasticity range between –1.71 and –2.1. Other estimates included a range of –0.002 to –0.69 by (Pacula et al. 2001), a range of –0.31 to –0.70 by (van Ours and Williams 2007), and, most recently, the value of –0.2 estimated by (Jacobi and Sovinsky 2016). In our model we use –0.2 from Jacobi and Sovinsky (2016).

We apply the Armington specification of homothetic separability (Armington 1969) and assume small variation of price indiced within each utility (expenditure) level (Edgerton 1997) to calculate own- and cross-price elasticities for licensed and unlicensed cannabis under two-stage demand. The Armington approach has been used extensively to model trade and agricultural commodities (Alston 1986, 1991; Rickard and Sumner 2008; Alston et al. 1990; Davis and Kruse 1993).

The two stages of consumer demand are then presented as follows. First, consumer expenditure is allocated between cannabis and non-cannabis consumer products depending on the corresponding group price indices. Second, expenditure for cannabis is allocated among the individual commodities within the cannabis product group, namely licensed and unlicensed cannabis products. For the time being, we ignore the heterogeneity of cannabis products within each group, and we assume that licensed and unlicensed cannabis products are represented by relatively homogeneous dried flower products.

Under the assumption that licensed and unlicensed cannabis comprise a weakly separable group, and under the assumption of homothetic separability, the elasticities of demand for individual commodities with respect to the individual prices can be expressed as:

$$\eta_{LL} = s_L \eta_T - s_U \sigma \tag{36}$$

$$\eta_{UU} = s_U \eta_T - s_L \sigma \tag{37}$$

$$\eta_{LU} = s_U (\eta_T + \sigma) \tag{38}$$

$$\eta_{UL} = s_L(\eta_T + \sigma) \tag{39}$$

In the equations above, subscripts L and U represent licensed and unlicensed cannabis, η_{ij} is own- or cross- price elasticity of demand, s_i is the budget share of cannabis sector i, calculated as $s_i = (\frac{P_i^* Q_i^*}{P_T^* Q_T^*})$, with subscript T representing the general market for cannabis that includes licensed and unlicensed cannabis. Budget shares are calculated using equilibrium prices and quantities, denoted by the superscript $*$. First-stage effects are represented by η, the overall elasticity of demand for cannabis. Second-stage effects include substitution and expansion effects. Substitution effect is determined by σ, the elasticity of substitution between licensed and unlicensed cannabis products. The second-stage expansion effects are not included. Detailed derivations of elasticity formulas and explanations of relevant assumption are included in the Appendix.

We include simulations over a range of values for this parameter in our sensitivity analysis. We assume that the elasticity of substitution between licensed and unlicensed cannabis equals 2.0, following previous work on cannabis (Sumner et al. 2018). In addition, we include a wide range of values for this parameter based on values used in other studies (Alston, Gray, and Sumner 1994; Rickard and Sumner 2008), as a part of the sensitivity analysis. We report results for short- and long-run simulations that include values of elasticity of substitution equal to 2, 5, and 10.

Other parameters include budget shares of licensed and unlicensed cannabis; taxes, including cultivation taxes, excise tax, local cannabis taxes, and state and county sales taxes; and wholesale and retail markups. Budget shares are calculated using prices and quantities reported in Sumner et al. (2020). Wholesale and retail markups are assumed to be percentage margins applied to wholesale or retail prices, as described in Equations (10), (11), (17), and (18). The percentage of the markup is discussed in Sumner et al. (2020). Marketing margins for agricultural commodities are typically modeled as a combination of percentage and absolute margin (Wohlgenant 2001; George and King 1971). The state of California uses an assumed average percentage markup applied to the wholesale price to calculate the amount of the excise tax (except in non-arm's length wholesale-to-resale transfers, where actual markup is used). We assume 100% margins at both the wholesale and retail stages for both licensed and unlicensed cannabis.

In order to address the limitations of available information and roughness of assumptions about cannabis, we define probability distributions for key model parameters, as previously done by (Davis and Espinoza 1998; Rickard and Sumner 2008; Lee, Sumner, and Champetier 2019). We specify probability distributions for: (a) farm supply elasticities of licensed and unlicensed cannabis; (b) consumer demand elasticity for cannabis; (c) elasticity of substitution between licensed and unlicensed cannabis products in consumer demand; and the resulting (d) cross-price elasticities between consumer demand for licensed and unlicensed cannabis.

We randomly draw 5,000 sets of parameters for each simulation, with each elasticity parameter following a truncated normal distribution with standardized coefficients of variation equal to 0.15 and the mean value set at the value presented in Table 1. The resulting parameter distributions are described in Table 2. Results from these stochastic simulations are used to confirm the robustness of our findings, and to examine the effect of each parameter distribution on the outcomes from our model.

Table 1. Model Parameters: Definitions, Value Specifications, and Sources

Table 2: Parameter distributions

Simulation Scenarios

On January 1, 2020, the state of California raised its two main cannabis taxes: the cannabis cultivation tax (from $148 to $154 per pound of cannabis flower cultivated) and the cannabis excise tax. The assumed markup used to calculate the excise tax rate also increased from 0.6 to 0.8, resulting in an effective excise tax increase from 24% of wholesale price to 27% of wholesale price (a 12.5% increase in the excise tax rate). We evaluated the impact of this change in earlier work (Sumner et al. 2020) and estimated that as a result of this change the quantity of licensed cannabis would decline by about 2.2%, or about 12,000 pounds, while the quantity of unlicensed cannabis would increase by about 0.6%, or about 13,000 pounds. The total quantity of cannabis would stay approximately the same. Therefore, the new tax policy accomplishes a negligible change in total amount of cannabis consumed in California, but with a shift of 12,000 pounds from the licensed to the unlicensed market segment.

We consider a set of regulatory changes that would increase the share of licensed cannabis relative to unlicensed cannabis, while causing few changes in costs to the state. Consumers will buy more licensed cannabis if it is made cheaper, either by directly reducing the price (eliminating some of the taxes or fees imposed on licensed cannabis), by reducing operating costs for licensed producers, or both. Alternatively, unlicensed cannabis can also be made more costly. Since the unlicensed segment is currently unregulated, it is not possible to impose taxes or fees on unlicensed cannabis. Instead, the price of unlicensed cannabis can be increased by increasing operating costs for unlicensed producers, for example, by increasing monitoring and enforcement of cannabis licensed by the authorities. Finally, demand for licensed or unlicensed cannabis at the current price can also change because of changes in consumer perceptions. We include two shifts in demand in our model: an increase in demand for licensed cannabis because of increased hours of operation; and a decrease in demand for licensed cannabis due to relaxation of testing standards.

We first report results for simulations that show the impact of eliminating one of the taxes specific to cannabis:

1. Complete elimination of the cultivation tax, which as of May 2020 is accessed at $154.40 per pound of dried flower equivalent.
2. Complete elimination of the excise tax, which as of May 2020 is assessed as 27% of the wholesale price.
3. Complete elimination of the local tax, which as of May 2020 averages 10% and is assessed on the wholesale price before the addition of excise tax.

Table 3 includes results from the first three scenarios. We report results that use elastic supply (medium- to long- run) and elasticity of substitution equal to 2. Results for simulations that use other values of elasticity of substitution, as well as inelastic supply (short run) are reported in the appendix.

Table 3. Simulated Impacts of Elimination of Three Separate Taxes

Scenario 1

Under the first scenario, the cultivation tax is eliminated. The cultivation tax is imposed as a specific tax per pound of cannabis sold by the farmers. The cultivation tax is collected at the time of sale by farmers to wholesalers, and is incorporated into the price of cannabis early in the supply chain. The current cultivation tax is assessed at $154.40 per pound of cannabis, which we round to $154 in our simulations. Using an average farm price of $1,100 per pound, the ad valorem equivalent tax rate is about 14% of the price received by farmers.

We find, based on our simulation, that eliminating cultivation tax would lead to a 13% increase in the quantity of licensed cannabis, a 5% decrease in the quantity of unlicensed cannabis, and about a 1% decrease in the quantity of total cannabis. At the same time, state tax revenue would decrease by about $70 million or 7%.

