Received: 16 July 2025 | Accepted: 17 September 2026

DOI: 10.1111/add.70664

RESEARCH REPORT

ADDICTION SSA

Price elasticity of cannabis demand in legal adult-use cannabis markets: Evidence from retail scanner data in the United States

Michael Cooper | Yuyan Shi

The Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego, La Jolla, CA, USA

Correspondence
Yuyan Shi, The Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego, 9500 Gilman Drive, La Jolla CA 92093-0628, United States.
Email: yus001@ucsd.edu

Funding information
This research was supported by grant R01DA049730 (PI: Shi) from the National Institute on Drug Abuse, United States. The California Department of Cannabis Control grant 130963.

Abstract

Background and aims: Cannabis for adult use is legally sold in nearly half of states in the United States, yet little is known about how cannabis demand responds to price changes or whether excise taxes can effectively influence cannabis demand in legal markets. This study aimed to (1) assess trends in market share and prices of cannabis flower products and (2) estimate the price elasticity of demand for cannabis flower products in adult-use markets in the United States.

Design: Secondary data analysis of retail scanner data from point-of-sale systems in a nonrandom sample of cannabis retailers, projected to represent statewide sales from 2020 to 2023. Descriptive statistics assessed trends in product market share and prices. Two-stage least squares models with state and time fixed effects estimated the price elasticity of demand for flower products, using state-level cannabis excise taxes as an instrumental variable for retail prices.

Setting: Ten states with legal adult-use cannabis markets in the United States.

Cases: A total of 864 616 product-state-quarter level observations on cannabis flower sales, including dried flower and pre-roll products.

Measurements: The primary outcome was quantity demanded in grams. The primary explanatory variable was tax-exclusive retail price per gram. The instrumental variable was state-level standardized excise tax per gram.

Results: Cannabis flower products remained the dominant category in adult-use markets, accounting for over 50% of total sales. The median price per gram declined from $8.23 to $6.12 over the 4-year study period. Using the instrumental variable approach, the price elasticity of demand for cannabis flower products was estimated at −2.29 (95% confidence interval = −2.61 to −1.89), indicating that a 1% decrease in price was associated with a 2.29% increase in quantity demanded.

Summary: In legal adult-use cannabis markets in the United States, cannabis flower product prices declined by 26% from 2020 to 2023. Demand was highly price elastic, as a 1% decrease in price was associated with more than a 2% increase in quantity sold in retail markets. Continued price declines may lead to increased cannabis demand, but this effect could be potentially counterbalanced by well-designed excise tax policies.

© 2026 Society for the Study of Addiction.
All rights reserved, including rights for text and data mining and training of artificial intelligence technologies or similar technologies.

KEYWORDS
cannabis, demand, excise tax, instrumental variable, legal market, price elasticity

INTRODUCTION

Price is a key determinant of cannabis demand [1, 2]. This relationship is summarized by 'the price elasticity of demand', defined as the percentage change in quantity demanded in response to a 1% change in prices, and holding other factors constant. Demand is elastic when the absolute value of the elasticity exceeds one, indicating that demand responds more than proportionally to price changes, and inelastic when the response is less than proportional. A central challenge in estimating elasticity with regressions is price endogeneity, which arises when prices are correlated with unobserved demand or supply shocks in the error term, violating the exogeneity assumption required for unbiased causal inference. Instrumental variable (IV) analysis addresses this problem by using a variable that is correlated with prices, uncorrelated with unobserved shocks and affects demand only through its effect on prices.

Estimating the price elasticity of cannabis demand is essential for informing public health strategies in response to market price fluctuations. Adult-use cannabis is legally sold in nearly half of states in the United States (US), and a consistent trend across these states has been a substantial decline in prices [3]. Taking dried flower prices as an example, in California, the average price for an eighth ounce dropped from $39 in 2020 to $23 in 2024 [4]. If this downward trend continues, understanding price elasticity will be critical for projecting changes in cannabis consumption and related public health consequences.

The price elasticity of cannabis demand is also a critical indicator of the effectiveness of taxation policies. Cannabis excise taxes are typically levied as a percentage of retail prices, although some states base taxes on cannabis potency or weight. Most states impose price-based excise taxes, with excise tax rates at the retail stage ranging from 6% (Missouri) to 37% (Washington) [5]. Although excise taxes are remitted by producers or retailers to the government, some tax burden is passed on to consumers through higher prices. In response, consumers generally reduce the quantity demanded and the extent of this reduction depends on the price elasticity of demand. Price elasticity also plays a critical role in determining the overall revenue-generating potential of excise taxes.

Previous studies estimating the price elasticity of cannabis demand are relatively limited [6–42]. We conducted a comprehensive literature review, with study details summarized in Table S1 and point estimates displayed in Figure 1. The elasticity estimates varied widely by study design (observational vs. experimental), data sources (objective vs. self-reported), outcome measures (quantity demanded vs. use participation) and statistical methods for identification (reduced-form regressions with or without IVs vs. structural modeling). Although a detailed comparison of these studies is beyond the scope of this study, several key observations are worth highlighting. First, elasticity estimates from pre-legalization observational studies of quantity demanded were generally larger in magnitude (median: −0.60, range: −0.42 to −1.90) than those of cannabis use participation (median: −0.20, range: −0.62 to 0.23) [Figure 1(a) vs. Figure 1(b)]. Second, observational studies of quantity demanded using post-legalization sales data often reported elastic estimates (i.e. absolute values >1) [Figure 1(a)] [8, 9, 42]. Third, most experimental studies produced parameters of demand equations that were not directly comparable to elasticity estimates from observational research. Among those that were comparable, the estimates tended to be elastic [Figure 1(c)]. Fourth, although some observational studies addressed price endogeneity through IV methods or structural modeling, the majority relied on reduced-form regressions without consideration of endogeneity. Fifth, pre-legalization studies often used self-reported prices or price data from drug enforcement agencies, both of which are subject to bias and limited representativeness. Finally, almost all studies drew from a single state or used non-representative samples with limited generalizability.

In this study, we aimed to (1) assess trends in market share and prices of cannabis flower products and (2) estimate the price elasticity of demand for cannabis flower products in adult-use cannabis markets in the United States. We focused on the flower category because it continues to dominate legal market sales [43]. We used a proprietary dataset of retail scanner data from point-of-sale systems in cannabis retailers across 10 states with legal adult-use markets from 2020 to 2023. We leveraged state-level cannabis excise taxes as an IV for retail prices to address price endogeneity in elasticity estimation [5].

METHODS

This is a secondary data analysis conducted at the product-state-quarter level in 10 states in the United States from the first quarter in 2020 to the fourth quarter in 2023. This study did not involve human subjects and, therefore, did not require institutional review board approval. The study was not pre-registered, and its findings should be interpreted as exploratory. The reporting adheres to relevant Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) standards (Checklist S1).

