# Substitution and Complementarity in the Consumption of Alcohol, Cannabis, and Opium

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**Abstract**

Understanding the behavior of populations of drug consumers has been and remains a topic of keen interest. Using a unique dataset on twenty-five districts from Bengal, India, from 1911 to 1925, we analyze whether populations of consumers treat alcohol, cannabis, and opium as economic substitutes or complements in a legal regime. Additionally, we examine responsiveness to prices and income. Alcohol acts as a substitute for cannabis bud and a complement for cannabis leaf and opium. Cannabis leaf is a complement for alcohol but a substitute for cannabis bud. Finally, we find that alcohol, opium, and cannabis leaf consumption are associated with changes in their prices, while changes in wages influence alcohol, cannabis bud, and opium use. Understanding the link between consumption patterns and economic factors can guide harm reduction strategies.

**Keywords**: Substitution; complementarity; alcohol; cannabis; opium; prices; income; elasticity.

**JEL Codes**: D12, I12, I18, N35

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# 1 Introduction

Polydrug use, involving simultaneous or sequential consumption of multiple substances, is widespread particularly in the US where cannabis and alcohol use are frequently combined, leading to heightened risk of adverse outcomes (Briere et al. 2011; Terry-McElrath et al. 2013; Subbaraman and Kerr 2015). According to the CDC, "Intentional polysubstance use occurs when a person takes a drug to increase or decrease the effects of a different drug or wants to experience the effects of the combination" (Centers for Disease Control and Prevention 2022). Recent literature highlights the concerning effects of combining cannabis and alcohol, showing additive impairment effects, pharmacological interactions, and increased risks of substance use disorders and mental health issues, especially among adolescents (Yurasek et al. 2017). Studies in various other countries also underscore the prevalence of polydrug use, including with drugs like heroin (Darke and Hall 1995; Font-Mayolas and Calvo 2022). Despite this, research on simultaneous drug use (including alcohol and cannabis) remains scarce, particularly concerning heroin or other opium due to its illegal status. Thus, understanding the behavior of populations engaged in consumption of multiple drugs is of great value to drug policy researchers and health economists alike.

The central aim of this study, therefore, is to analyze the simultaneous consumption of alcohol, cannabis bud, cannabis leaf, and opium with a view to determining the degree to which these different substances are treated as substitutes or complements for one another. Other aims of this paper include investigating whether, in a regime in which all three substances are legal, (i) alcohol, cannabis, and opium display habit forming characteristics consistent with addiction, and (ii) whether changes in their consumption are associated with changes in their own prices and wages.

In the early 20th century, a variety of psychoactive substances, including alcohol, cannabis, cocaine, and opium, remained legal throughout much of the world. In colonial

Asia, sales of alcohol, cannabis, and opium formed important sources of tax revenue much as alcohol and tobacco sales contribute to government budgets today. Debates about the legal status and degree of regulation of these drugs were as common then as they are today.[1] It is unsurprising, therefore, that researchers then (as now) felt it important to understand how populations of drug consumers would respond to changes in a variety of economic variables, including the prices of these substances and incomes.

We answer these questions by utilizing a unique archival dataset of retail sales and prices for alcohol, cannabis, and opium from the Bengal Presidency, one of the largest administrative subdivisions of British India. We use data on 25 districts within Bengal from 1911 to 1925. We model the consumption of each of these substances as a function of past consumption, their own prices, prices of other substances, and real wages. We use the Generalized Methods of Moments (GMM) to estimate the price and income elasticities associated with the consumption of these substances. The regulated nature of drug markets in British India meant that the prices of alcohol, cannabis, and opium were set by the government, thereby avoiding possible endogeneity issues associated with the prices of these substances.

Consistent with the literature, we find evidence of habit formation for all these substances. Results suggest negative own-price elasticity for alcohol, opium, and cannabis leaf. Further, alcohol, opium, and cannabis bud show limited wage responsiveness. Cross price elasticity estimates reveal interesting patterns in the relationships among these substances. We find that alcohol is a substitute for cannabis bud and a complement for cannabis leaf and opium. While cannabis leaf is a complement for alcohol and a substitute for cannabis bud, neither cannabis bud nor opium consumption are asso-

1. Two of the most comprehensive research projects on drugs were conducted in the late 19th century precisely to create this kind of understanding. In response to debates about the legal status of cannabis and opium in India, the House of Commons in London created the Indian Hemp Drugs Commission and the Royal Commission on Opium to examine the extent of regulation, manufacture, and sale of "ganja and allied drugs" (Indian Hemp Drugs Commission 1894, v.1, p.1), and opium throughout Asia. We explore questions that were of interest to the Indian Hemp Drugs Commission and the Royal Commission of Opium as well as to the drug research community today.

ciated with prices of any other substances. Finally, we corroborate these findings with anecdotal evidence on the consumption patterns of these drugs from various historical documents including administration reports of the Bengal Excise Department and the Indian Hemp Drug Commission Report.

To produce unbiased estimates of elasticites, our GMM technique uses first differencing, which eliminates district-specific correlated unobservables. We also estimate a 2SLS model with district fixed effects as a robustness check. While most elasticity estimates from the 2SLS models are similar in magnitude and direction to the baseline estimates, they are less precise and potentially biased due to the use of weak instruments. Thus, we prefer GMM as it is better suited to estimate dynamic panel data models.

We also estimate a rational addiction model, similar in spirit to Becker et al. (1994) and Chaloupka (1991) by including the lead of consumption in the econometric specification, and find estimates similar to our baseline results. We conduct sensitivity analyses to examine whether our results are sensitive to different GMM specifications. We also check the sensitivity of own-price and wage elasticities by excluding cross-price effects from the GMM specifications.

Finally, we perform a series of additional robustness checks to rule out endogeneity of drug prices due to licensing and smuggling effects. We again find estimates similar to the baseline results across the various sensitivity and robustness analyses. More recent research, using individual-level data, has estimated addiction parameters explicitly and also built learning into models of consumption behavior via biomarker information (Darden 2017) or experimentation (Matsumoto 2016). Because our data are aggregated, such analyses are beyond the scope of this paper.

This paper contributes to the literature in health economics on the responses of consumers of psychoactive substances to changes in key economic variables, including prices and incomes or wages (Becker et al. 1994; Chandra and Chandra 2015; Gallet 2014; Pacula and Lundberg 2013; Van Ours 2007; Van Ours and Williams 2007). Patterns of consumption, including substitution and complementarity among populations that are simultaneously consuming alcohol, cannabis and opium have never been studied. While studies on alcohol and tobacco are numerous and easy to conduct because of their legal status (Bader et al. 2011; Chaloupka 1991, 1999; Chaloupka et al. 2002), there are far fewer studies that focus on cannabis, which has only recently been legalized or decriminalized in limited regions of the world.

Studies on opiates, which remain illegal throughout most of the world, are scarcer, and have had to rely on data from the early 20th century, when opium was legal and its sale was carefully recorded for accounting purposes. The absence of reliable price and consumption data on cannabis and opiates presents a high hurdle for research on the properties of these drugs (Caulkins 2007; Chandra and Barkell 2013). The only study that used population level data on the simultaneous consumption of opiates and cannabis drew on data from the Punjab province of India for the years 1907 to 1918 (Chandra and Chandra 2015). Therefore, this paper fills an important gap in the literature by utilizing a unique dataset to study patterns of simultaneous consumption of alcohol, cannabis, and opium in a regulated market.