Scenario 2

Under the second scenario, the excise tax is eliminated. The excise tax rate is currently 15% and it is applied to the wholesale price of cannabis, multiplied using a state-mandated markup of 80%. The effective excise tax rate is then 27% of the wholesale price. Eliminating the excise tax would result in about an 11% increase in the quantity of licensed cannabis, about a 4% decrease in the quantity of unlicensed cannabis, and total quantity of cannabis would decrease by 1%. State tax revenue under Scenario 2 would decrease by $397 million, or 31%.

Scenario 3

Under the third scenario, the local tax is eliminated. The local tax is applied to the retail price of licensed cannabis before excise tax, and is set at 10%. Eliminating the local tax would result in in an 8% increase in the quantity of licensed cannabis, a 3% decrease in the quantity of unlicensed cannabis, and a decrease of about 1% in the quantity of total cannabis. State tax revenue would decrease by 22%, or $291 million.

Under each of the three scenarios above, quantities of licensed and unlicensed cannabis, as well as the total quantity of cannabis change by a very similar amount. In each case, the decrease in price of licensed cannabis increases the quantity of licensed cannabis sold to consumers. This increase in quantity is at the expense of unlicensed cannabis, which sees a drop in demand. Total quantity in each case changes by about 1 percent.

Of the three scenarios, cultivation tax accomplishes these changes with the least loss of tax revenue. Tax revenue declines by $70 million under Scenario 1, and by about $300 to $400 million under Scenarios 2 and 3. The reason for this difference is that the cultivation tax is applied much earlier in the supply chain. The cultivation tax becomes a part of the price paid for cannabis by the processing/wholesale operations. The cultivation tax is then subject to both the wholesale and the retail markups, which we assume are applied as a percentage of price. As a result, cultivation tax contributes only $154 per pound of cannabis sold to the tax revenue, but it contributes $616 to producer revenue, split between the wholesale and retail sectors. This effect is due to the assumption that markups are applied as percentages of wholesale price.

The second set of regulatory policies that could increase the demand for licensed cannabis and reduce the demand for unlicensed cannabis include reducing operating costs for licensed cannabis-related businesses, or increasing the demand for licensed cannabis at the current prices, by making it more attractive to consumers. We report results from three additional simulation scenarios:

4. Elimination of testing for pesticide residue, which would cut the testing costs by about 40%.
5. Elimination of testing for pesticide residue with a decrease in demand for licensed cannabis equal to 2.5% due to consumer perception of licensed cannabis as less safe because of the reduced scope of testing.
6. Removal of California's restriction on operating hours for licensed cannabis distributors, resulting in a 7% increase in consumer demand for licensed cannabis.

Table 4 includes results from the the three above scenarios. We report results that use elastic supply (medium- to long-run) and elasticity of substitution equal to 2. Results for simulations that use other values of elasticity of substitution, as well as inelastic supply (short run) are reported in the Appendix.

Table 4. Simulated Impacts of Reduction in Testing Fees and Shifts in Consumer Demand

Scenario 4

In Scenario 4, we reduce testing costs for legal cannabis. Average testing costs were previously calculated to be around $136 per pound. In California, all batches of cannabis flowers and products must be sampled and tested by licensed laboratories before being delivered to retailers, per Medicinal and Adult-Use Cannabis Regulation and Safety Act of 2017 (MAUCRSA). Testing costs would be incorporated into operating costs at the wholesale level in this model, and so the reduction in testing costs would be equivalent to reducing the wholesale-to-retail markup m_L^W by the same amount. In addition, reducing testing costs would also reduce the markup used by the State of California to calculate the amount of excise tax, m_L^T.

Valdes-Donoso, Sumner, and Goldstein (2019) describe the state of California's testing requirements, process, and costs in detail. Cannabis is tested for cannabinoid content, heavy metals, pesticide residue, mycotoxins, solvents, microbial and moisture content. Tests for pesticide residue are especially strict, with zero tolerance limits, which are stricter than limits used for organic produce. We estimate, based on (Valdes-Donoso, Sumner, and Goldstein 2020), that eliminating tests for pesticide residue would reduce testing costs by about 40%, or $54 per pound. As a result, we find that quantity of licensed cannabis would increase by about 3%, quantity of unlicensed cannabis would decrease by about 1%, and the total quantity of cannabis would remain about the same. Total state tax revenue under this scenario would increase by 0.5%, or $5 million.

Scenario 5

Licensed cannabis is attractive to consumers partially because of the higher perceived quality due to some of testing requirements. We expect that eliminating testing requirements would not only reduce the retail price of licensed cannabis but also reduce consumer demand for licensed cannabis. Under Scenario 5, we calculate the decrease in consumer demand that would neutralize the increase in quantity of licensed cannabis caused by the decrease in testing fees. We show that consumer demand for licensed cannabis could decline by about 2 percent ("inward" shift in demand) without a negative effect on the quantity of licensed cannabis consumed. In other words, the decrease in the price of licensed cannabis due to reduced testing fees could offset about a 2 percent decrease in demand due to loss of confidence in quality.

Scenario 6

Under California's current set of cannabis regulations, licensed cannabis retailers (including both storefronts and delivery-only retailers) have restricted hours of operation from 9am to 10pm. This regulation makes licensed cannabis less available to consumers who want to shop outside of those hours.

In 2017, Sumner et al. (2018) estimated that about 13% of the opening hours of medicinal cannabis retailers that existed in the unregulated pre-MAUCRSA market fell outside of legally allowable hours of operation for licensed cannabis retailers under MAUCRSA. Between 10pm and 2am, which are busy hours for cannabis delivery in some areas, unlicensed retailers are the only option available to consumers. Some consumers will adjust to the 10pm curfew and buy in advance from licensed retailers, whereas others will not. We assume that eliminating this restriction on operating hours would increase consumer demand for licensed cannabis in California by 7%, defined as an outward (right) shift in demand.

We find that increasing the operating hours would increase the quantity of licensed cannabis by 7.3%, decrease the quantity of unlicensed cannabis by 3%, and decrease the total quantity of cannabis by about 1%. At the same time, tax revenue would increase by 8.5%, or $86 million.

In a third set of simulations, we look at policy changes that would increase the costs of unlicensed cannabis or limit its availability, thus shifting some of the demand towards licensed cannabis. Such policies could include stricter enforcement of licensing requirements, which would increase the operating costs for unlicensed producers. Another example of a policy change would be an information campaign highlighting undesirability of unlicensed cannabis as a sector that operates illegally and is not subject to any safety regulations. We report results from three additional simulation scenarios:

7. Stricter enforcement of licensing requirements resulting in increased operating costs for unlicensed wholesalers and retailers by 30%. We model this scenario as an increase in wholesale and retail markups.
8. A negative advertising campaign to reduce the social acceptability of unlicensed cannabis and highlight the lack of safety regulations for unlicensed cannabis products. We model this scenario as a decrease in consumer demand for unlicensed cannabis by 10%.
9. A combination of stricter enforcement and negative advertising, which combines the effects of the two above scenarios. We model this scenario as an increase in wholesale and retail markups for unlicensed cannabis by 30% each and a 10% decrease in consumer demand for unlicensed cannabis.

Table 5 includes results from scenarios 7, 8, and 9. We report results that use elastic supply (medium- to long-run) and elasticity of substitution equal to 2. Results for simulations that use other values of elasticity of substitution, as well as inelastic supply (short run), are reported in the appendix.

Table 5. Simulated Impacts of Increased Enforcement and Negative Advertising Targeting Unlicensed Cannabis

Scenario 7

We find that increased operating costs for unlicensed cannabis wholesalers and retailers would increase the price of unlicensed cannabis by about 28%, which would reduce demand for unlicensed cannabis by about 19%. Some demand would shift to licensed cannabis: demand for licensed cannabis would increase by 27%, but the total quantity of cannabis would still decrease by 9%. Because the demand for licensed cannabis will increase, this scenario would result in an increase in tax revenue of $329 million.