Primary data sources

We obtained commercially available cannabis point-of-sale retail scanner data from BDSA, a market research firm specializing in US cannabis industry analytics. BDSA contacts all licensed cannabis retailers within each state and recruits those that agree to participate in its sample. Retailers are not offered monetary incentives, but instead receive access to BDSA's data analytics and business insight products. Table S2 reports BDSA's sample coverage as a percentage of all

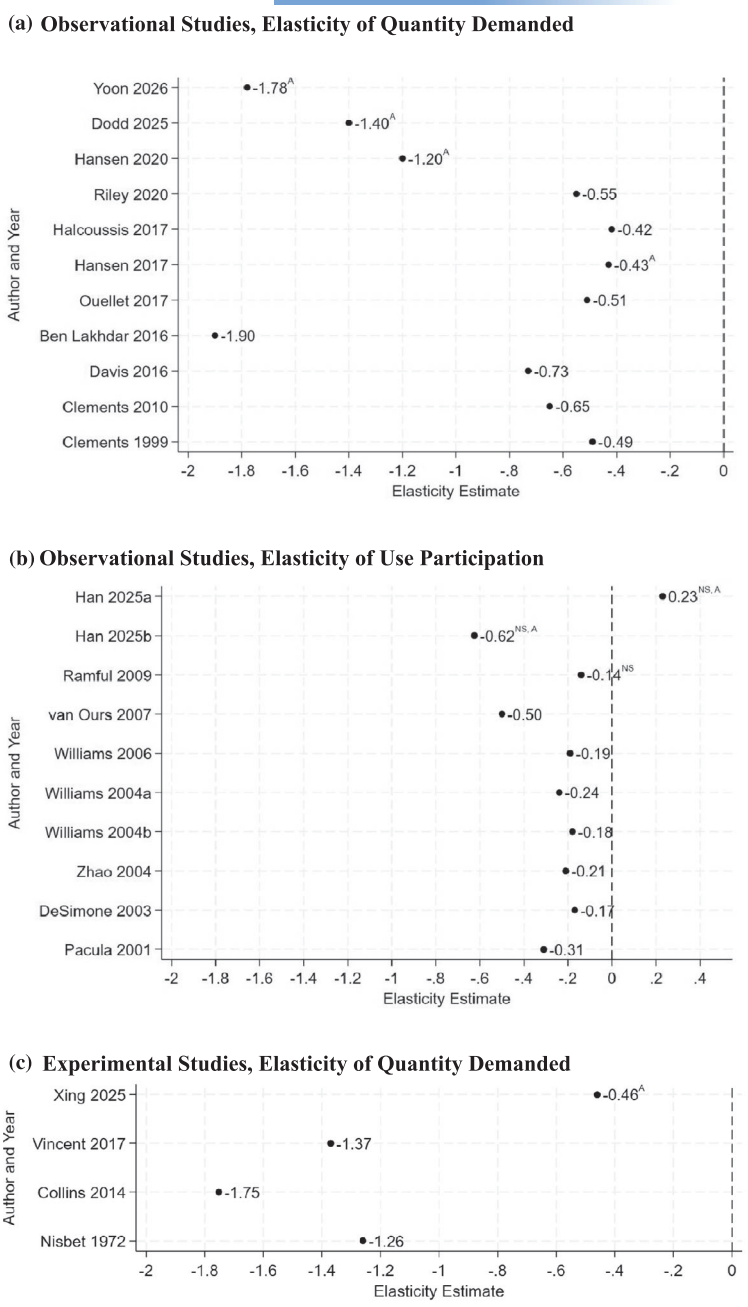


FIGURE 1 Literature review of cannabis price elasticity estimates. (a) Observational studies, elasticity of quantity demanded. (b) Observational studies, elasticity of use participation. (c) Experimental studies, elasticity of quantity demanded. If the authors provided a single estimate from a 'preferred specification,' that estimate is displayed. If the authors provided a range of estimates from several specifications without denoting a preferred estimate, the midpoint of the range is displayed. If the authors provided estimates for short-term and long-term measures, the short-term estimate is displayed. [NS]These studies provided a point estimate that was not statistically significant. (Han 2025a [6]; Han 2025b [7]; Ramful and Zhao [17]). [A]These studies used data after adult-use cannabis legalization in the sample locations. (Yoon *et al.* [42]; Dodd *et al.* [8]; Hansen *et al.* [9]; Hansen *et al.* [12]; Han 2025a [6], Han 2025b [7]; Xing and Shi [26]).

licensed retailers and as a percentage of total state-level sales for each state and year. Because participation is voluntary, the BDSA retailer sample is not probability based. To improve representativeness, BDSA purposely recruits multi-store chains, large single retailers and smaller single retailers across urban, suburban and rural areas. To estimate total market activity, BDSA applies proprietary upscaling algorithms that project state-wide sales from the sample data and align the projected values to exactly match official state government statistics on total sales. BDSA has validated this projection methodology through internal tests using random samples in a state where it has complete retailer coverage. A previous study used the same BDSA data source to derive cannabis excise tax rates [44]. Another study relied on data from other cannabis market research firms that adopted similar sampling and projection methods to estimate state-wide sales [45]. Additional details on BDSA's data methodology are provided in Technical Note S1.

We analyzed BDSA's projected state-wide sales data from 10 states (Arizona, California, Colorado, Illinois, Maryland, Massachusetts, Michigan, Nevada, New Jersey and Oregon) with legal adult-use cannabis markets in 2020 to 2023 (Table S2). We excluded data from medical channels in all states except California, which did not differentiate between adult-use and medical channels in the BDSA dataset. We retained California in the analysis because (1) it represents the largest legal cannabis market in the United States; (2) its medical purchase only accounts for approximately 8% of total sales [46]; and (3) it has applied the same excise tax rates in both adult-use and medical markets, supporting the use of state excise taxes as an IV for prices in both markets.

The BDSA projected dataset is structured at the product-state-quarter level, with each observation capturing the total pre-tax sales (in dollars), total quantity sold (in grams) and various product characteristics for a specific product within a given state and quarter. Products sold in multiple package sizes (e.g. 1 vs. 3.5 g) entered the data as separate observations for each size. The flower product category includes dried flower and pre-rolled joints, which are generally comparable across key product characteristics such as package size and price.

Measures

Primary predictor: Tax-exclusive prices

We constructed product-state-quarter-level cannabis prices using BDSA projected data. The price per gram for each product was standardized by dividing total pre-tax sales (in dollars) by the total quantity sold (in grams). It included any discounts offered by retailers, but excluded excise and sales taxes.

Primary outcome: Quantity demanded

We constructed product-state-quarter-level measures of cannabis demand from BDSA data, quantified as total quantity sold (in grams).

IV for retail prices: State excise taxes

We obtained state–quarter-level cannabis excise tax data from Park *et al.* [5], supplemented with updated information provided by the authors through the end of 2023. Details of tax construction are described in the original study [5] and summarized in Technical Note S2. Briefly, the authors compiled a comprehensive database of state-level cannabis excise tax policies, including price-, potency- and weight-based taxes applied at the cultivation, wholesale and retail stages. The final standardized tax measure aggregated all applicable taxes across tax types and supply chain stages. To address concerns that price-based taxes are endogenous to prices because they are calculated as a percentage of price, we used price-based taxes calculated using the average retail prices across all available years within each state during the study period. As a result, the excise tax variable varied only with changes in state cannabis tax policies and not with quarterly fluctuations in retail prices.

Product- and state-level covariates

We included two product-state-quarter-level covariates: an indicator for whether the product description referenced mood-specific effects, and an indicator for whether the product belonged to the pre-roll subcategory.