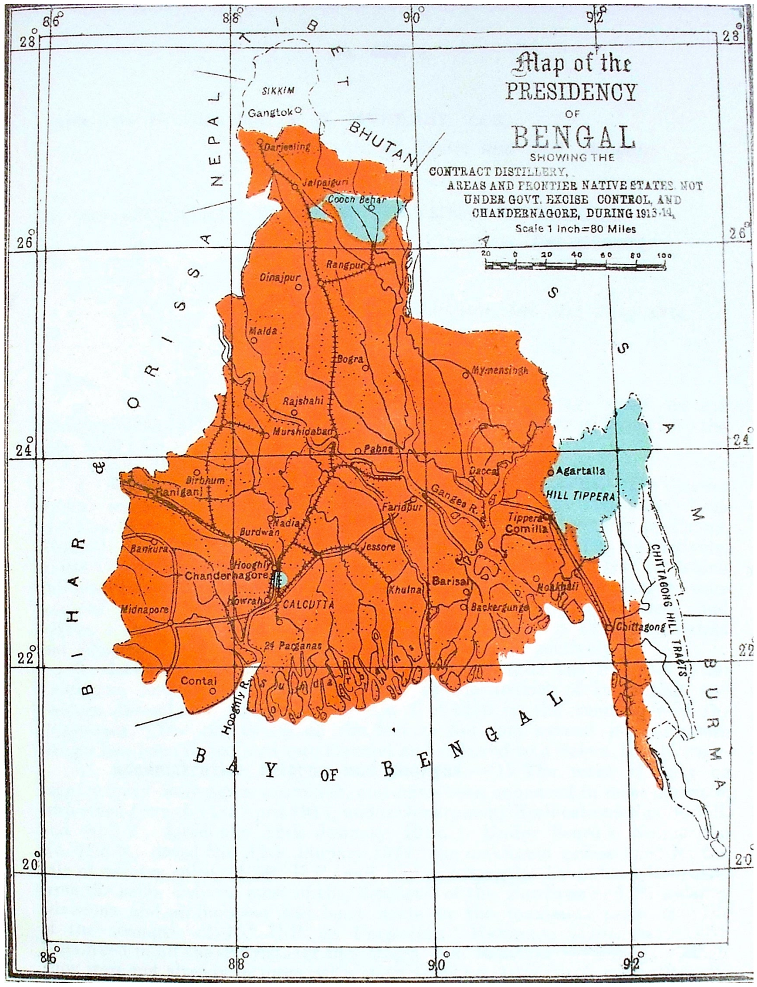
This paper also contributes to our understanding of how the consumption of these psychoactive substances interacts with economic incentives and can inform harm reduction strategies. Debates past and present about the legal status of alcohol, cannabis, and opiates are usually informed by whether consumers will consume more or less of the substance depending on its legal status and the degree to which its consumption may be habit forming (Becker et al. 1994). Further, the responsiveness of populations of users to changes in economic conditions, including prices and income, and the health effects are of great policy relevance (Fleming et al. 2021; Simmons et al. 2020). In addition, substituting one psychoactive product for another with the aim of reducing adverse outcomes is a common treatment or public health strategy (Barnett 1999; Reiman 2009). Empirical studies have shown that the additive effects of two psychoactive substances can be detrimental for public safety (Bramness et al. 2010; Sewell et al. 2009; Simmons et al. 2020), and hastily adopted policies targeting the use of one substance might inadvertently affect consumption of another (Subbaraman 2016).

The rest of this article is structured as follows. Section 2 provides a brief historical context followed by description of the data and variables in Section 3. Section 4 outlines the empirical model for the analysis. Section 5 reports the results and robustness checks followed by a discussion on policy implications and conclusion in Section 6.

## 2 Historical context

In the early 1900s in British India, the production and sale of alcohol, cannabis, and opium was legal and heavily regulated by the government. Bengal was one of the largest administrative subdivisions of India in terms of area. Figure 1 shows the map of the Bengal Presidency with the districts marked by dotted lines. According to the *Census of 1921*, Bengal was also the most populous province in India with a population of 47 million, 93.3% of whom lived in rural areas (Marten 1924). Supported by excise laws, the government exercised sweeping authority over the production and sale of alcohol, cannabis, and opium (Bengal, Excise Department 1909). Across the districts of Bengal, the District Collectors and Excise Commissioners, as the senior-most representatives of the government, implemented the provisions of the excise laws. For a fee, farmers, manufacturers, and retailers were licensed to grow, manufacture, or sell alcohol, cannabis, or opium. Prices and rates of taxation were set by the government. According to the Administration Report of Bengal of 1923-24, excise revenues, 82% of which were derived from the sales of alcohol, cannabis, and opium constituted 21% of the government's overall revenue (Bengal 1924, p. 122; Bengal, Excise Department, various years, p. 6-14).

Figure 1: Map of the Bengal Presidency




Notes: Our sample includes the 25 districts shaded with orange that were under government excise control during our sample period. Blue shaded areas are the Frontier Native States, not under the Government Excise control. Chittagong Hill Tracts and Sikkim were under partial Government Excise Control and are not included in our sample. Source: Excise Report of the Bengal Presidency 1913/14.

## 2.1 Nature of regulation of the excise market

At the local level, the excise market was governed by the provincial excise act (Government of Eastern Bengal and Assam, Legislative Department 1910). The issuance of licenses, and the setting of strength, license fees, rates of duty, and retail prices through administrative orders were the primary mechanisms through which the local Government exercised control over the market for country spirits (Bengal, Excise Department, various years, 1915/16 to 1918/19), which were sold at various strengths in different districts.[2] For example, the local Government in Calcutta issued an Administrative Order with effect from April 1, 1917 setting the strength and prices at which retail vendors could sell Country Spirits in Calcutta (Bengal, Excise Department, various years, 1916/17). Similar forms of regulation were exercised for cannabis and opium.[3] As an example, the Government raised the retail price of cannabis leaf, cannabis bud and opium for the districts of Hooghly, Howrah, 24 Parganas and Calcutta with effect from April 1918 ((Bengal, Excise Department, various years), 1917/18). Unsurprisingly, there was substantial variation in these prices and the fees and duties that comprised them over time and across districts. For example, in 1919-1920, the mean 'vend fee' per proof gallon of country liquor ranged from Rs. 0.67 (in Birbhum district) to Rs. 4.62 (in Tippera district), and per seer of opium, it varied from Rs. 14.96 (in Rangpur) to Rs. 78.77 (in Bakerganj — see Bengal Excise Department, 1921, Appendix A, x, xv).