Scenario 8

We find that a reduction in demand for unlicensed cannabis, modeled as a shift in the demand curve, would result in a 7% decrease in quantity of unlicensed cannabis, a 1% decrease in the quantity of licensed cannabis, and a 6% decrease in the total amount of cannabis sold. Under this scenario, tax revenue will also decrease by $15 million.

Scenario 9

We find that combining increased enforcement with a negative information campaign targeted at unlicensed cannabis would decrease the demand for unlicensed cannabis by 25%, increase the demand for licensed cannabis by 26%, and decrease the total demand for cannabis by 15%. Tax revenue would increase by $312 million. Of these three scenarios, combining enforcement and a negative information campaign that targets unlicensed cannabis will result in the largest gain in market share for licensed cannabis, and the largest decrease in demand for unlicensed cannabis, as well as an increase in tax revenue. However, this scenario is also likely to be the most costly.

Sensitivity Analysis

In addition to specifying distributions for each key parameter, we repeat scenarios 1 through 6 using a range of mean parameter values. Results are reported in the Appendix in Tables A1-A12.

Next we trace variation in output to variations in individual parameters. This part of the sensitivity analysis is especially important in the context of cannabis because, as acknowledged above, reliable estimates of supply and demand elasticities do not yet exist. We computed the matrixes of partial correlation coefficients that trace the effect of variation in each parameter to variation in each outcome variable. Results are reported in the Appendix in Tables A13-A19.

Discussion

Increasing taxes on licensed cannabis will likely result in a shift away from licensed to unlicensed cannabis, with total quantity of cannabis changing only slightly. Therefore, if the purpose of additional regulations were to increase the market share of licensed cannabis or to reduce the total demand for cannabis, then reducing taxes may be more appropriate. We model several scenarios where taxes or other regulatory burden on consumers and producers of licensed cannabis are reduced. Under each of the six scenarios, the share of licensed cannabis increases, while the share of unlicensed cannabis decreases. We show how similar effects on quantities can be achieved at various costs. Specifically, in the example of California, eliminating the cultivation tax, which is applied early in the supply chain has a much smaller effect on the resulting loss in tax revenue than eliminating excise or local taxes applied at the time of the retail sale. Simply increasing the hours of operation for licensed cannabis retailers, and thus making licensed cannabis more accessible to consumers, has an effect on quantities similar to that of eliminating cultivation, excise, or local taxes, but with a gain in tax revenue rather than a loss. Stricter enforcement of licensing requirements also increases tax revenue and may be effective in shifting market share from unlicensed to licensed cannabis. However, our model does not include enforcement costs, which are likely to be significant.

Table 1. Model Parameters: Definitions, and Values

Parameter Notation	Parameter Description	Baseline Values
	Baseline market equilibrium	
QDL	Quantity of cannabis distributed through licensed retailers	540,000 lbs
QDU	Quantity of cannabis distributed through unlicensed retailers	2.22 mln lbs
PDL^F	Farm price of licensed cannabis	$1,100/lb
PDU^F	Farm price of unlicensed cannabis	$900/lb
SL	Budget share of licensed cannabis	0.31
SU	Budget share of unlicensed cannabis	0.69
T_c	Cultivation tax	$154/lb
m_L^W	Wholesale markup, licensed cannabis	1.0
m_U^W	Wholesale markup, unlicensed cannabis	1.0
m_L^T	Retail markup used to calculate excise tax	0.8
m_L^R	Retail markup, licensed cannabis	1.0
m_U^R	Retail markup, unlicensed cannabis	1.0
t_e	Excise tax	0.15
t_l	Local sales tax	0.10
$t_{ss} + t_{cs}$	State and county sales tax	0.0825
	Demand and supply curves	
η_T	Elasticity of demand for cannabis	–0.2
σ	Elasticity of substitution between licensed and unlicensed cannabis products	2,5,10
η_{LL}	Elasticity of demand for licensed cannabis	–1.45
η_{UU}	Elasticity of demand for unlicensed cannabis	–0.75
η_{LU}	Cross-price elasticity of demand for licensed and unlicensed cannabis	1.25
η_{UL}	Cross-price elasticity of demand for unlicensed and licensed cannabis	0.55
ε_L	Elasticity of supply for licensed cannabis	5(long run),1 (short run)
ε_U	Elasticity of demand for unlicensed cannabis	5(long run),1 (short run)

Table 2: Parameter Distributions

	Min	Max	Mean	CV	SD	Min	Max	Mean	CV	SD
	Med- to long- run					Short run				
Specified distributions										
η_T	–Inf	0	–0.2	0.15	0.03	–Inf	0	–0.2	0.15	0.03
σ_1	0	+Inf	2	0.15	0.3	0	+Inf	2	0.15	0.3
σ_2	0	+Inf	5	0.15	0.3	0	+Inf	5	0.15	0.75
σ_3	0	+Inf	10	0.15	0.3	0	+Inf	10	0.15	1.5
ε_L	0	+Inf	5	0.15	0.75	0	+Inf	1	0.15	0.15
ε_U	0	+Inf	5	0.15	0.75	0	+Inf	1	0.15	0.15
Calculated distributions										
	Med- to long- run					Short run				
					$\boldsymbol{\sigma = \sigma_1}$					
η_{LL}	–Inf	0	-1.44	0.14	0.21	–Inf	0	-1.44	0.14	0.21
η_{UU}	–Inf	0	-0.76	0.13	0.10	–Inf	0	-0.76	0.13	0.10
η_{LU}	–Inf	+Inf	1.24	0.17	0.21	–Inf	+Inf	1.24	0.17	0.21
η_{UL}	–Inf	+Inf	0.56	0.17	0.09	–Inf	+Inf	0.56	0.17	0.09
					$\boldsymbol{\sigma = \sigma_2}$					
η_{LL}	–Inf	0	-3.50	0.15	0.52	–Inf	0	-3.50	0.15	0.52
η_{UU}	–Inf	0	-1.70	0.14	0.24	–Inf	0	-1.70	0.14	0.24
η_{LU}	–Inf	+Inf	3.30	0.16	0.52	–Inf	+Inf	3.30	0.16	0.52
η_{UL}	–Inf	+Inf	1.50	0.16	0.23	–Inf	+Inf	1.50	0.16	0.23
					$\boldsymbol{\sigma = \sigma_3}$					
η_{LL}	–Inf	0	-6.94	0.15	1.03	–Inf	0	-6.94	0.15	1.03
η_{UU}	–Inf	0	-3.26	0.14	0.47	–Inf	0	-3.26	0.14	0.47
η_{LU}	–Inf	+Inf	6.74	0.15	1.03	–Inf	+Inf	6.74	0.15	1.03
η_{UL}	–Inf	+Inf	3.06	0.15	0.47	–Inf	+Inf	3.06	0.15	0.47

Note: Distributions of demand and supply elasticities and elasticity of substitution are truncated normal; own- and cross- price elasticities are calculated using total demand elasticity and elasticity of substitution.

Table 3. Simulated Impacts of Elimination of Three Separate Taxes.

	Simulation Scenarios		
	1	2	3
	Elimination of:		
	Cultivation Tax	Excise Tax	Local Tax
Variables	**Percent change (Confidence interval[a])**		
Tax Revenue	–0.07 (–0.10,–0.04)	–0.31 (–0.33,–0.30)	–0.22 (–0.24,–0.21)
Total quantity of cannabis	–0.01 (–0.02, –0.01)	–0.01 (–0.02,–0.01)	–0.01 (–0.01,–0.01)
Quantity of licensed cannabis	0.13 (0.10,0.15)	0.11 (0.09,0.14)	0.08 (0.07,0.10)
Quantity of unlicensed cannabis	–0.05 (–0.06,–0.04)	–0.04 (–0.05,–0.03)	–0.03 (–0.04,–0.02)
Retail price of licensed cannabis	–0.10 (–0.11,–0.09)	–0.09 (–0.09, –0.08)	–0.07 (–0.07,–0.06)
Retail price of unlicensed cannabis	–0.01 (–0.01,–0.01)	–0.01 (–0.01,–0.01)	–0.01 (–0.01,–0.00)
Price received by licensed suppliers	0.03 (0.02,0.03)	0.02 (0.02,0.03)	0.02 (0.01,0.02)
Price received by unlicensed suppliers	–0.01 (–0.01,–0.01)	–0.01 (–0.01,–0.01)	–0.01 (–0.01,–0.00)
	Welfare Change, $ Millions (Confidence interval[a])		
Consumer Surplus	448 (411,487)	397 (364,431)	291 (251,336)
Producer Surplus	–2 (–10,5)	–2 (–9,5)	–2 (–7,3)
Tax Revenue	–70 (–96,–44)	–316 (–333,–300)	–224 (–239,–210)
Net Welfare	376 (335,417)	79 (46,112)	65 (40,90)

[a] Values reported in parentheses are 95% confidence intervals based on distributions of coefficients that result from stochastic draws from specified parameter distributions.