We also included several state-level covariates to address potential demand-side confounding factors such as policy environments of related substances and socio-economic conditions: state cigarette taxes (in dollars per pack), state e-cigarette taxes (in dollars per 0.7 fluid mL), the unadjusted unemployment rate (seasonal adjustment was not used because of the inclusion of quarter fixed effects) and demographic composition by race/ethnicity, age and educational attainment. All state-level covariates were measured quarterly, except for demographic composition, which was available only at the annual level. We did not include alcohol taxes because of minimal variation over the study period.

No inflation adjustment

All monetary measures in this study were expressed in nominal dollars without inflation adjustment. This approach was taken because adjusting for national inflation rates would obscure meaningful local variation in cannabis prices and could introduce artificial variation in tax measures, particularly in cases where tax policies remained unchanged over time. We controlled for year and quarter fixed effects to capture any national-level inflation trends.

Statistical analysis

Data trimming

Following standard practice in prior research [47, 48], we trimmed observations identified as price outliers, specifically, those with prices below the first percentile or above the 99th percentile of the price-per-gram distribution. In our data on flower products, the first percentile price was \$0.02/g and the 99th percentile was \$25.95/g. These extreme values were likely because of reporting errors or promotional giveaways and were unlikely to reflect actual market prices. The final analytical sample for elasticity estimation included 864 616 product–state-quarter observations on flower products.

Descriptive trend analysis

We analyzed trends in total sales and market shares across all product categories, as well as trends in prices and excise taxes for flower products. We included the following six categories to compare flower products with other categories: (1) dried flower; (2) pre-rolls; (3) vapes; (4) extracts; (5) edibles; and (6) absorbables [45]. Products outside these categories, such as accessories, were excluded. For analyses of price and tax trends, we focused exclusively on dried flower and pre-rolls, consistent with the product types included in the subsequent price elasticity estimation.

Rationale for excise taxes as IV

Directly regressing quantity demanded on prices would produce biased estimates because prices are endogenous. We addressed price

endogeneity by using state cannabis excise taxes as an IV for retail prices. The validity of this approach depends on instrument relevance and the exclusion restriction [49]. Relevance is satisfied if excise taxes are associated with retail prices, reflecting the pass-through of tax burdens from retailers to consumers. We assessed instrument relevance by examining the association between excise taxes and retail prices and by reporting the first-stage Wald *F* statistic, with larger values indicating a lower risk of weak instruments.

The exclusion restriction requires that excise taxes affect quantity demanded only through prices and are otherwise unrelated to unobserved demand or supply shocks. Cannabis excise taxes are typically set through legislative or regulatory processes, adjusted infrequently and implemented with substantial administrative lead times. When changes occur, they are motivated primarily by revenue, regulatory or public health objectives rather than short-term fluctuations in retail sales, making it unlikely that quarterly tax variation reflects contemporaneous or anticipated demand shocks. We conducted two tests to provide suggestive evidence in support of the exclusion restriction. First, we regressed quantity demanded on leads and lags of excise taxes to test for anticipatory behavior or policy responses to rising demand. Second, we regressed excise taxes on state unemployment rates to assess whether tax changes responded to general economic conditions. Additional details on the IV assumptions are provided in Technical Note S3.

State excise taxes have been widely used as instruments for prices in the tobacco literature [50–53], and prior studies have shown that this measure was a strong predictor of cannabis prices and a valid instrument for estimating cannabis price elasticities [6, 7].

Price elasticity estimation

To estimate the price elasticity of demand for flower products, we implemented four regression models. Model 1 estimated a baseline ordinary least squares (OLS) regression of quantity demanded on prices, including all product- and state-level covariates. Models 2 through 4 used a two-stage least squares (2SLS) IV approach to address price endogeneity, with no product- or state-level covariates in model 2, adding product-level covariates in model 3 and further adding state-level covariates in model 4. In the first stage of the 2SLS models, we regressed prices on excise taxes to isolate the exogenous component of price variation attributable to tax policies. In the second stage, we regressed quantity demanded on the predicted prices from the first stage.

In all models, both the outcome variable (quantity demanded) and the key explanatory variable (pre-tax prices) were log-transformed. This log–log specification allows the coefficient on prices to be directly interpreted as price elasticity (i.e. the percentage change in quantity demanded associated with a 1% change in prices). All models included state fixed effects to control for time-invariant differences across states and year and quarter fixed effects to account for national trends and seasonality.

Standard errors were estimated using two-way clustering at the state and product levels. Confidence intervals (CI) and *P*-values were based on the wild cluster bootstrap to account for the small number of state clusters [54, 55], with conventional asymptotic inference also reported for comparison. We report the Kleibergen-Paap Wald *F* statistic as a test for weak instruments that is robust to heteroskedasticity and clustering [56]. For all second-stage price elasticity estimates, we report Anderson-Rubin bootstrapped *P*-values, which provide inference robust to weak instruments [57].

As a robustness check, we conducted a jack-knife analysis by re-estimating our preferred specification (model 4) while sequentially excluding each of the 10 states from the sample to assess the sensitivity of the elasticity estimates to any single state.

RESULTS

Descriptive analysis

Figure 2(a) displays quarterly total sales of all cannabis products in legal adult-use markets by category. Total sales more than doubled over the study period, increasing from $1.81 billion in the first quarter of 2020 to $4.13 billion in the fourth quarter of 2023. Figure 2(b) shows quarterly market shares by category. Cannabis flower, including dried flower and pre-rolls, consistently dominated the market, maintaining a combined market share slightly above 50% throughout the study period. The market share of vapes increased from 22.8% to 25.9%, while extracts declined from 7.8% to 5.1%. The market share of edibles remained relatively stable.

Figure 3 presents trends in cannabis flower prices. The median pre-tax price per gram declined by approximately 26%, from $8.23 in the first quarter of 2020 to $6.12 in the fourth quarter of 2023 [-Figure 3(a)]. Price distributions were right-skewed [Figure 3(b)], and log transformation helped normalize the distribution [Figure 3(c)].

Figure 4 illustrates trends in cannabis excise taxes (based on the average retail prices across all available years during the study period). The median tax per gram declined from $1.43 in the 1st quarter of 2020 to $1.18 in the 4th quarter of 2023.

Elasticity estimates

Table 1 presents descriptive statistics for the study sample. On average, the quantity demanded was 4693.61 g per product per state-quarter. The mean price per gram was $7.80, with a median of $6.99. The average state excise tax was $1.24 per gram. Approximately two-thirds of the observations were dried flower products.

Table 2 presents price elasticity estimates across four model specifications, with full regression results reported in Table S3. In model 1, the OLS regression that did not account for endogeneity produced a small and statistically non-significant elasticity estimate of −0.18. Models 2 through 4 applied IV approach, with additional covariates sequentially added in each specification. Across all three models, first-stage estimates showed positive associations between excise taxes and retail prices. Second-stage elasticity estimates ranged from −1.67 to −2.29, all statistically significant at the 5% level.