In addition to this kind of spatial variation, duties and fees also varied over time. For example, in 1919-20, the average sum of the duty and the vend fee for opium and country spirit in Burdwan district were Rs. 76.29 per seer and Rs. 8.29 per proof gallon (Bengal Excise Department, 1921, Appendix A, x, xv). By 1921-22, the corresponding figures were Rs. 77.02 per seer and Rs. 11.35 per proof gallon (Bengal Excise Department, 1922, Appendix A, xv). A further source of variation in the price data is the normalization by the price level to generate the real price variable used in the analysis. We show the mean and standard deviation of prices and per-capita consumption of the four substances by districts respectively in Tables C1 and C2 in Appendix C, 'Supplementary Tables.' These tables show substantial variation in the average prices and consumption both across districts and over time within each district.

2. We convert all quantities of country spirit to their London Proof equivalent, measured in Imperial Gallons.

3. For example, a clause in the provincial excise act reads: "A duty, at such rate or rates as the Local Government may direct, may be imposed, either generally or for any specified local area, on any exciseable article — (a) imported; or (b) exported; or (c) transported; or (d) manufactured, cultivated or collected under any license granted under section 15; or (e) manufactured in any brewery or distillery licensed or established under section 16:..."(see Government of Eastern Bengal and Assam, Legislative Department 1910, Chapter V, article 21, p.11).

# 3 Data

This study uses aggregate retail sales and price data for country spirits, cannabis leaf (*bhang*), cannabis bud (*ganja*), and opium reported in the Excise Reports of Bengal Presidency (Bengal, Excise Department, various years, 1911/12 to 1925/26) over a period of 15 years for 25 districts of Bengal Presidency (n = 375).

In line with the government's classification of cannabis products, we treat cannabis leaf (*bhang*) and cannabis bud (*ganja*) as different products because (a) they differed in potency, with the leaf being the less potent of the two, and (b) they were perceived as being different by consumers. Cannabis leaf, which was usually ingested, was consumed during religious festivals ((Indian Hemp Drugs Commission 1894), pp. 160-61), recreationally, and as an energizing or cooling drink. Cannabis bud, on the other hand, was often smoked ((Indian Hemp Drugs Commission 1894), p. 154). Because of its closer association with religious ritual, the consumption of cannabis leaf was also more socially acceptable than cannabis bud. Differences between the two cannabis products are discussed in more detail in Appendix A.

While a number of prior studies have used aggregate sales or consumption data to estimate price elasticities and other features of markets for addictive substances (Gruber et al. 2003; Nargis et al. 2020), those estimates can be interpreted to reflect individual behavior only under strict assumptions (Norstrom 1989; Rehm and Gmel 2001). While these assumptions may or may not hold for the current dataset, a safer interpretation of the results of this paper pertains to population-level behavior — a negative market-level price elasticity demonstrates that consumers in aggregate reduce their consumption, with analogous interpretations for cross price elasticities.[4]

The 25 districts in our sample spanned the present nation of Bangladesh and the state of West Bengal in India. We also use data on daily wages for agricultural workers,

4. We elaborate on this point in Section 6.3 below.

who formed the vast majority of the population across Bengal, from two sources, (i) the *Annual Report of Prices and Wages in India* for 1911 and 1916 (the wages for Bengal were updated in five-year intervals) and (ii) the *Report on the Fourth Wage Census of Bengal* for 1925, yielding wage data for three years, 1911, 1916 and 1925. We linearly interpolate these data to produce annual time series of the daily wage for the period 1911-1925 for each district.

In order to compute per capita consumption of the four drugs, we divide aggregate retail sales for each district by the population in that district (Becker et al. 1994; Chaloupka 1991; Chandra et al. 2012).[5] We use annual district-level data on the price of rice, the staple food crop of Bengal from the Season and Crop Reports of Bengal (Bengal, Department of Agriculture, various years, 1911/12 to 1925/26) to adjust the wage and price data for inflation. Table 1 shows the summary statistics and the units of measure for the variables used in the empirical analysis.

Table 1: Summary statistics of key variables used in the empirical analysis

| Variable | Units | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Price of Alcohol | (pies per liter) | 2.38 | 1.04 | 0.35 | 8.14 |
| Price of Opium | (pies per gram) | 138.43 | 60.10 | 40.63 | 465.26 |
| Price of Cannabis bud | (pies per gram) | 89.07 | 39.66 | 35.12 | 313.16 |
| Price of Cannabis leaf | (pies per gram) | 17.34 | 10.74 | 3.76 | 71.58 |
| Wage | (pies per day) | 0.69 | 0.28 | 0.28 | 2.38 |
| Per Capita Consumption of Alcohol | (liters per capita) | 0.05 | 0.05 | 0.00 | 0.26 |
| Per Capita Consumption of Cannabis bud | (grams per capita) | 1.48 | 0.78 | 0.24 | 5.44 |
| Per Capita Consumption of Cannabis leaf | (grams per capita) | 0.29 | 0.40 | 0.00 | 1.71 |
| Per Capita Consumption of Opium | (grams per capita) | 0.75 | 0.66 | 0.02 | 2.83 |

Notes: The price variables and wage are adjusted for the price of rice (the key staple grain of Bengal), which was used as an indicator of the cost of living (i.e., inflation). N = 375.

5. We calculate per capita measures of consumption by dividing total consumption in each district by the population of that district, derived from Chandra et al. (2012). Because we use officially recorded data on the sales of psychoactive substances, our data are not affected by the threats to validity observed in self-reported data on the consumption of such substances (Brener et al. 2003).

We adjust the price of country spirits for strength by computing a quantity-weighted average of price. Reflecting the widespread use of rice, comprising 85% of all agricultural produce in Bengal (Bengal, Department of Agriculture, various years, 1911/12 to 1925/26), as a staple food, we adjust the retail prices of country spirit, cannabis leaf, cannabis bud, and alcohol for inflation using the price of rice as a deflator. Finally, in keeping with standard practice for such models, and for the ease of interpretation, we transform all of the original variables into their natural logarithms. Figure 2 shows the average consumption of the four drugs against their prices. In general, when the price rises, consumption falls and vice versa.[6]