Table 4. Simulated Impacts of Reduction in Testing Fees and Shifts in Consumer Demand

	Simulation Scenarios		
	4	**5**	**6**
	Decrease in testing costs by 40%	**Decrease in testing costs and decrease in demand for licensed cannabis**	**Allowing for more hours of operation per day**
Variables	**Percent change (Confidence interval[a])**		
Tax Revenue	0.01	–0.03	0.09
	(–0.00,0.01)	(–0.03,–0.03)	(0.07,0.10)
Total quantity of cannabis	–0.003	0.00	–0.01
	(–0.01,–0.00)	(0.00,0.00)	(–0.01,–0.01)
Quantity of licensed cannabis	0.03	0.00	0.07
	(0.03,0.04)	(0.00,0.00)	(0.06,0.09)
Quantity of unlicensed cannabis	–0.01	0.00	–0.03
	(–0.02,–0.01)	(0.00,0.00)	(–0.03,–0.02)
Retail price of licensed cannabis	–0.03	–0.03	0.01
	(–0.03,–0.02)	(–0.03,–0.03)	(0.01,0.02)
Retail price of unlicensed cannabis	–0.002	0.00	–0.01
	(–0.003,–0.002)	(0.00,0.00)	(–0.01,–0.003)
Price received by licensed suppliers	0.01	0.00	0.02
	(0.00,0.01)	(0.00,0.00)	(0.01,0.02)
Price received by unlicensed suppliers	–0.002	0.00	–0.01
	(–0.003,–0.002)	(0.00,0.00)	(–0.01,–0.003)
	Welfare Change, $ Millions (Confidence interval[a])		
Consumer Surplus	110	113	–12
	(101,119)	(113,113)	(–33,9)
Producer Surplus	–1	0	–2
	(–3,1)	(0,0)	(–6,3)
Tax Revenue	5	–32	85
	(–3,12)	(–32,–32)	(68,103)
Net Welfare	114	81	71
	(103,124)	(81,81)	(48,95)

[a] Values reported in parentheses are 95% confidence intervals based on distributions of coefficients that result from stochastic draws from specified parameter distributions.

Table 5. Simulated Impacts of Reduction in Testing Fees and Shifts in Consumer Demand

	Simulation Scenarios		
	7	**8**	**9**
	Increase in operating costs of unlicensed cannabis by 30% from enforcement	**Decrease in demand for unlicensed cannabis of 10% from negative advertising**	**Combined enforcement and negative advertising targeting unlicensed cannabis**
Variables	**Percent change (Confidence interval[a])**		
Tax Revenue	0.32	–0.02	0.31
	(0.24,0.43)	(–0.04,–0.01)	(0.23,0.39)
Total quantity of cannabis	–0.09	–0.06	–0.15
	(–0.11,–0.08)	(–0.07,–0.04)	(–0.18,–0.12)
Quantity of licensed cannabis	0.27	–0.01	0.26
	(0.20,0.34)	(–0.02,–0.01)	(0.19,0.32)
Quantity of unlicensed cannabis	–0.19	–0.07	–0.25
	(–0.21,–0.15)	(–0.08,–0.05)	(–0.30,–0.20)
Retail price of licensed cannabis	0.06	–0.003	0.05
	(0.04,0.07)	(–0.004,–0.002)	(0.04,0.07)
Retail price of unlicensed cannabis	0.28	–0.01	0.27
	(0.27,0.29)	(–0.02,–0.01)	(0.25,0.29)
Price received by licensed suppliers	0.06	–0.003	0.05
	(0.04,0.07)	–0.004,–0.001)	(0.04,0.07)
Price received by unlicensed suppliers	–0.04	–0.01	–0.05
	(–0.05,–0.03)	(–0.02,–0.01)	(–0.07,–0.03)
	Welfare Change, $ Millions (Confidence interval[a])		
Consumer Surplus	-2,293	116	–2,108
	(-2,247,-2,179)	(73,58)	(–2,252,1,965)
Producer Surplus	–31	–28	–55
	(–55,-7)	(–38,–18)	(–85,24)
Tax Revenue	329	–15	312
	(243,415)	(–24,–7)	(234,391)
Net Welfare	-1,995	72	–1,851
	(–2,054,–1,700)	(47,97)	(–2,007,–1,694)

[a] Values reported in parentheses are 95% confidence intervals based on distributions of coefficients that result from stochastic draws from specified parameter distributions.

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Appendix

Tax Rate Formula

$$t_0 = [t_F PSL^F + PDL^R(1 + m_L^T)t_e + PSL^R \times t_l(PSL^R + PDL^R(1 + m_L^T) \times t_e + PSL^R t_l)(t_{ss} + t_{cs})]/PDL^c (29)$$

And

$$t_1 = [t_{F1} PSL_1^F + PDL_1^R(1 + m_{L1}^T)t_{e1} + PSL_1^R \times t_{l1}(PSL_1^R + PDL_1^R(1 + m_{L1}^T) \times t_{e1} + PSL_1^R t_{l1})(t_{ss1} + t_{cs1})]/PL$$

In Equation (30), variables with subscript 1 denote new values of each exogenously determined parameter or endogenously determined price.

Calculation of Own- and Cross-Price Elasticities

A group of goods can be considered weakly separable if the marginal rates of substitution among the commodities in that group are independent of the individual prices and quantities of goods not in the group. Applied to cannabis, substitution between licensed and unlicensed cannabis products is assumed to be independent from prices and quantities of non-cannabis goods. Imposing this assumption allows for the expression of elasticities of demand and supply for licensed and unlicensed cannabis as functions of fundamental demand and supply parameters. In addition to the assumption of weak separability, we also impose the assumption of small variation of price indices within each utility (expenditure) level (Edgerton 1997).

Consumer demand for cannabis may then be represented in two stages. First, consumer expenditure is allocated between cannabis and non-cannabis consumer products depending on the corresponding group price indices. Second, expenditure for cannabis is allocated among the individual commodities within the cannabis product group, namely, licensed and unlicensed cannabis products. For the time being, we ignore the heterogeneity of cannabis products within each group, and assume that licensed and unlicensed cannabis products are represented by relatively homogeneous dried flower products.