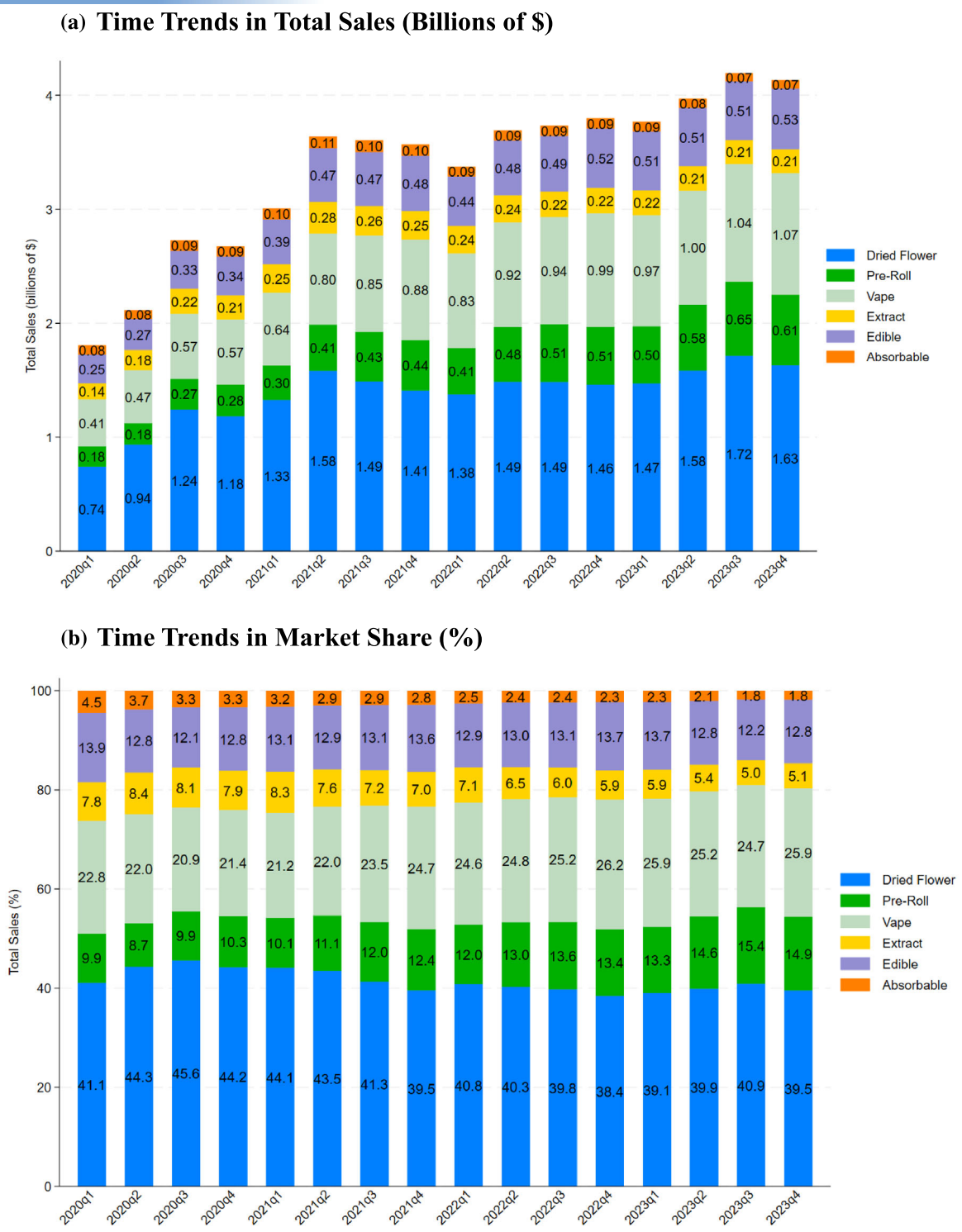


FIGURE 2 Time trends in cannabis sales and market share by product category. (a) Time trends in total sales (billions of $). (b) Time trends in market share (%). BDSA cannabis sales data had six states at the start of the study period and 10 states at the end of the study period from 2020 to 2023. Within each of the six product categories, we dropped outliers with price outside the 1st or 99th percentile.

Our preferred specification, model 4, included the full set of product- and state-level covariates, along with state and time fixed effects. In the first stage, a 1% increase in excise taxes was associated with a 0.87% increase in retail prices (bootstrapped *P*-value = 0.072; asymptotic *P*-value = 0.002). The Kleibergen-Paap Wald *F* statistic was 19.42, exceeding commonly used thresholds for weak instrument concerns [58, 59]. In the second stage, this model yielded a price elasticity estimate of −2.29 (95% CI = −2.61 to −1.89; bootstrapped Anderson-Rubin *P*-value = 0.040), indicating highly elastic demand, with a 2.29% increase in quantity demanded associated with a 1% decrease in price.