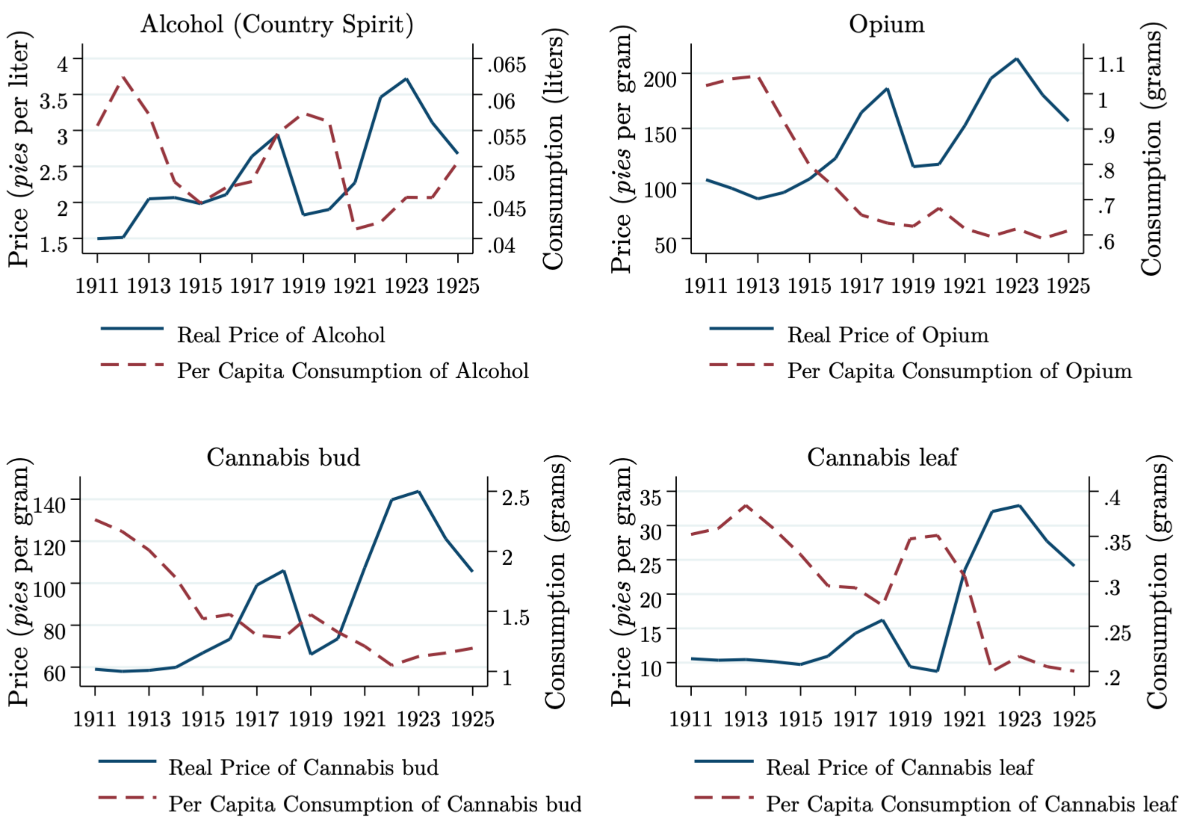
## 4 Empirical Model

For each of the four substances, we model the logarithm of current consumption as a function of the logarithms of past consumption, the real price of the substance, the real prices of the three other substances, and real wages. Econometric models of the consumption of psychoactive substances capture the phenomenon of habit formation by including past consumption as an explanatory variable (Becker and Murphy 1988; Becker et al. 1994; Stigler and Becker 1977; Suranovic et al. 1999). A positive parameter estimate between 0 and 1 in value provides evidence of habit formation. In the logarithmic specification, the parameter estimates for all of the other variables (own price, price of other substances, and wages) can be interpreted as an elasticity or the percentage change in consumption associated with a percentage change in the variable under consideration.

A common issue that arises in the estimation of price elasticities of consumption is that of identification. In an unregulated market, since quantities consumed are a function of the price, determined by the interaction of demand and supply, observed variations in consumption in response to changes in the price cannot be attributed solely to

6. We also provide time series plots of nominal prices and per-capita consumption of the four substances for each district in Appendix B. Figure B2 shows evidence of cross-district variation in nominal prices and consumption over time in our sample.

Figure 2: Real Price and Per Capita Consumption of Alcohol, Opium, Cannabis Bud, and Cannabis Leaf




consumer behavior — competing producers also respond to changes in price by adjusting their output. Fortunately, the heavily regulated nature of markets for excise goods in India eliminates this identification problem. Rather than a collection of competing profit-maximizing producers making production decisions, government entities at different levels artificially set the duties and fees for these goods, and these duties and fees comprised a large component of the final retail price. This was for a mix of stated and often conflicting reasons, from raising revenue to curbing negative public health consequences from widespread consumption and dampening opposition to the practice from prohibitionist forces, including segments of the missionary community in India (Mills 2005).

Therefore, a simplifying but reasonable assumption underlying our empirical analysis is that the prices of the four substances are exogenous and we treat them as predetermined variables in the econometric model. The general econometric model for each drug is specified as follows:

$$\log(c_{it}^{d}) = \alpha + \beta \log(c_{it-1}^{d}) + \gamma \log(p_{it}^{d}) + \Lambda \mathbf{P}_{it}^{-d} + \delta \log(\omega_{it}) + \epsilon_{it} \tag{1}$$

where $\log(c_{it}^{d})$ is the logarithm of per capita consumption of the drug $d$ in district $i$ in year $t$, $\log(c_{it-1}^{d})$ is the one-period lag of the logarithm of per capita consumption, $\log(p_{it}^{d})$ is the logarithm of the real price of drug $d$, $\mathbf{P}_{it}^{-d}$ is the vector of logarithms of prices of other drugs, $\log(\omega_{it})$ is the logarithm of real wages and $\epsilon_{it}$ is a random error term. We estimate the above model for each of the four drugs i.e., $d \in \{$alcohol, opium, cannabis bud, cannabis leaf$\}$.

The above model is classified as a Dynamic Panel Data Model because it utilizes the lag of the dependent variable (consumption) as an explanatory variable. The inclusion of lagged consumption introduces the problem of endogeneity because lagged consumption is correlated with the error term, leading to biased estimates (Wooldridge 2010). There exist a variety of statistical techniques to address endogeneity in such models, including the Generalized Methods of Moments (GMM; see Arellano and Bover (1995) and Blundell and Bond (1998)).

GMM estimators can be generated using Difference GMM or System GMM models, both of which employ instrumental variables. Difference GMM estimates parameters using first differences of the original variables in the model. First differencing eliminates time-invariant unobserved heterogeneity within the groups (in this case, districts). The endogenous first-differenced variables are instrumented with their lagged levels as they are uncorrelated with the differenced error terms. By contrast, System GMM estimates a levels equation in conjunction with the first difference equation. The levels equation is instrumented using first differences of the independent variables (Arellano and Bover 1995; Blundell and Bond 1998).[7]

Using these panel data methods avoids issues of autocorrelation that can arise when aggregate data on habit-forming substances are being used, thereby addressing an important critique of such models (Auld and Grootendorst 2004; Dragone and Raggi 2018, 2021). Given that our dataset is of limited duration $T$ (15 years) relative to groups $N$ (25 districts), the System GMM approach is robust to autocorrelation issues prevalent in models with long $T$ (Arellano and Bover 1995; Dragone and Raggi 2018). We confirm this with the AR(2) test for auto-correlation across all our specifications. We avoid further endogeneity issues because we are not estimating a rational addiction model (i.e. we do not include $c_{t+1}$).

A final choice is between the One-Step and Two-Step GMM model computation procedures. These procedures differ in the specification of the weighting matrix and moment conditions for the GMM estimator. Though estimates from both procedures are consistent, Two-Step estimators are both asymptotically efficient and robust to heteroscedasticity and cross-correlation (Roodman 2006, 2009). Based on these considerations, we select Two-Step System GMM estimates for the models of alcohol, cannabis bud, and cannabis leaf consumption. Because the Two-Step System GMM model for opium consumption shows evidence of overidentification, we select Two-Step Difference GMM estimates for the Opium model.