Under the assumption that licensed and unlicensed cannabis comprise a weakly separable group, the elasticities of demand for individual commodities with respect to the individual prices can be expressed as:

$$\eta_{LL} = s_L \gamma_L \eta_T - s_U \sigma \quad (32)$$

$$\eta_{UU} = s_U \gamma_U \eta_T - s_L \sigma \quad (33)$$

$$\eta_{LU} = s_U (\gamma_L \eta_T + \sigma) \quad (34)$$

$$\eta_{UL} = s_L (\gamma_H \eta_T + \sigma) \quad (35)$$

In the equations above, subscripts L and U represent licensed and unlicensed cannabis, η_{ij} is own- or cross- price elasticity of demand, s_i is the budget share of cannabis sector i, calculated as $s_i = (\frac{P_i^* Q_i^*}{P_T^* Q_T^*})$, with subscript T representing the general market for cannabis that includes licensed and unlicensed cannabis. Budget shares are calculated using equilibrium prices and quantities, denoted by the superscript $*$. First-stage effects are represented by η, the overall elasticity of demand for cannabis. Second-stage effects include substitution and expansion effects. Substitution effect is determined by σ, the elasticity of substitution between licensed and unlicensed cannabis products. The second-stage expansion effects are determined by γ_i, the elasticity of demand for licensed or unlicensed cannabis with respect to group expenditure. Following Armington specification (Armington 1969), we restrict the elasticities of demand with respect to changes in group expenditure to be equal to one for both categories of cannabis ($\gamma_L = \gamma_H$). Under this assumption of homothetic separability, quantities consumed of the different categories of products change by the same proportion, unless their prices change. The same homothetic separability assumption can be applied to elasticities of supply in models of vertically integrated markets. Armington approach has been used extensively to model trade and agricultural commodities (Alston 1986; 1991; Rickard and Sumner 2008; Alston et al. 1990; Davis and Kruse 1993). Under this specification, we no longer include the second-stage expansion effects in the calculated elasticities:

$$\eta_{LL} = s_L \eta_T - s_U \sigma \tag{36}$$

$$\eta_{UU} = s_U \eta_T - s_L \sigma \tag{37}$$

$$\eta_{LU} = s_U (\eta_T + \sigma) \tag{38}$$

$$\eta_{UL} = s_L(\eta_T + \sigma) \tag{39}$$

In addition, we can apply the assumption of product homogeneity and eliminate the substitution between licensed and unlicensed cannabis ($\sigma = 0$). This assumption is used to evaluate changes in aggregate prices and quantities, treating licensed and unlicensed cannabis as identical products. Since unlicensed cannabis is illegal and so cannot be subject to regulations imposed on legal cannabis (such as taxes and fees), this assumption is of limited use to us. However, we could use it to illustrate errors in estimated effects of policies that would target, for example, shifts in consumer demand.

Sensitivity Analysis

Description of Variables

EQDL change in consumer demand for licensed cannabis

EQDU change in consumer demand for unlicensed cannabis

EPDCL change in retail (consumer) price of licensed cannabis

EPDCU change in retail (consumer) price of unlicensed cannabis

EPSFL change in price farmers receive for licensed cannabis

EPSFU change in price farmers receive for unlicensed cannabis

EQDT change in total quantity of cannabis (licensed and unlicensed)

ETS change in Tax Revenue

Table A1: Scenario 1, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.127	0.100	0.154	0.216	0.175	0.256	0.285	0.233	0.337
EQDU	-0.047	-0.059	-0.035	-0.087	-0.105	-0.069	-0.119	-0.142	-0.095
EPDCL	-0.097	-0.105	-0.089	-0.079	-0.090	-0.068	-0.065	-0.076	-0.054
EPDCU	-0.010	-0.013	-0.006	-0.018	-0.024	-0.012	-0.024	-0.031	-0.017
EPSFL	0.026	0.018	0.034	0.044	0.033	0.055	0.058	0.046	0.069
EPSFU	-0.010	-0.013	-0.006	-0.018	-0.024	-0.012	-0.024	-0.031	-0.017
EQDT	-0.013	-0.018	-0.008	-0.028	-0.035	-0.021	-0.040	-0.048	-0.031
ETS	-0.070	-0.096	-0.044	0.021	-0.015	0.057	0.093	0.050	0.136
					$ million				
DCS	449	411	487	454	388	519	452	365	538
DPS	-2	-10	5	-5	-19	8	-6	-24	11
DTR	-70	-96	-44	21	-15	57	94	51	137
NWC	376	335	417	469	402	537	539	450	628

Table A2: Scenario 1, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.062	0.050	0.073	0.076	0.061	0.091	0.082	0.065	0.100
EQDU	-0.019	-0.023	-0.014	-0.025	-0.031	-0.019	-0.028	-0.035	-0.021
EPDCL	-0.060	-0.071	-0.049	-0.046	-0.056	-0.036	-0.040	-0.049	-0.030
EPDCU	-0.019	-0.025	-0.013	-0.026	-0.033	-0.018	-0.029	-0.036	-0.021
EPSFL	0.063	0.052	0.074	0.077	0.067	0.087	0.083	0.074	0.092
EPSFU	-0.019	-0.025	-0.013	-0.026	-0.033	-0.018	-0.029	-0.036	-0.021
EQDT	-0.003	-0.005	-0.001	-0.005	-0.008	-0.003	-0.007	-0.009	-0.004
ETS	-0.092	-0.103	-0.081	-0.068	-0.079	-0.058	-0.057	-0.069	-0.045
					$ million				
DCS	377	304	449	376	287	465	375	278	472
DPS	0	-15	16	-3	-22	16	-5	-26	16
DTR	-93	-103	-82	-68	-79	-58	-57	-69	-45
NWC	285	229	341	304	234	375	313	235	391

Table A3: Scenario 2, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	0.113	0.089	0.137	0.192	0.156	0.228	0.254	0.207	0.300
EQDU	-0.042	-0.053	-0.031	-0.078	-0.094	-0.062	-0.106	-0.126	-0.085
EPDCL	-0.086	-0.094	-0.079	-0.070	-0.080	-0.061	-0.058	-0.068	-0.048
EPDCU	-0.009	-0.012	-0.005	-0.016	-0.021	-0.011	-0.022	-0.028	-0.015
EPSFL	0.023	0.016	0.030	0.039	0.029	0.049	0.051	0.041	0.061
EPSFU	-0.009	-0.012	-0.005	-0.016	-0.021	-0.011	-0.022	-0.028	-0.015
EQDT	-0.011	-0.016	-0.007	-0.025	-0.031	-0.019	-0.035	-0.043	-0.028
ETS	-0.315	-0.332	-0.299	-0.258	-0.281	-0.235	-0.212	-0.241	-0.184
				$ million					
DCS	398	364	431	401	343	460	400	323	476
DPS	-2	-9	5	-5	-17	7	-6	-22	9
DTR	-316	-333	-300	-259	-282	-236	-213	-242	-185
NWC	79	46	112	138	82	193	180	107	254

Table A4: Scenario 2, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	0.055	0.045	0.065	0.068	0.054	0.081	0.073	0.058	0.089
EQDU	-0.017	-0.021	-0.013	-0.022	-0.028	-0.017	-0.025	-0.031	-0.019
EPDCL	-0.054	-0.063	-0.044	-0.041	-0.050	-0.032	-0.035	-0.044	-0.027
EPDCU	-0.017	-0.022	-0.012	-0.023	-0.029	-0.016	-0.025	-0.032	-0.018
EPSFL	0.056	0.046	0.066	0.068	0.059	0.077	0.074	0.065	0.082
EPSFU	-0.017	-0.022	-0.012	-0.023	-0.029	-0.016	-0.025	-0.032	-0.018
EQDT	-0.003	-0.005	-0.001	-0.005	-0.007	-0.003	-0.006	-0.008	-0.003
ETS	-0.335	-0.341	-0.329	-0.321	-0.328	-0.314	-0.315	-0.322	-0.307
				$ million					
DCS	335	270	399	334	255	414	334	248	420
DPS	0	-13	14	-3	-20	14	-5	-23	14
DTR	-336	-343	-330	-322	-329	-315	-316	-324	-308
NWC	-1	-52	50	9	-55	73	13	-56	83

Table A5: Scenario 3, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.084	0.066	0.101	0.188	0.115	0.169	0.188	0.153	0.222
EQDU	-0.031	-0.039	-0.023	-0.078	-0.069	-0.046	-0.078	-0.094	-0.063
EPDCL	-0.064	-0.069	-0.059	-0.043	-0.059	-0.045	-0.043	-0.050	-0.036
EPDCU	-0.006	-0.009	-0.004	-0.016	-0.016	-0.008	-0.016	-0.021	-0.011
EPSFL	0.017	0.012	0.022	0.038	0.022	0.036	0.038	0.031	0.045
EPSFU	-0.006	-0.009	-0.004	-0.016	-0.016	-0.008	-0.016	-0.021	-0.011
EQDT	-0.009	-0.012	-0.005	-0.026	-0.023	-0.014	-0.026	-0.032	-0.020
ETS	-0.223	-0.238	-0.209	-0.135	-0.194	-0.154	-0.135	-0.159	-0.111
					$ million				
DCS	291	267	316	293	251	336	293	237	349
DPS	-2	-7	3	-6	-13	4	-6	-18	6
DTR	-224	-239	-210	-136	-195	-155	-136	-160	-111
NWC	65	40	90	151	72	156	151	95	207