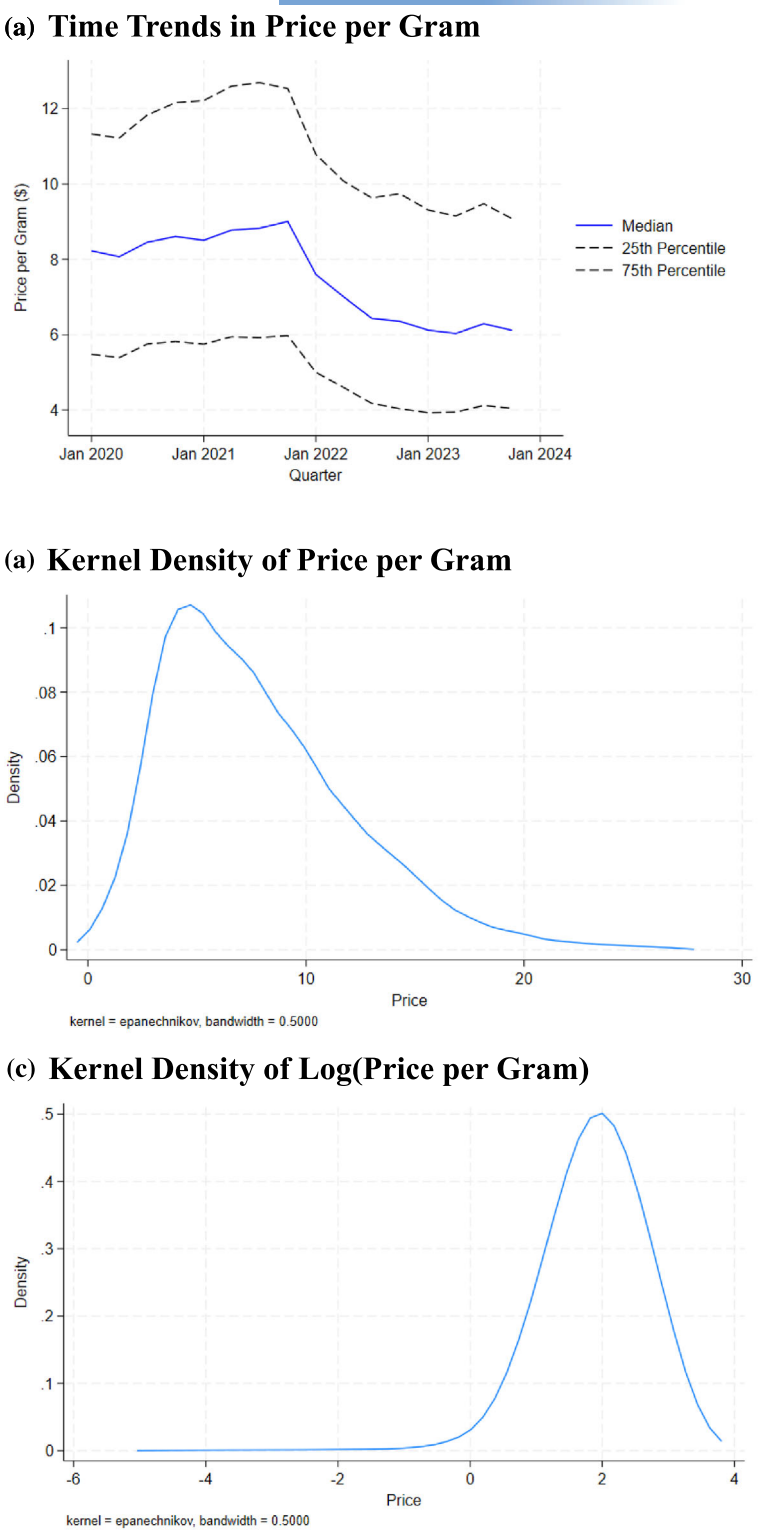


FIGURE 3 Cannabis flower product prices. (a) Time trends in price per gram. (b) Kernel density of price per gram. (c) Kernel density of log (price per gram). BDSA cannabis sales data had six states at the start of the study period and 10 states at the end of the study period from 2020 to 2023. Only dried flower and pre-roll products were included. Price outliers below the 1st or above the 99th percentile of price per gram were dropped.

Table S4 reports jack-knife results from re-estimating IV model 4 while omitting one state at a time. Elasticity estimates generally remained close to −2, although statistical significance was lost in some specifications. This likely reflected the conservative treatment of clustered standard errors with a small number of clusters, as well as limited identifying variation in excise tax rates across states. California accounted for a substantial share of the identifying variation, reflecting both its status as the largest cannabis market and the fact that it experienced greater changes in excise taxes than any other state.

Tables S5 and S6 provide suggestive evidence supporting the IV exclusion restriction for excise taxes. We found no evidence that cannabis demand was associated with quarterly leads of excise taxes. In addition, excise taxes were not associated with state unemployment rate.

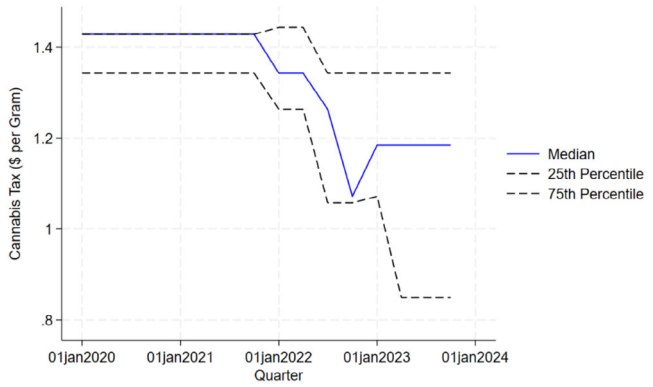


FIGURE 4 Time trends in cannabis excise tax instrument. The cannabis excise tax instrument was calculated using constant retail prices (the average over all available quarters) rather than contemporaneous retail prices to avoid price endogeneity in taxes based on a percentage of retail price. Median, 25th percentile and 75th percentile of cannabis excise tax were calculated based on one observation per state-quarter, independent of the number of products per state-quarter in the BDSA data.

DISCUSSION

This study anticipates contributing to literature in several ways. First, it is among the very few to examine demand in newly legalized markets. Second, our inclusion of 10 states enhanced the generalizability of the findings. Third, we leveraged objective data on prices and demand from a large-scale retail scanner dataset, thereby avoiding biases associated with self-reported data. Fourth, we used an IV approach to address price endogeneity, with standardized state excise taxes as an instrument. Finally, the multi-year scope of the data enabled us to evaluate the longer-term effects of price changes on cannabis demand.

Our preferred specification produced an elasticity estimate of −2.29, indicating highly elastic demand that responded more than proportionally to changes in prices. Compared to prior observational studies with similar outcomes and study designs shown in Figure 1(a), our estimate was notably more elastic than studies conducted before adult-use cannabis legalization [10, 11, 13–16, 25]. However, our findings were closer to observational studies that analyzed legal market sales data in individual jurisdictions, such as the −1.2 estimate based on retail transactions from Washington State, United States (years 2016–2017) and the −1.4 estimate using wholesale transactions from British Columbia, Canada (years 2022–2024) [8, 12]. Our estimate was very close to the most recent study in 15 US states from 2014 to 2023, which estimated the price elasticity of legal cannabis at −1.78 [42]. Unlike our analysis of retail scanner data for cannabis flower, that study relied on state-reported aggregate sales data for all cannabis products. Our results were also closer to results of several experimental studies shown in Figure 1(c), which reported elasticity estimates ranging from −1.26 to −1.75 [34, 40, 41].

Several factors may explain why our estimate was generally more elastic than those reported in previous studies. First, cannabis demand may have been less elastic before legalization, when consumers had fewer substitution options. Legalization may also have expanded the market to include more price-sensitive users. Second, statistical methods for identification differed. Earlier observational studies often did not address price endogeneity, whereas experimental studies relied on hypothetical scenarios. Finally, differences in sample selection and study period may have contributed. Our analysis focused on cannabis flower products, whose demand may be more elastic than overall cannabis demand because consumers can substitute toward vapes, extracts or edibles. We also examined retail rather than wholesale demand. In addition, our study period was later than that of most previous studies, encompassing both early- and later-legalizing states.

Our estimate, along with other recent findings, suggested that cannabis demand in legal adult-use markets may be more price elastic

TABLE 1 Descriptive statistics of outcome and predictor variables.

	Mean	Standard deviation
Cannabis demand, prices and taxes		
Quantity demanded (gram)	4693.61	51 382.16
Pre-tax price ($ per gram)	7.80	4.36
State excise tax ($ per gram)	1.24	0. 29
Cannabis product characteristics		
Mood-specific effects (%)	1.87	
Dried flower (%)	66.56	
Pre-roll (%)	33.44	
State tobacco taxes		
Cigarette tax ($ per pack)	2.60	0.68
E-cigarette tax ($ per 0.7 fluid mL)	1.34	0.88
State characteristics		
Unemployment rate (%)	4.95	2.59
Race/ethnicity (%)		
Non-Hispanic White	58.70	15.96
Hispanic	23.18	11.94
Non-Hispanic Black	6.33	4.38
Other non-Hispanic minorities	11.78	4.83
Age group, y, (%)		
0–17	21.04	0.95
18–29	15.84	0.65
30–64	45.69	0.91
65+	17.42	1.61
Education (%)		
Less than high school	10.52	2.80
High school	24.25	2.51
Some college	30.69	3.01
Bachelor's degree or higher	34.54	4.85
No. of observations	864 616	864 616

Note: Descriptive statistics are reported for the sample that was used for elasticity estimates.

TABLE 2 Estimates of price elasticity of demand for cannabis flower products.