# 5 Results

Table 2 reports estimates from the Two-Step System GMM models for alcohol, cannabis leaf, and cannabis bud and the Two-Step Difference GMM model for opium. The coef-

7. We use a combination of the Sargan/Hansen test for overidentifying restrictions and the Arellano-Bond test for second order autocorrelation, AR(2) to determine the number of lags of the dependent variable to be included as instruments in the equations for the GMM models (Hansen 1982). These tests indicate a choice of up to two periods for the first equation and a single lag for the second equation.

ficient of the log of lagged consumption for all four substances is positive, statistically significant at the 5 percent level and less than 1, consistent with habit formation or addictive behavior (Becker and Murphy 1988). This relationship implies that long-term changes in consumption in response to a one-time change in the current price are larger than the short-term (i.e., current) change in consumption associated with the change in the price.

Changes in the consumption of alcohol, opium, and cannabis leaf are associated with changes in their own prices (i.e., negative coefficients), but this association is limited or inelastic (i.e., the coefficient in question is less than 1 in magnitude). For cannabis bud, this coefficient is not statistically significant. The coefficient of the logarithm of wages is positive and less than 1 in value for alcohol, opium and cannabis bud, indicating wage inelasticity. For cannabis leaf, this coefficient is statistically insignificant. Taken together, these three properties for the four drugs are consistent with habit forming substances for which price and income incentives alter behavior, albeit in a limited manner.

Interestingly, the cross price elasticity estimates reveal evidence of a variety of interrelationships in the consumption of the four substances. For example, a 10 percent increase in the price of cannabis bud is associated with a 10.5 percent increase in the consumption of alcohol (a substitution effect). On the other hand, increases in the prices of opium and cannabis leaf are associated with drops in alcohol consumption, with elasticities of -0.53 and -0.30 respectively (both complementarity effects). In addition, a 10 percent increase in the price of cannabis bud is associated with an 8 percent increase in the consumption of cannabis leaf (a substitution effect), while a 10 percent increase in the price of alcohol is associated with a 4 percent drop in cannabis leaf consumption (a complementarity effect).

Note that for some substances we only observe a 'one-way' substitution or complementarity effect. For example, the substitution effect between cannabis bud and alcohol is only observed with consumption of alcohol as the dependent variable in Column (1).

Table 2: Estimates from the Dynamic Panel Data Models

| | *Dependent variable:* Log of Consumption | | | |
|---|---|---|---|---|
| | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) | (4) |
| Lagged Log of Consumption | 0.235** | 0.383*** | 0.485** | 0.567*** |
| | (0.105) | (0.104) | (0.184) | (0.105) |
| Log of Price of Alcohol | -0.909*** | 0.0984 | -0.400** | 0.0453 |
| | (0.270) | (0.072) | (0.175) | (0.069) |
| Log of Price of Cannabis bud | 1.049*** | -0.261 | 0.883* | 0.073 |
| | (0.285) | (0.232) | (0.433) | (0.166) |
| Log of Price of Cannabis leaf | -0.303* | -0.098 | -0.626** | -0.052 |
| | (0.157) | (0.103) | (0.241) | (0.037) |
| Log of Price of Opium | -0.527** | -0.217 | 0.044 | -0.535*** |
| | (0.248) | (0.162) | (0.139) | (0.103) |
| Log of Wage | 0.690* | 0.447** | 0.003 | 0.432*** |
| | (0.364) | (0.205) | (0.232) | (0.088) |
| Constant | -2.681*** | -1.707** | -6.144** | — |
| | (0.846) | (0.612) | (2.443) | |
| Arellano-Bond test for AR(2) | 0.73 | 0.82 | 0.64 | 1.14 |
| $(Pr > z)$ | 0.46 | 0.41 | 0.52 | 0.25 |
| Hansen Test for Overidentification ($\chi^2$) | 2.50 | 0.11 | 2.10 | 0.00 |
| $(Pr > z)$ | 0.29 | 0.74 | 0.35 | — |
| Observations | 306 | 312 | 309 | 287 |
| Number of Groups | 25 | 25 | 25 | 25 |
| Number of Instruments | 9 | 8 | 9 | 6 |

Notes: This table shows results for Dynamic Panel Data models in Equation 1 for Alcohol, Cannabis bud, Cannabis leaf, and Opium. Two-Step System GMM for Alcohol, Cannabis bud, and Cannabis leaf; and Two-Step Difference GMM for Opium. Difference GMM results for Opium are preferred since System GMM is overidentified. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Observations differ across the specification due to different optimal number of lag variables. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

However, the coefficient estimate for log of alcohol price is statistically insignificant in the specification in Column (2). In a similar vein, the complementarity between opium and alcohol is only present in Column (1) but absent in Column (4). Similarly, the weak substitution effect between cannabis leaf and cannabis bud is observed in Column (3) but not in Column (2).

To investigate this issue, we estimate the GMM specifications by excluding the variable of interest. We then plot the residuals obtained from these regressions against the excluded variable to check for any remaining variation in the residuals that could be explained by the excluded variable. We perform this exercise for the specifications of (i) cannabis bud consumption without alcohol price, (ii) cannabis bud consumption without cannabis leaf price, and (iii) opium consumption without alcohol price. For all the three cases, we do not find any patterns between the residuals and the excluded variable (Figure B3 in Appendix B). In other words, these residual-variable plots suggest that there is not enough evidence for a relationship between the consumption and prices of the specific substances.

## 5.1 Robustness and Sensitivity analysis

We estimate One-Step System GMM models for alcohol, cannabis leaf, and cannabis bud, and a Difference GMM model for opium (Table D3 in Appendix D) as robustness checks. Because the Difference GMM model for opium is exactly identified, (i.e. the number of instruments is equal to the number of regressors), the One- and Two-Step GMM procedures yield identical estimates. Results in Table D3 show that using One-Step GMM does not change our conclusions.

To check the sensitivity of our results to model specification, we estimate a classic 2SLS specification with the lagged consumption instrumented using lagged prices (Becker et al. 1994; Chaloupka 1991). For the 2SLS models, we use district level fixed effects to control for correlated unobservables. Table D4 in Appendix D shows that while the 2SLS estimates are similar in direction to our baseline GMM estimates, they differ somewhat in magnitudes for some substances. However, the low first stage F-statistic values for alcohol and cannabis leaf show evidence of a weak instruments problem.

Thus, we prefer the GMM specifications as they are more stable and better suited for estimation in a dynamic panel data setting (Lee 2007).

We also estimate models without cross-price effects to study the sensitivity of the own-price elasticity estimates. We estimate the following specifications for each of the four substances:

$$\log(c_{it}^{d}) = \alpha + \beta \log(c_{it-1}^{d}) + \gamma \log(p_{it}^{d}) + \delta \log(\omega_{it}) + \epsilon_{it} \tag{2}$$

here, $\log(c_{it}^{d})$ is the logarithm of per capita consumption of drug $d$ in district $i$ in year $t$, $\log(c_{it-1}^{d})$ is the one-period lag of the logarithm of per capita consumption of that drug, $\log(p_{it}^{d})$ is the logarithm of the real price, $\log(\omega_{it})$ is the logarithm of real wages and $\epsilon_{i,t}$ is a random error term. Coefficient estimates of lagged consumption, own price elasticity, and income elasticity in Table D5 are quantitatively similar to the baseline estimates in Table 2.