Table A6: Scenario 3, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.041	0.033	0.048	0.050	0.040	0.060	0.054	0.043	0.066
EQDU	-0.012	-0.015	-0.009	-0.017	-0.021	-0.013	-0.019	-0.023	-0.014
EPDCL	-0.040	-0.047	-0.032	-0.030	-0.037	-0.024	-0.026	-0.033	-0.020
EPDCU	-0.013	-0.016	-0.009	-0.017	-0.022	-0.012	-0.019	-0.024	-0.014
EPSFL	0.041	0.034	0.049	0.051	0.044	0.057	0.055	0.048	0.061
EPSFU	-0.013	-0.016	-0.009	-0.017	-0.022	-0.012	-0.019	-0.024	-0.014
EQDT	-0.002	-0.003	-0.001	-0.004	-0.005	-0.002	-0.004	-0.006	-0.002
ETS	-0.240	-0.246	-0.235	-0.228	-0.234	-0.222	-0.223	-0.229	-0.216
					$ million				
DCS	247	200	295	247	188	306	247	183	310
DPS	0	-10	10	-3	-15	10	-4	-18	10
DTR	-241	-247	-236	-229	-235	-223	-224	-230	-217
NWC	6	-32	44	15	-32	62	19	-32	71

Table A7: Scenario 4, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	0.032	0.025	0.039	0.055	0.044	0.065	0.072	0.059	0.086
EQDU	-0.012	-0.015	-0.009	-0.022	-0.027	-0.018	-0.030	-0.036	-0.024
EPDCL	-0.025	-0.027	-0.023	-0.020	-0.023	-0.017	-0.017	-0.019	-0.014
EPDCU	-0.002	-0.003	-0.002	-0.005	-0.006	-0.003	-0.006	-0.008	-0.004
EPSFL	0.007	0.004	0.009	0.011	0.008	0.014	0.015	0.012	0.017
EPSFU	-0.002	-0.003	-0.002	-0.005	-0.006	-0.003	-0.006	-0.008	-0.004
EQDT	-0.003	-0.005	-0.002	-0.007	-0.009	-0.005	-0.010	-0.012	-0.008
ETS	0.005	-0.003	0.012	0.030	0.020	0.041	0.050	0.038	0.063
				$ million					
DCS	110	101	119	111	94	127	110	89	132
DPS	-1	-3	1	-2	-6	1	-3	-8	2
DTR	5	-3	12	30	20	41	51	38	63
NWC	114	103	124	139	121	156	158	135	181

Table A8: Scenario 4, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	0.016	0.013	0.019	0.019	0.015	0.023	0.021	0.016	0.025
EQDU	-0.005	-0.006	-0.004	-0.006	-0.008	-0.005	-0.007	-0.009	-0.005
EPDCL	-0.015	-0.018	-0.012	-0.012	-0.014	-0.009	-0.010	-0.013	-0.008
EPDCU	-0.005	-0.006	-0.003	-0.006	-0.008	-0.005	-0.007	-0.009	-0.005
EPSFL	0.016	0.013	0.019	0.019	0.017	0.022	0.021	0.019	0.023
EPSFU	-0.005	-0.006	-0.003	-0.006	-0.008	-0.005	-0.007	-0.009	-0.005
EQDT	-0.001	-0.001	0.000	-0.001	-0.002	-0.001	-0.002	-0.002	-0.001
ETS	-0.004	-0.007	-0.001	0.002	-0.001	0.005	0.005	0.002	0.009
				$ million					
DCS	95	76	113	95	72	117	95	70	119
DPS	0	-4	4	-1	-6	4	-2	-7	4
DTR	-4	-7	-1	2	-1	5	5	2	9
NWC	90	76	105	96	78	114	98	78	118

Table A9: Scenario 5, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EQDU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPDCL	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031
EPDCU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPSFL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPSFU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EQDT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ETS	-0.032	-0.032	-0.032	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031
					$ million				
DCS	113	113	113	113	113	113	113	113	113
DPS	0	0	0	0	0	0	0	0	0
DTR	-32	-32	-32	-32	-32	-31	-31	-32	-31
NWC	81	81	82	82	81	82	82	82	82

Table A10: Scenario 5, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EQDU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPDCL	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031	-0.031
EPDCU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPSFL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EPSFU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EQDT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ETS	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032	-0.032
					$ million				
DCS	113	113	113	113	113	113	113	113	113
DPS	0	0	0	0	0	0	0	0	0
DTR	-32	-32	-32	-32	-32	-32	-32	-32	-32
NWC	81	81	81	81	81	81	81	81	81

Table A11: Scenario 6, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.072	0.057	0.088	0.123	0.100	0.146	0.162	0.133	0.192
EQDU	-0.027	-0.034	-0.020	-0.050	-0.060	-0.039	-0.068	-0.081	-0.054
EPDCL	0.015	0.010	0.019	0.025	0.019	0.031	0.033	0.026	0.039
EPDCU	-0.005	-0.008	-0.003	-0.010	-0.013	-0.007	-0.014	-0.018	-0.010
EPSFL	0.015	0.010	0.019	0.025	0.019	0.031	0.033	0.026	0.039
EPSFU	-0.005	-0.008	-0.003	-0.010	-0.013	-0.007	-0.014	-0.018	-0.010
EQDT	-0.007	-0.010	-0.005	-0.016	-0.020	-0.012	-0.023	-0.028	-0.018
ETS	0.085	0.068	0.102	0.145	0.121	0.170	0.193	0.164	0.223
					$ million				
DCS	-12	-33	9	-17	-53	19	-23	-70	24
DPS	-2	-6	3	-4	-12	4	-5	-16	5
DTR	85	68	103	146	122	170	194	164	224
NWC	71	48	95	125	86	163	166	115	217

Table A12: Scenario 6, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
					% change				
EQDL	0.035	0.029	0.042	0.043	0.035	0.052	0.047	0.037	0.057
EQDU	-0.011	-0.013	-0.008	-0.014	-0.018	-0.011	-0.016	-0.020	-0.012
EPDCL	0.036	0.029	0.042	0.044	0.038	0.049	0.047	0.042	0.053
EPDCU	-0.011	-0.014	-0.008	-0.015	-0.019	-0.010	-0.016	-0.021	-0.012
EPSFL	0.036	0.029	0.042	0.044	0.038	0.049	0.047	0.042	0.053
EPSFU	-0.011	-0.014	-0.008	-0.015	-0.019	-0.010	-0.016	-0.021	-0.012
EQDT	-0.002	-0.003	0.000	-0.003	-0.005	-0.002	-0.004	-0.005	-0.002
ETS	0.065	0.058	0.072	0.080	0.073	0.087	0.087	0.079	0.095
					$ million				
DCS	-45	-86	-4	-46	-96	4	-47	-101	7
DPS	0	-9	9	-2	-13	8	-3	-15	8
DTR	65	58	72	80	73	87	87	79	95
NWC	20	-12	52	32	-9	72	37	-8	81

Table A13: Scenario 7, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
	% change								
EQDL	0.271	0.200	0.342	0.504	0.400	0.609	0.686	0.552	0.820
EQDU	-0.185	-0.219	-0.151	-0.291	-0.339	-0.243	-0.373	-0.434	-0.312
EPDCL	0.055	0.036	0.074	0.102	0.076	0.129	0.139	0.110	0.167
EPDCU	0.285	0.272	0.297	0.263	0.246	0.281	0.246	0.225	0.267
EPSFL	0.055	0.036	0.074	0.102	0.076	0.129	0.139	0.110	0.167
EPSFU	-0.038	-0.050	-0.025	-0.059	-0.077	-0.042	-0.076	-0.097	-0.055
EQDT	-0.096	-0.113	-0.079	-0.135	-0.157	-0.114	-0.166	-0.191	-0.141
ETS	0.328	0.242	0.413	0.628	0.506	0.750	0.874	0.726	1.023
	$ million								
DCS	-2,293	-2,407	-2,179	-2,263	-2,445	-2,081	-2,279	-2,514	-2,044
DPS	-31	-55	-7	-25	-63	13	-13	-61	35
DTR	329	243	415	631	508	753	878	729	1,027
NWC	-1,995	-2,126	-1,865	-1,657	-1,855	-1,460	-1,414	-1,670	-1,158