	(1) OLS Coefficient [95% CI] (*P*-value)	(2) IV Coefficient [95% CI] (*P*-value)	(3) IV, add cannabis product covariates Coefficient [95% CI] (*P*-value)	(4) IV, add state covariates Coefficient [95% CI] (*P*-value)
First stage				
Log (excise tax per gram)	N/A	0.57	0.68	0.87
Asymptotic		[0.12–1.01] (P = 0.018)	[0.22–1.15] (P = 0.009)	[0.42–1.32] (P = 0.002)
Wild cluster bootstrap		[−1.52 to 2.81] (P = 0.346)	[−1.47 to 2.91] (P = 0.282)	[−0.30 to 1.51] (P = 0.072)
OLS/second stage				
Log (pre-tax price per gram)	−0.18	−1.67	−1.87	−2.29
Asymptotic	[−0.51 to 0.14] (P = 0.234)	[−2.74 to −0.60] (P = 0.006)	[−2.83 to −0.91] (P = 0.002)	[−2.86 to −1.73] (P < 0.001)
Wild cluster bootstrap	[−0.50 to 0.13] (P = 0.306)	[−53.88 to −0.76] (P = 0.024)	[−6.59 to −0.93] (P = 0.017)	[−2.61 to −1.89] (P = 0.040)
State fixed effects	Y	Y	Y	Y
Year and quarter fixed effects	Y	Y	Y	Y
Product-level covariates	Y	N	Y	Y
State-level covariates	Y	N	N	Y
Kleibergen-Paap rk Wald *F* statistic	N/A	8.37	10.95	19.42
No. of observations	864616	864 616	864 616	864 616

Note: The outcome variable for OLS and the second stage IV estimates was log (total grams demanded). The first stage IV regression used the same control variables as in the second stage. Asymptotic standard errors were estimated with two-way clustering at the state and product levels. Bootstrap standard errors were estimated using the wild cluster bootstrap with two-way error clustering at the state and product levels. For the second stage elasticity estimates, Anderson-Rubin bootstrapped *P*-values are reported. Product-level covariates included an indicator for mood-specific effects and an indicator for pre-rolled products. State-level covariates included cigarette and e-cigarette excise taxes, unemployment rate, race/ethnicity, age and education. Abbreviations: CI, confidence interval; IV, instrumental variable; OLS, ordinary least squares.

than in the pre-legalization era [8, 12, 42]. This has important public health and policy implications. First, cannabis prices have steadily declined following legalization. In our study period alone, flower product prices fell by 26% over 4 years. Our finding of highly elastic demand for legal cannabis implied a substantial increase in quantity demanded, although any point projection would assume constant elasticity across the wide price range observed in the study, when in practice elasticity may vary with price level in a non-linear way. This direction is consistent with national trends, for example, past-month cannabis use among adults rose from approximately 7.6% in 2013 to 15.1% in 2022 [60]. If prices continue to fall, we should anticipate further increases in consumption and prevalence of use. This may lead to heightened public health burdens.

Second, our estimated price elasticity suggested that increasing cannabis excise taxes could be an effective policy for reducing demand in legal markets and mitigating the effects of declining prices. However, over the 4-year study period, median cannabis excise taxes in dollars per gram declined by two-thirds, from $1.54 to $0.57 (when incorporating quarterly price changes, unlike our constant-price excise tax instrument). This decline could be largely attributable to the widespread adoption of price-based tax structures, under which taxes decrease as prices fall. A promising policy alternative is the adoption of potency-based tax structures, which not only discourage consumption of high-potency products, but also help maintain or even increase the share of taxes in cannabis expenditures despite falling prices [26]. Nonetheless, potential unintended consequences of potency-based taxes should be also considered. For example, consumers may shift from legal to illicit markets where products are not subject to taxes, or they may substitute higher-potency products with larger quantities of lower-potency ones to maintain their desired total Δ-9-tetrahydrocannabinol intake [26].

The marginally significant coefficient on cannabis excise taxes in the preferred first-stage specification (model 4, bootstrapped P = 0.072) warrants brief discussion. Because the number of state clusters is small (10 states), we recommended the more conservative wild cluster bootstrap method for statistical inference rather than conventional asymptotic inference, which yielded a highly significant *P*-value (P = 0.002). Concerns about weak instruments are mitigated by several considerations. First, the Kleibergen-Paap Wald *F* statistic is 19, exceeding commonly used rule-of-thumb thresholds for weak instruments [58, 59]. Second, second-stage inference was based on Anderson-Rubin test statistics, which remained valid in the presence of weak instruments and rejected the null hypothesis for our elasticity estimates [57]. Third, the marginal first-stage significance under

conservative bootstrap inference likely reflected limited statistical power rather than a lack of substantive relevance, a common issue in settings with few policy clusters and infrequently changing instruments [61].

This study has several limitations, most of which stem from the nature of data sources. First, the retail scanner data relied on proprietary methods to extrapolate sales from a non-random sample of cannabis retailers to generate state-level estimates. As external data users, we were unable to independently validate these extrapolation methods or assess the degree to which the resulting data fully represent the universe of cannabis sales. However, research on emerging or under-regulated markets has consistently faced challenges in accessing accurate and comprehensive sales data. BDSA quarterly samples have a typical sample coverage ranging from 20% to 50% across states, comparable in quality to other recent studies. For example, recent research on e-cigarette sales has relied on Nielsen retail scanner data, which captured 4.8% of national e-cigarette sales [62]. A study used cannabis sales data from different vendors, which used similar upscaling techniques to project state-level sales [45].

Second, our analysis relied on substantial identifying variation from a small number of effective policy clusters, particularly California. Although our results were robust to weak identification, their generalizability to other tax policy changes should be interpreted with caution. Third, our findings are not generalizable to non-flower products, medical cannabis markets, illicit markets, or jurisdictions outside the 10 sampled states in the United States. Fourth, the analysis included only a limited set of product-level covariates. Important attributes such as potency levels were not available. Last, the aggregate nature of the sales data precluded analysis of individual-level determinants and estimation of price elasticity within specific subpopulations.

CONCLUSION

In our study sample of 10 legal adult-use cannabis markets in the United States, cannabis flower prices declined by 26% from 2020 to 2023. The estimated price elasticity suggested that cannabis demand was highly elastic, with demand responding more than proportionally to price changes. Continued price declines may lead to increased cannabis demand, but this effect could be counterbalanced by carefully designed excise tax policies.

AUTHOR CONTRIBUTIONS

Michael Cooper: Conceptualization; writing—original draft; methodology; validation; visualization; writing—review and editing; formal analysis; data curation. **Yuyan Shi:** Conceptualization; investigation; funding acquisition; methodology; writing—original draft; writing—review and editing; formal analysis; project administration; supervision; resources.

ACKNOWLEDGMENTS

The authors have nothing to report.

DECLARATION OF INTERESTS

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from BDSA. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the author(s) with the permission of BDSA.