We next check whether our results are driven by specific districts and time periods, especially between 1918 to 1922. Bengal went through a period of high inflation during this period, mainly due to post war depression, occasional crop failures, and cyclones.[8] We conduct a leave-one-out analysis for this period to verify whether our results are sensitive to the exclusion of specific years and districts.[9] Figures D4 to D7, in Appendix D, show the range of coefficient estimates obtained by estimating Equation 1 for each substance by excluding one district and a year at a time. The elasticity estimates obtained from these regressions lie within the 95 percent confidence intervals of the baseline estimates in Table 2. Further, the average of these leave-one-out estimates is close to the

8. For example, the it Excise Report from 1919-20 mentions that "The fall in consumption [of Cannabis Bud] in Midnapore was mainly due to an increase in the retail price as compared with the previous year, and that in Dacca and Tippera to the general economic depression and also to the distressed condition of the people on account of the cyclone of September last." The pattern of real prices in Figure 2 also shows evidence of these phenomenon, reflected in prices.

9. We thank an anonymous referee for this suggestion.

baseline coefficient estimates, confirming that our estimates are robust and not driven by specific years and districts in our sample.

Another concern is that drug prices could be endogenous to the number of shop licenses issued by the government. We use the data from Bengal, Excise Department (various years) to control for the number of licensed opium and cannabis shops in the baseline specifications. Since we do not observe these data for alcohol, we are not able to estimate this specification for alcohol. Results in Table D6 are similar to the baseline estimates for cannabis leaf and opium, alleviating this concern.

Finally, we estimate rational addiction models pioneered by Becker and Murphy (1988) and Chaloupka (1991) and compare them with our baseline results in Table 2. To that end, we estimate versions of Equation 1 with the lead of the logarithm of per capita consumption ($\log(c_{it+1})$) included for each substance. The results of rational addiction models in Table D7 are consistent with findings of habit formation and negative own-price elasticity from Chaloupka (1991) and Becker et al. (1994). Most coefficient estimates in Table D7 are similar in direction and magnitude to the estimates in Table 2, but are less precisely estimated.

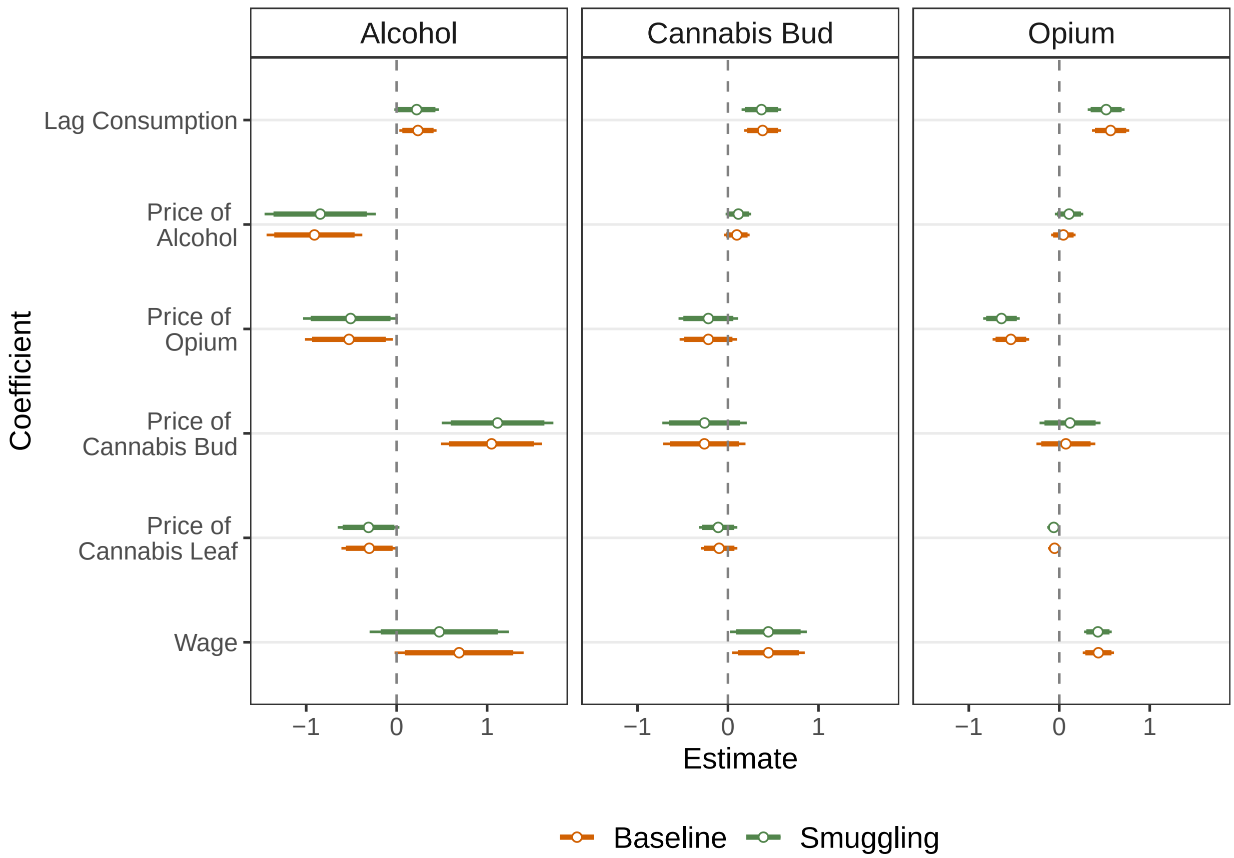
## 5.2 Endogeneity due to smuggling

A common source of endogeneity in such an analysis is illegal smuggling, which could be correlated with drug prices and the outcome variable, consumption, leading to omitted variable bias (Gruber et al. 2003). In our context, smuggling is mainly an issue for alcohol, cannabis bud, and opium, owing to the higher prices of these substances. Cannabis leaf, which was more bulky, much cheaper, easier to obtain, and consumed as part of local tradition, was not subject to the same incentives for smuggling.

We follow Gruber et al. (2003) to address the issue of omitted variable bias due to smuggling by excluding districts with high prevalence of smuggling and explicitly controlling for smuggling activity based on seizures. We use evidence of smuggling from the

Bengal, Excise Department (various years) to create a list of districts where smuggling was more prevalent for each substance. We then estimate our baseline specification in Equation 1 by excluding these districts (we refer to this as the *smuggling model*). Figure 3 shows the elasticity estimates for Alcohol, Cannabis bud, and Opium for the baseline model from Table 2 and the smuggling model. The coefficient estimates from the smuggling model are very similar to the baseline estimates, suggesting that in this setting, endogeneity due to smuggling is not a major cause of concern.

Figure 3: Elasticity estimates from the baseline model and the smuggling model excluding districts with evidence of smuggling




Notes: This figure compares the coefficient estimates from the baseline model to the smuggling model, which estimates the baseline specification in Equation 1 using a sample excluding districts with evidence of smuggling (Gruber et al. 2003) from the Bengal Excise Reports (various years). For Alcohol, the excluded districts are Jalpaiguri and Hooghly; for Cannabis Bud, the excluded district is Rajshahi; for Opium, the excluded district is Chittagong. All of the specifications (baseline and smuggling) exclude Calcutta owing to higher prevalence of smuggling across all of the substances. 90 and 95 percent confidence intervals are shown along with the point estimates.