Table A14: Scenario 7, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
	% change								
EQDL	0.109	0.082	0.136	0.146	0.111	0.181	0.163	0.123	0.203
EQDU	-0.103	-0.119	-0.087	-0.120	-0.139	-0.100	-0.127	-0.149	-0.106
EPDCL	0.110	0.084	0.136	0.147	0.120	0.174	0.164	0.137	0.191
EPDCU	0.218	0.193	0.243	0.201	0.175	0.228	0.193	0.166	0.221
EPSFL	0.110	0.084	0.136	0.147	0.120	0.174	0.164	0.137	0.191
EPSFU	-0.105	-0.130	-0.080	-0.121	-0.148	-0.095	-0.129	-0.157	-0.101
EQDT	-0.061	-0.073	-0.050	-0.068	-0.080	-0.055	-0.071	-0.083	-0.058
ETS	0.207	0.167	0.248	0.281	0.235	0.327	0.316	0.264	0.368
	$ million								
DCS	-2,074	-2,323	-1,825	-2,084	-2,372	-1,796	-2,091	-2,397	-1,785
DPS	-129	-186	-72	-134	-200	-69	-136	-205	-67
DTR	208	167	249	282	236	329	317	265	369
NWC	-1,995	-2,167	-1,822	-1,936	-2,136	-1,736	-1,910	-2,123	-1,696

Table A15: Scenario 8, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	-0.013	-0.021	-0.006	0.156	0.124	0.189	0.686	0.552	0.820
EQDU	-0.067	-0.082	-0.052	-0.090	-0.105	-0.075	-0.373	-0.434	-0.312
EPDCL	-0.003	-0.004	-0.001	0.032	0.023	0.040	0.139	0.110	0.167
EPDCU	-0.014	-0.019	-0.009	-0.018	-0.024	-0.013	0.246	0.225	0.267
EPSFL	-0.003	-0.004	-0.001	0.032	0.023	0.040	0.139	0.110	0.167
EPSFU	-0.014	-0.019	-0.009	-0.018	-0.024	-0.013	-0.076	-0.097	-0.055
EQDT	-0.057	-0.070	-0.043	-0.042	-0.049	-0.035	-0.166	-0.191	-0.141
ETS	-0.015	-0.024	-0.007	0.186	0.151	0.221	0.874	0.726	1.023
				$ million					
DCS	116	73	158	16	-39	71	-2,279	-2,514	-2,044
DPS	-28	-38	-18	-15	-27	-3	-13	-61	35
DTR	-15	-24	-7	187	151	222	878	729	1,027
NWC	72	47	97	188	136	240	-1,414	-1,670	-1,158

Table A16: Scenario 8, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
				% change					
EQDL	0.034	0.026	0.042	0.146	0.111	0.181	0.050	0.038	0.063
EQDU	-0.032	-0.037	-0.027	-0.120	-0.139	-0.100	-0.039	-0.046	-0.033
EPDCL	0.034	0.026	0.042	0.147	0.120	0.174	0.051	0.042	0.059
EPDCU	-0.032	-0.040	-0.025	0.201	0.175	0.228	-0.040	-0.049	-0.031
EPSFL	0.034	0.026	0.042	0.147	0.120	0.174	0.051	0.042	0.059
EPSFU	-0.032	-0.040	-0.025	-0.121	-0.148	-0.095	-0.040	-0.049	-0.031
EQDT	-0.019	-0.023	-0.016	-0.068	-0.080	-0.055	-0.022	-0.026	-0.018
ETS	0.062	0.050	0.074	0.281	0.235	0.327	0.093	0.079	0.108
				$ million					
DCS	129	50	208	-2,084	-2,372	-1,796	124	27	222
DPS	-43	-61	-25	-134	-200	-69	-47	-69	-26
DTR	63	51	74	282	236	329	94	79	109
NWC	148	93	203	-1,936	-2,136	-1,736	171	103	239

Table A17: Scenario 9, med- to long- run

	Elastic Supply (med- to long- run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
	% change								
EQDL	0.258	0.193	0.323	0.661	0.524	0.797	0.899	0.723	1.074
EQDU	-0.252	-0.301	-0.203	-0.381	-0.444	-0.318	-0.489	-0.569	-0.409
EPDCL	0.053	0.035	0.070	0.134	0.099	0.169	0.182	0.145	0.219
EPDCU	0.271	0.254	0.288	0.245	0.222	0.268	0.223	0.195	0.250
EPSFL	0.053	0.035	0.070	0.134	0.099	0.169	0.182	0.145	0.219
EPSFU	-0.052	-0.069	-0.034	-0.078	-0.101	-0.055	-0.100	-0.127	-0.072
EQDT	-0.152	-0.181	-0.124	-0.177	-0.205	-0.149	-0.218	-0.251	-0.184
ETS	0.311	0.233	0.389	0.840	0.675	1.005	1.177	0.975	1.378
	$ million								
DCS	-2,108	-2,252	-1,965	-2,232	-2,469	-1,994	-2,303	-2,607	-1,998
DPS	-55	-85	-24	-20	-69	30	6	-56	69
DTR	312	234	391	843	677	1,009	1,181	979	1,383
NWC	-1,851	-2,007	-1,694	-1,408	-1,659	-1,157	-1,115	-1,439	-791

Table A18: Scenario 9, short run

	Inelastic Supply (short run)								
	Sigma=2			Sigma=5			Sigma=10		
	Mean	Low CI	High CI	Mean	Low CI	High CI	Mean	Low CI	High CI
	% change								
EQDL	0.143	0.108	0.178	0.191	0.145	0.237	0.213	0.161	0.266
EQDU	-0.135	-0.156	-0.114	-0.157	-0.182	-0.131	-0.167	-0.195	-0.139
EPDCL	0.144	0.110	0.179	0.193	0.158	0.228	0.215	0.179	0.250
EPDCU	0.186	0.153	0.218	0.164	0.129	0.198	0.153	0.117	0.190
EPSFL	0.144	0.110	0.179	0.193	0.158	0.228	0.215	0.179	0.250
EPSFU	-0.137	-0.170	-0.104	-0.159	-0.194	-0.124	-0.169	-0.205	-0.133
EQDT	-0.081	-0.095	-0.066	-0.089	-0.105	-0.073	-0.092	-0.109	-0.076
ETS	0.276	0.221	0.331	0.376	0.313	0.438	0.423	0.352	0.493
	$ million								
DCS	-1,944	-2,270	-1,619	-1,970	-2,346	-1,594	-1,986	-2,386	-1,586
DPS	-163	-238	-89	-167	-252	-82	-169	-259	-78
DTR	277	222	332	377	314	440	424	354	495
NWC	-1,831	-2,055	-1,607	-1,761	-2,020	-1,501	-1,730	-2,007	-1,453

Correlation Coefficients

Table A13: Scenario 1

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1280	0.0822	0.7806	-0.5636	-0.0763	-0.0527	0.0945	0.0945
DPS	-0.1510	-0.1505	-0.6465	0.6978	0.1435	0.1145	-0.1648	-0.1648
DTR	-0.0845	0.9878	0.0510	0.0812	-0.9906	-0.9826	0.9747	0.9747
NWC	0.0377	0.6726	0.6397	-0.3438	-0.6702	-0.6486	0.6732	0.6732
EDTS	-0.0845	0.9878	0.0510	0.0812	-0.9906	-0.9826	0.9747	0.9747