ORCID

Michael Cooper https://orcid.org/0000-0002-1126-7582
Yuyan Shi https://orcid.org/0000-0001-9293-0659

REFERENCES

1. Zhu B, Guo H, Cao Y, An R, Shi Y. Perceived importance of factors in Cannabis purchase decisions: a best-worst scaling experiment. Int J Drug Policy. 2021;91:102793. https://doi.org/10.1016/j.drugpo.2020.102793
2. Pacula RL, Lundberg R. Why changes in Price matter when thinking about Marijuana policy: a review of the literature on the elasticity of demand. Public Health Rev. 2013;35(2):1–18. https://doi.org/10.1007/BF03391701
3. Kilmer B, Perez-Davila S. Nine insights from 10 years of legal Cannabis for nonmedical purposes. Clin Ther. 2023;45(6):496–505. https://doi.org/10.1016/j.clinthera.2023.03.005
4. ERA Economics. California cannabis market outlook 2024 report [Internet]. 2024. Available from: https://abp.assembly.ca.gov/system/files/2025-03/5-california-cannabis-market-outlook-full-report.pdf
5. Park H, Yoon DW, Yang Q, He Y, Han B, Shi Y, et al. Recreational cannabis excise taxation in the USA: constructing a comparable tax measure for empirical analysis. Int J Drug Policy. 2024;134:104630. https://doi.org/10.1016/j.drugpo.2024.104630
6. Han B, Park H, He Y, Shang C, Shi Y. Estimating price elasticity of cannabis use among U.S. adolescents: Evidence from states with recreational cannabis commercialization. J Adolesc Health. 2026;78(1):61–8. PMID: under review.
7. Han B, Park H, He Y, Shang C, Shi Y. Estimating the price elasticity of cannabis use among U.S. adults: Evidence from states with recreational cannabis commercialization. Cannabis Cannabinoid Res. 2025;10(3):480–8. https://doi.org/10.1089/can.2024.0164
8. Dodd T, Colistro T, Maillet M. A. Price elasticity of demand for cannabis: Post-legalization estimates of the regulated cannabis market in British Columbia, Canada. Int J Drug Policy. 2025;142:104838. https://doi.org/10.1016/j.drugpo.2025.104838
9. Hansen B, Miller K, Seo B, Weber C. Taxing the potency of sin goods: Evidence from recreational cannabis and liquor markets. Natl Tax J. 2020;73(2):511–44. https://doi.org/10.17310/ntj.2020.2.07
10. Riley S, Vellios N, van Walbeek C. An economic analysis of the demand for cannabis: Some results from South Africa. Drugs Educ Prev Policy. 2020;27(2):123–30. https://doi.org/10.1080/09687637.2019.1581139
11. Halcoussis D, Lowenberg AD, Roof Z. Estimating the price elasticity of demand for cannabis: A geographical and crowdsourced approach. Rev Métodos Cuantit Econ Empresa. 2017;23:119–36.
12. Hansen B, Miller K, Weber C. The taxation of recreational marijuana: evidence from Washington state. Cambridge (MA): National Bureau of Economic Research; 2017.
13. Ouellet M, Macdonald ML, Bouchard M, Morselli C, Frank R. The price of cannabis in Canada. Ottawa (ON): Public Safety Canada; 2017.
14. Ben Lakhdar C, G. Vaillant N, Wolff F. Price elasticity of demand for cannabis: Does potency matter? Addict Res Theory. 2016;24(4):300–12. https://doi.org/10.3109/16066359.2016.1139699

15. Davis AJ, Geisler KR, Nichols MW. The price elasticity of marijuana demand: evidence from crowd-sourced transaction data. Empir Econ. 2016;50(4):1171–92. https://doi.org/10.1007/s00181-015-0992-1
16. Clements KW, Lan Y, Zhao X. The demand for marijuana, tobacco and alcohol: inter-commodity interactions with uncertainty. Empir Econ. 2010;39(1):203–39. https://doi.org/10.1007/s00181-009-0302-x
17. Ramful P, Zhao X. Participation in marijuana, cocaine and heroin consumption in Australia: a multivariate probit approach. Appl Econ. 2009;41(4):481–96. https://doi.org/10.1080/00036840701522853
18. van Ours JC, Williams J. Cannabis prices and dynamics of cannabis use. J Health Econ. 2007;26(3):578–96. https://doi.org/10.1016/j.jhealeco.2006.10.001
19. Williams J, Pacula RL, Chaloupka FJ, Wechsler H. College students' use of cocaine. Subst Use Misuse. 2006;41(4):489–509. https://doi.org/10.1080/10826080500521755
20. Williams J, Liccardo Pacula R, Chaloupka F. J, Wechsler H. Alcohol and marijuana use among college students: Economic complements or substitutes? Health Econ. 2004;13(9):825–43. https://doi.org/10.1002/hec.859
21. Williams J. The effects of price and policy on marijuana use: what can be learned from the Australian experience? Health Econ. 2004;13(2):123–37. https://doi.org/10.1002/hec.796
22. Zhao X, Harris M. N. Demand for marijuana, alcohol and tobacco: Participation, levels of consumption and cross-equation correlations. Econ Rec. 2004;80(251):394–410. https://doi.org/10.1111/j.1475-4932.2004.00197.x
23. DeSimone J, Farrelly MC. Price and enforcement effects on cocaine and marijuana demand. Econ Inq. 2003;41(1):98–115. https://doi.org/10.1093/ei/41.1.98
24. Pacula R. L, Grossman M, Chaloupka F. J, O'Malley P. M, Johnston L. D, Farrelly M. C. Marijuana and youth. In: Risky behavior among youths: An economic analysis University of Chicago Press; 2001. p. 271–326.
25. Clements K. W, Daryal M. The economics of marijuana consumption University of Western Australia, Economic Research Centre; 1999.
26. Xing J, Shi Y. Estimating and comparing the effects of price- and potency-based taxes on cannabis purchase patterns in an experimental cannabis marketplace. Addiction. 2025;120(9):1770–9. https://doi.org/10.1111/add.70086
27. Gonzalez-Roz A, Belisario K, Secades-Villa R, Muniz J, MacKillop J. Behavioral economic analysis of legal and illegal cannabis demand in Spanish young adults with hazardous and non-hazardous cannabis use. Addict Behav. 2024;149:107878. https://doi.org/10.1016/j.addbeh.2023.107878
28. Cooper M, Panchalingam T, Ce S, Shi Y. Behavioral economic relationship between cannabis and cigarettes: evidence from hypothetical purchase tasks. Int J Drug Policy. 2023;112:103951. https://doi.org/10.1016/j.drugpo.2022.103951
29. Panchalingam T, Cooper M, Shang C, Shi Y. Behavioral economic relationship between cannabis flower and concentrates: evidence from simulated purchase tasks. Exp Clin Psychopharmacol. 2023;31(3):694–703. https://doi.org/10.1037/pha0000618
30. Teeters JB, Meshesha LZ, Dennhardt AA, Murphy JG. Elevated demand and proportionate substance-related reinforcement are associated with driving after cannabis use. Can J Addict. 2019;10(3):42–50. https://doi.org/10.1097/CXA.0000000000000062
31. Patel H, Amlung M. Elevated cannabis demand is associated with driving after cannabis use in a crowd-sourced sample of adults. Exp Clin Psychopharmacol. 2019;27(2):109–14. https://doi.org/10.1037/pha0000240
32. Amlung M, MacKillop J. Availability of legalized cannabis reduces demand for illegal cannabis among Canadian cannabis users: evidence from a behavioural economic substitution paradigm. Can J Public Health. 2019;110(2):216–21. https://doi.org/10.17269/s41997-018-0160-4
33. Amlung M, Reed DD, Morris V, Aston ER, Metrik J, MacKillop J. Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. Addiction. 2019;114(1):112–8. https://doi.org/10.1111/add.14437
34. Vincent PC, Collins RL, Liu L, Yu J, De Leo JA, Earleywine M. The effects of perceived quality on behavioral economic demand for marijuana: a web-based experiment. Drug Alcohol Depend. 2017;170:174–80. https://doi.org/10.1016/j.drugalcdep.2016.11.013
35. Hindocha C, Lawn W, Freeman TP, Curran HV. Individual and combined effects of cannabis and tobacco on drug reward processing in non-dependent users. Psychopharmacology (Berl). 2017;234(21):3153–63. https://doi.org/10.1007/s00213-017-4698-2
36. Peters EN, Rosenberry ZR, Schauer GL, O'Grady KE, Johnson PS. Marijuana and tobacco cigarettes: estimating their behavioral economic relationship using purchasing tasks. Exp Clin Psychopharmacol. 2017;25(3):208–15. https://doi.org/10.1037/pha0000122
37. Strickland JC, Lile JA, Stoops WW. Unique prediction of cannabis use severity and behaviors by delay discounting and behavioral economic demand. Behav Processes. 2017;140:33–40. https://doi.org/10.1016/j.beproc.2017.03.017
38. Aston ER, Metrik J, Amlung M, Kahler CW, MacKillop J. Interrelationships between marijuana demand and discounting of delayed rewards: convergence in behavioral economic methods. Drug Alcohol Depend. 2016;169:141–7. https://doi.org/10.1016/j.drugalcdep.2016.10.014
39. Aston ER, Metrik J, MacKillop J. Further validation of a marijuana purchase task. Drug Alcohol Depend. 2015;152:32–8. https://doi.org/10.1016/j.drugalcdep.2015.04.025
40. Collins RL, Vincent PC, Yu J, Liu L, Epstein LH. A behavioral economic approach to assessing demand for marijuana. Exp Clin Psychopharmacol. 2014;22(3):211–21. https://doi.org/10.1037/a0035318
41. Nisbet C. T, Vakil F. Some estimates of price and expenditure elasticities of demand for marijuana among UCLA students. Rev Econ Stat. 1972;54(4):473–5. https://doi.org/10.2307/1924578
42. Yoon DW, Park H, He Y, Han B, Shi Y, Shang C. The impact of taxes on prices and the demand for legally sold recreational Cannabis in the U.S.-An economic evaluation. Int J Drug Policy. 2026;155:105343. https://doi.org/10.1016/j.drugpo.2026.105343
43. Carrel L. Cannabis market has matured to point of declining sales growth [Internet]. Forbes. 2023. Available from: https://www.forbes.com/sites/lcarrel/2023/06/12/cannabis-market-has-matured-to-point-of-declining-sales-growth/?sh=ab7ef4071554
44. Han B, Cooper M, Shang C, Shi Y. Standardizing recreational Cannabis excise tax rates in the United States: new retail Price-based measurements by product category. Int J Environ Res Public Health. 2026;23(1):114. https://doi.org/10.3390/ijerph23010114
45. Pechmann C, Calder D, Timberlake D, Rhee J, Padon A, Silver L. Young adult retail purchases of cannabis, product category preferences and sales trends in California 2018-21: Differences compared with older adults. Addiction. 2018;119(10):1774–83. https://doi.org/10.1111/add.16617
46. California Department of Cannabis Control. Monthly sales summary report [Internet]. 2026. Available from: https://www.cannabis.ca.gov/resources/data-dashboard/daily-sales-customer-type-item-category-report/
47. Smart R, Caulkins JP, Kilmer B, Davenport S, Midgette G. Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state. Addiction. 2017;112(12):2167–77. https://doi.org/10.1111/add.13886
48. Han B, Shi Y. Multilevel determinants of cannabis prices in legal markets: evidence from products sold in nearly 4000 cannabis dispensaries in the United States. Int J Drug Policy. 2025;137:104722. https://doi.org/10.1016/j.drugpo.2025.104722
49. Angrist J. D, Pischke J. Mostly harmless econometrics: An empiricist's companion Princeton university press; 2009.