Next, we explicitly account for the level of smuggling based on data on seizures. While we are limited in our ability to control for this phenomenon, we use periodically reported figures on opium smuggling from the *Bengal Excise Reports* to create a variable measuring the quantity of smuggled opium seized from 1911 to 1925. We use this variable to control for the level of opium smuggling and estimate the Difference GMM model for opium. Column (1) in Table 3 shows that, conditional on smuggling, the own price elasticity of opium is slightly smaller in magnitude than the estimates from Table 2, which is consistent with economic theory. These elasticity estimates are also very similar to the baseline estimates. As expected, the parameter estimate on the level of smuggling is negative, indicating an inverse association between observed consumption and smuggling.

As a final check, we estimate a specification (Column (2) in Table 3) by excluding the district with a higher prevalence of smuggling (Chittagong) and controlling for the level of smuggling. The elasticity estimates from this exercise are similar to Column (1) in Table 3 and baseline estimates for opium in Column (4) in Table 2.

## 5.3 Short- and Long-run elasticities

The lagged consumption model in Equation 1 allows us to express contemporaneous drug consumption as a function of prior prices. We derive the steady state consumption level as a function of prices by recursively substituting for lagged consumption, and calculating the geometric sum of the resulting series. We then use coefficient estimates from Table 2 to compute long-run own price and income elasticity under the assumption of a permanent change in prices (or wages).[10]

10. Note that we do not estimate short- and long-run elasticities based on the canonical rational-addiction model which in some cases is shown to produce unstable estimates (Dragone and Raggi 2018, 2021). Instead we use the GMM based techniques that are robust to autocorrelation in this context. Our calculations of long-run elasticities are equivalent to the long-run elasticities for a myopic consumer as in Dragone and Raggi (2018). More recent research, using individual-level data, has estimated addiction parameters explicitly and also built learning into models of consumption behavior via biomarker information as in Darden (2017) and Darden et al. (2018) or experimentation in Matsumoto (2016).

Table 3: Estimates from the Dynamic Panel Data Model Controlling for Opium Smuggling

| | *Dependent variable:* Log of Consumption | |
|---|---|---|
| | (1) | (2) |
| Lagged Log of Consumption | 0.468*** | 0.421*** |
| | (0.105) | (108) |
| Log of Price of Alcohol | 0.061 | 0.114 |
| | (0.071) | (0.083) |
| Log of Price of Cannabis bud | 0.148 | 0.174 |
| | (0.190) | (0.197) |
| Log of Price of Cannabis leaf | -0.071 | -0.078* |
| | (0.045) | (0.045) |
| Log of Price of Opium | -0.426*** | -0.529*** |
| | (0.089) | (0.068) |
| Log of Wage | 0.292** | 0.311** |
| | (0.120) | (0.113) |
| Log of Smuggled Quantity Seized | -0.069* | -0.064* |
| | (0.034) | (0.033) |
| Arellano-Bond test for AR(2) | 1.33 | 1.32 |
| $(Pr > z)$ | 0.18 | 0.19 |
| Hansen Test for Overidentification ($\chi^2$) | 0.00 | 0.00 |
| $(Pr > z)$ | — | — |
| Observations | 271 | 260 |
| Sample | All districts | Excluding Chittagong |
| Number of Groups | 25 | 24 |
| Number of Instruments | 7 | 7 |

Notes: This table shows elasticity estimates for Two-Step Difference GMM for Opium in Equation 1 including the log of the (smuggled) quantity seized. Column (1) uses the complete sample of 25 districts of Bengal from 1911/12 to 1925/26. Column (2) excludes Chittagong from the sample. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table 4 reports the short- and long-run elasticities for own price and income for all of the four substances. All substances are wage inelastic in both the short- and the long-

Table 4: Short- and long-run elasticity estimates

| | | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
|---|---|---|---|---|---|
| Own-price Association | Elastic/inelastic | Inelastic | None† | Inelastic | Inelastic |
| | Short-term elasticity | -0.91 | -0.26 | -0.63 | -0.54 |
| | long-run elasticity | -1.19 | -0.42 | -1.22 | -1.25 |
| Income Association | Elastic/inelastic | Inelastic | Inelastic | None† | Inelastic |
| | Short-term elasticity | 0.69 | 0.45 | 0.00 | 0.43 |
| | long-run elasticity | 0.90 | 0.72 | 0.01 | 1.00 |

Notes: This table reports long-run elasticities of own price and income for myopic consumers, for a permanent change in prices (or wages). We use estimates from Table 2 to compute the long-run elasticities.
† Price of cannabis bud is not statistically significant in the cannabis bud model, and wage is not statistically significant in the cannabis leaf model.

run. However, with the exception of cannabis bud all of the substances are inelastic with respect to their own prices in the short-run but elastic in the long-run.

# 6 Discussion, Policy Implications and Conclusion

## 6.1 Discussion

Key findings of this study are, first, evidence consistent with limited (inelastic) price and income responsiveness in the consumption of the four substances. These effects, where present, have the expected signs, i.e., price increases are associated with decreases in consumption, and wage increases are associated with increases in consumption. Second, we observe substitution effects from cannabis bud to cannabis leaf and alcohol, a one-way complementarity effect between opium and alcohol due to changes in the price of opium, and a two-way complementarity effect between cannabis leaf and alcohol.The latter set of findings on substitution and complementarity is new to the literature on the consumption of psychoactive substances.

Moreover, a number of these findings broadly align with anecdotal evidence from documents relating to the consumption of these substances in India, including various editions of the *Administration Report of the Excise Department* and the *Indian Hemp Drugs Commission Report*. Table 5 lists the frequency with which phenomena that can be interpreted as own-price, wage, or cross-price elasticity were mentioned in annual issues of the *Excise Administration Report for Bengal* during our sample period(i.e., 1911-1925). The maximum value that any cell can take is 14, i.e. the phenomenon was mentioned in each of the 14 annual issues of the report for which this information was available.

Table 5: Frequency of Mentions of Own-Price, Wage, and Cross-Price Responsiveness of Consumption of Alcohol, Cannabis bud, Cannabis leaf, and Opium, 1911-1925

| Phenomenon | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
|---|---|---|---|---|
| Own-price responsiveness | 13 | 13 | 11 | 10 |
| Cross-price responsiveness | 1 | 6† | 2 | 1 |
| Wage responsiveness | 14 | 12 | 3 | 8 |

Notes: Mentions are sourced from the 14 annual reports for which qualitative data were available. Hence the maximum possible value for the frequency is 14, indicating that the phenomenon in question was mentioned at least once in each of the 14 annual reports. †The majority of mentions supporting cross-price responsiveness refer to increases in consumption of cannabis bud in response to higher prices of alcohol (country spirit), i.e., a substitution effect.