Table A14: Scenario 2

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1299	0.0755	0.7771	-0.5686	-0.0695	-0.0458	0.0881	0.0881
DPS	-0.1509	-0.1589	-0.6443	0.6982	0.1519	0.1227	-0.1731	-0.1731
DTR	-0.0835	0.9832	0.1085	0.0813	-0.9859	-0.9779	0.9702	0.9702
NWC	0.0604	0.5383	0.7210	-0.3995	-0.5350	-0.5125	0.5417	0.5417
EDTS	-0.0835	0.9832	0.1085	0.0813	-0.9859	-0.9779	0.9702	0.9702

Table A15: Scenario 3

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1338	0.0613	0.7694	-0.5792	-0.0552	-0.0311	0.0743	0.0743
DPS	-0.1507	-0.1763	-0.6397	0.6989	0.1693	0.1398	-0.1905	-0.1905
DTR	-0.0835	0.9832	0.1084	0.0812	-0.9859	-0.9779	0.9702	0.9702
NWC	0.0546	0.5841	0.6946	-0.3860	-0.5810	-0.5586	0.5868	0.5868
EDTS	-0.0835	0.9832	0.1084	0.0812	-0.9859	-0.9779	0.9702	0.9702

Table A16: Scenario 4

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1409	0.0355	0.7548	-0.5977	-0.0291	-0.0044	0.0494	0.0494
DPS	-0.1503	-0.2067	-0.6311	0.6994	0.1996	0.1694	-0.2206	-0.2206
DTR	-0.0835	0.9831	0.1092	0.0812	-0.9858	-0.9777	0.9700	0.9700
NWC	0.0382	0.6842	0.6286	-0.3427	-0.6817	-0.6597	0.6847	0.6847
EDTS	-0.0835	0.9831	0.1092	0.0812	-0.9858	-0.9777	0.9700	0.9700

Table A17: Scenario 5

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1409	0.0497	0.7526	-0.5997	-0.0432	-0.0182	0.0634	0.0634
DPS	-0.1501	-0.2187	-0.6275	0.6995	0.2116	0.1812	-0.2326	-0.2326
DTR	-0.0834	0.9827	0.1122	0.0812	-0.9854	-0.9773	0.9697	0.9697
NWC	0.0382	0.6877	0.6252	-0.3423	-0.6852	-0.6631	0.6881	0.6881
EDTS	-0.0834	0.9827	0.1122	0.0812	-0.9854	-0.9773	0.9697	0.9697

Table A18: Scenario 6

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	-0.0774	0.9392	0.3097	0.0792	-0.9417	-0.9336	0.9270	0.9270
EQDU	-0.1695	-0.9379	-0.2577	-0.1233	0.9292	0.8792	-0.9502	-0.9502
EPDCL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPDCU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EPSFL	-0.0624	0.6226	-0.7583	0.0447	-0.6247	-0.6212	0.6134	0.6134
EPSFU	-0.1190	-0.6524	-0.1670	0.7178	0.6462	0.6113	-0.6611	-0.6611
EQDT	-0.4212	-0.8673	-0.1831	-0.1614	0.8472	0.7562	-0.9050	-0.9050
DCS	0.1449	-0.0306	0.7507	-0.6006	0.0371	0.0610	-0.0160	-0.0160
DPS	-0.1506	-0.1831	-0.6379	0.6991	0.1760	0.1463	-0.1972	-0.1972
DTR	-0.0836	0.9838	0.1030	0.0812	-0.9865	-0.9784	0.9707	0.9707
NWC	0.0396	0.6751	0.6343	-0.3491	-0.6725	-0.6505	0.6758	0.6758
EDTS	-0.0836	0.9838	0.1030	0.0812	-0.9865	-0.9784	0.9707	0.9707

Table A19: Scenario 7

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	0.1695	0.9379	0.2577	0.1233	-0.9292	-0.8792	0.9502	0.9502
EQDU	0.3572	-0.8876	-0.1954	-0.1843	0.9028	0.9433	-0.8477	-0.8477
EPDCL	0.1187	0.6920	-0.6807	0.0853	-0.6859	-0.6501	0.7005	0.7005
EPDCU	0.1927	-0.5051	-0.0959	0.8221	0.5133	0.5345	-0.4835	-0.4835
EPSFL	0.1187	0.6920	-0.6807	0.0853	-0.6859	-0.6501	0.7005	0.7005
EPSFU	0.1927	-0.5051	-0.0959	0.8221	0.5133	0.5345	-0.4835	-0.4835
EQDT	0.7115	-0.6605	-0.1038	-0.1954	0.6921	0.7978	-0.5866	-0.5866
EDTS	0.1741	0.9692	0.0666	0.1266	-0.9603	-0.9088	0.9819	0.9819
DCS	-0.3659	0.1649	0.5956	-0.6570	-0.1813	-0.2396	0.1277	0.1277
DPS	0.2348	-0.0133	-0.4327	0.8365	0.0239	0.0635	0.0101	0.0101
DTR	0.1741	0.9692	0.0666	0.1266	-0.9603	-0.9088	0.9819	0.9819
NWC	-0.1634	0.7794	0.4868	-0.3391	-0.7860	-0.7960	0.7594	0.7594

Table A20: Scenario 8

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	0.0143	-0.8543	-0.1184	0.4925	0.8540	0.8371	-0.8488	-0.8488
EQDU	0.1980	-0.9660	0.0153	-0.1435	0.9739	0.9857	-0.9417	-0.9417
EPDCL	0.0186	-0.7800	0.3903	0.4600	0.7800	0.7655	-0.7744	-0.7744
EPDCU	0.1219	-0.6239	0.0204	0.7619	0.6288	0.6353	-0.6088	-0.6088
EPSFL	0.0186	-0.7800	0.3903	0.4600	0.7800	0.7655	-0.7744	-0.7744
EPSFU	0.1219	-0.6239	0.0204	0.7619	0.6288	0.6353	-0.6088	-0.6088
EQDT	0.1830	-0.9785	0.0011	-0.0778	0.9857	0.9946	-0.9556	-0.9556
DCS	-0.1072	0.6441	-0.0723	-0.7442	-0.6482	-0.6518	0.6303	0.6303
DPS	0.1110	-0.6334	0.0559	0.7539	0.6378	0.6423	-0.6194	-0.6194
DTR	0.0152	-0.8596	-0.0433	0.4970	0.8594	0.8425	-0.8540	-0.8540
NWC	-0.1343	0.5524	-0.1171	-0.8026	-0.5579	-0.5682	0.5364	0.5364
EDTS	0.0152	-0.8596	-0.0433	0.4970	0.8594	0.8425	-0.8540	-0.8540

Table A21: Scenario 9

	Eta_T	Sigma	E_L	E_U	Eta_LL	Eta_UU	Eta_LU	Eta_UL
EQDL	0.1853	0.9185	0.2657	0.1900	-0.9091	-0.8569	0.9325	0.9325
EQDU	0.3106	-0.9204	-0.1312	-0.1732	0.9335	0.9653	-0.8850	-0.8850
EPDCL	0.1286	0.6683	-0.6919	0.1334	-0.6617	-0.6248	0.6779	0.6779
EPDCU	0.1734	-0.5409	-0.0633	0.8084	0.5481	0.5653	-0.5210	-0.5210
EPSFL	0.1286	0.6683	-0.6919	0.1334	-0.6617	-0.6248	0.6779	0.6779
EPSFU	0.1734	-0.5409	-0.0633	0.8084	0.5481	0.5653	-0.5210	-0.5210
EQDT	0.5045	-0.8446	-0.0607	-0.1514	0.8665	0.9330	-0.7903	-0.7903
DCS	-0.3345	0.4143	0.4435	-0.6961	-0.4290	-0.4764	0.3790	0.3790
DPS	0.2052	-0.1706	-0.3173	0.8825	0.1797	0.2107	-0.1494	-0.1494
DTR	0.1908	0.9509	0.0704	0.1961	-0.9412	-0.8874	0.9653	0.9653
NWC	-0.1715	0.8255	0.3812	-0.3696	-0.8324	-0.8428	0.8045	0.8045
EDTS	0.1908	0.9509	0.0704	0.1961	-0.9412	-0.8874	0.9653	0.9653