50. Jawad M, Lee JT, Glantz S, Millett C. Price elasticity of demand of non-cigarette tobacco products: a systematic review and meta-analysis. Tob Control. 2018;27(6):689–95. https://doi.org/10.1136/tobaccocontrol-2017-054056
51. Chaloupka F. Rational addictive behavior and cigarette smoking. J Polit Econ. 1991;99(4):722–42. https://doi.org/10.1086/261776
52. Kohler A, Vinci L, Mattli R. Cross-country and panel data estimates of the price elasticity of demand for cigarettes in Europe. BMJ Open. 2023;13(6):e069970. https://doi.org/10.1136/bmjopen-2022-069970
53. Gruber J, Sen A, Stabile M. Estimating price elasticities when there is smuggling: the sensitivity of smoking to price in Canada. J Health Econ. 2003;22(5):821–42. https://doi.org/10.1016/S0167-6296(03)00058-4
54. Cameron AC, Gelbach JB, Miller DL. Bootstrap-based improvements for inference with clustered errors. Rev Econ Stat. 2008;90(3):414–27. https://doi.org/10.1162/rest.90.3.414
55. Roodman D, Nielsen MØ, MacKinnon JG, Webb MD. Fast and wild: bootstrap inference in Stata using boottest. Stata J. 2019;19(1):4–60. https://doi.org/10.1177/1536867X19830877
56. Kleibergen F, Paap R. Generalized reduced rank tests using the singular value decomposition. J Econom. 2006;133(1):97–126. https://doi.org/10.1016/j.jeconom.2005.02.011
57. Mikusheva A. Robust confidence sets in the presence of weak instruments. J Econom. 2010;157(2):236–47. https://doi.org/10.1016/j.jeconom.2009.12.003
58. Staiger D, Stock JH. Instrumental variables regression with weak instruments. Econometrica. 1997;65(3):557–86. https://doi.org/10.2307/2171753
59. Stock J, Yogo M. Testing for weak instruments in linear IV regression. In: Identification and Inference for Econometric Models New York: Cambridge University Press; 2005. p. 80–108 https://doi.org/10.1017/CBO9780511614491.006
60. Mattingly DT, Richardson MK, Hart JL. Prevalence of and trends in current cannabis use among US youth and adults, 2013–2022. Drug Alcohol Depend Rep. 2024;12:100253. https://doi.org/10.1016/j.dadr.2024.100253
61. Cameron A. C, Miller D. L. A practitioner's guide to cluster-robust inference. J Hum Resour. 2015;50(2):317–72. https://doi.org/10.3368/jhr.50.2.317
62. Cotti C, Courtemanche C, Maclean JC, Nesson E, Pesko MF, Tefft NW. The effects of e-cigarette taxes on e-cigarette prices and tobacco product sales: evidence from retail panel data. J Health Econ. 2022;86:102676. https://doi.org/10.1016/j.jhealeco.2022.102676

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Cooper M, Shi Y. Price elasticity of cannabis demand in legal adult-use cannabis markets: Evidence from retail scanner data in the United States. Addiction. 2026. https://doi.org/10.1111/add.70664