To provide added context to Table 5, specific excerpts from these reports and the *Indian Hemp Drugs Commission Report* are presented in Appendix E. For example, the reports provide evidence supporting the habit forming properties of cannabis and convey a sense that, in the event of prohibition or other restrictions on the consumption of cannabis, consumers would switch to alcohol and other drugs (see Appendix E). This aligns with the observation of a substitution effect from cannabis bud, the most widely consumed form of cannabis in Bengal, to alcohol. We can speculate as to the cause of this effect. Like alcohol, cannabis bud was a moderately intoxicating drug (rather than a weakly intoxicating drug, like cannabis leaf), which probably made alcohol the substitute of choice for some users looking for an intoxicating product of similar strength.

The results on habit formation or addictive behavior and own-price and wage elasticity also align closely with the findings of earlier studies which have employed a similar methodology (Chandra and Chandra 2015; J.-L. Liu et al. 1999; Van Ours 1995). The similarity of our estimates, which are based on historical data, to comparable estimates based on more recent data suggests that the behavior of drug consuming populations 100 years ago was not very different from behavior today, and that important drivers (such as human biology) of this behavior may transcend time and geography.

Furthermore, depending on the cannabis product in question, we find a substitution effect (between alcohol and cannabis bud), which is broadly in line with findings from earlier studies (Karoly et al. 2021; Lucas et al. 2013; Reiman 2009; Subbaraman 2016) as well as a complementarity effect (between alcohol and cannabis leaf), which aligns with findings from other studies (Ellickson and Hays 1991; Gripe et al. 2018; Kandel and Maloff 1983; Pape et al. 2009).

While the aforementioned studies differ in their methodologies and some do not measure cross price elasticities, our findings suggest that different types of cannabis products may be treated differently by consumers in relation to other products. This may be for reasons of relative strength (cannabis leaf is less potent than the resin-rich cannabis bud), culture (different forms of cannabis in India were and continue to be used for different reasons, including religious ritual and recreation in a manner analogous to the use of alcohol in some western societies), or mode of consumption (i.e., ingested (cannabis leaf) vs. smoked (cannabis bud)).

## 6.2 Policy Implications

The results of this study contribute to a variety of ongoing debates on the properties of and policies relating to psychoactive substances. In the context of the debate on the legalization of cannabis, the study provides clues about how populations of cannabis consumers may respond to price and income changes in a legal but regulated regime.

First, changes in income are associated with changes in consumption for cannabis leaf, suggesting that income-focused policies, such as taxation or subsidization, can affect consumption (Baltagi and Levin 1986; Chaloupka et al. 2012; Callison and Kaestner 2014; Keeler et al. 1993; H. Liu et al. 2015; Matsumoto 2016). However, these findings also underscore that price- (or taxation-) related interventions focusing on any one drug take into consideration potential substitution and complementarity effects on other drugs, thereby avoiding unintended consequences for the consumption of related drugs (Pacula 1998). The widespread phenomenon of polydrug abuse also underscores the need for a perspective that considers consequences for *both* the target drug and its complements and substitutes.

Second, the evidence of habit formation suggests that a change in prices or income, possibly effected through different types of taxation or subsidization, will have not only short-term effects on cannabis leaf consumption, but also long-run effects because of the intertemporal relationship between present and future consumption levels inherent in habit-formation models.

Third, the differentiated consumer responses between cannabis leaf and cannabis bud suggest that product differentiation matters because different products may have differing potency, be consumed by different types of consumers in different contexts and ways, and be viewed differently in the social and cultural context of the time and place in which they are being consumed. Therefore, these differences in modes of consumption and the associated behaviors should be taken into account in the design of policies in much the same way in which policies relating to alcohol (by type of beverage) and tobacco (by mode of consumption — smoked vs. ingested) are often differentiated.

## 6.3 Limitations

The above said, a limitation of this study is its contextual specificity — the data cover a specific regulatory regime (i.e., alcohol, cannabis, and opium were simultaneously legal) in a specific location (Bengal, India) at a specific time in history (the early 20th century) in a primarily rural population. To the extent that the findings align with those of other studies looking at other combinations of drugs in different contexts, however, they suggest phenomena that are robust across contexts and possibly of a predominantly biological or psychological nature.

A second limitation of this study concerns the individual-oriented interpretation of findings based on aggregate data. While this is valid only under strict assumptions (Stoker 1993) and for a subset of the phenomena being studied (i.e., wage and price responses, but not discounting), the findings have the advantage of reflecting market phenomena that cannot be characterized using data from a limited collection of individuals unless that group is very carefully constructed.

A related limitation of the data relates to the era in which it was collected and its aggregate nature. We do not have access to the detailed individual level information (e.g. drug use history, experimentation and biomarker information, which was unavailable in the early 20$^{\text{th}}$ century) that recent research has used, making it impossible for us to incorporate learning and related dynamics into models of consumption behavior (Matsumoto 2016; Darden 2017; Darden et al. 2018).

Finally, we are unable to account for individual-level heterogeneity in drug consumption, including patterns of cessation, relapse, and other individual characteristics that are important for modeling addictive stock (Darden et al. 2018). However, since our focus is identifying short-run changes in market consumption patterns in response to changes in prices, this is a second-order concern for our analysis. While we acknowledge that changes in consumption patterns can indeed lead to changes in addictive stock and thus long-run impacts on morbidity and mortality, measuring these effects may be an interesting extension of our study, but it is beyond the scope of the current paper.

## 6.4 Conclusion

The above limitations notwithstanding, this study makes a number of contributions to the literature on the behavior of populations of drug consumers. The analysis of the simultaneous consumption of cannabis, alcohol, and opium in a regime in which all three classes of drugs are legally available, made possible by the unique nature of the dataset, allows us to test hypotheses not only about own-price and wage associations with the consumption of these drugs in such a regulatory milieu, but also on how and the degree to which the consumption of these drugs is interrelated. Because there exists no regime in the world today in which all three drug classes are simultaneously legally and widely available for recreational use and for which systematic data on prices, consumption, and wages are being collected, this analysis allows us to present unique insights into the behavior of populations of consumers of multiple psychoactive substances.

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# Appendices

## A Definitions of and distinctions between Cannabis Leaf (*Bhang*) and Cannabis Bud (*Ganja*)

Cannabis was consumed in various forms in British India. In Bengal, the vast majority of cannabis was consumed in the form of *bhang* (cannabis leaf) and *ganja* (cannabis bud). *Bhang* was defined as:

> "the dry leaves of the hemp plant, whether male or female and whether cultivated or uncultivated."
>
> Indian Hemp Drugs Commission (1894), v. 4, p. i

*Ganja*, by contrast, consisted

> "of the dried flowering tops of cultivated female hemp plants which have become coated with resin in consequence of having been unable to set seeds freely."
>
> Indian Hemp Drugs Commission (1894), v. 4, p. i

The resin present in cannabis bud, which is rich in THC and cannabidiol, contributed to significantly greater potency of the bud compared to the leaf,

> "The bhangs contain from 8.31 to 12.63 per cent. of resins, or an average of about 10 per cent. which is one-half the amount yielded by average samples of ganja."
>
> Indian Hemp Drugs Commission (1894), v. 3, p. 204

# B Supplementary Figures

Figure B1: Nominal Price and Per Capita Consumption of Alcohol, Opium, Cannabis Bud, and Cannabis Leaf

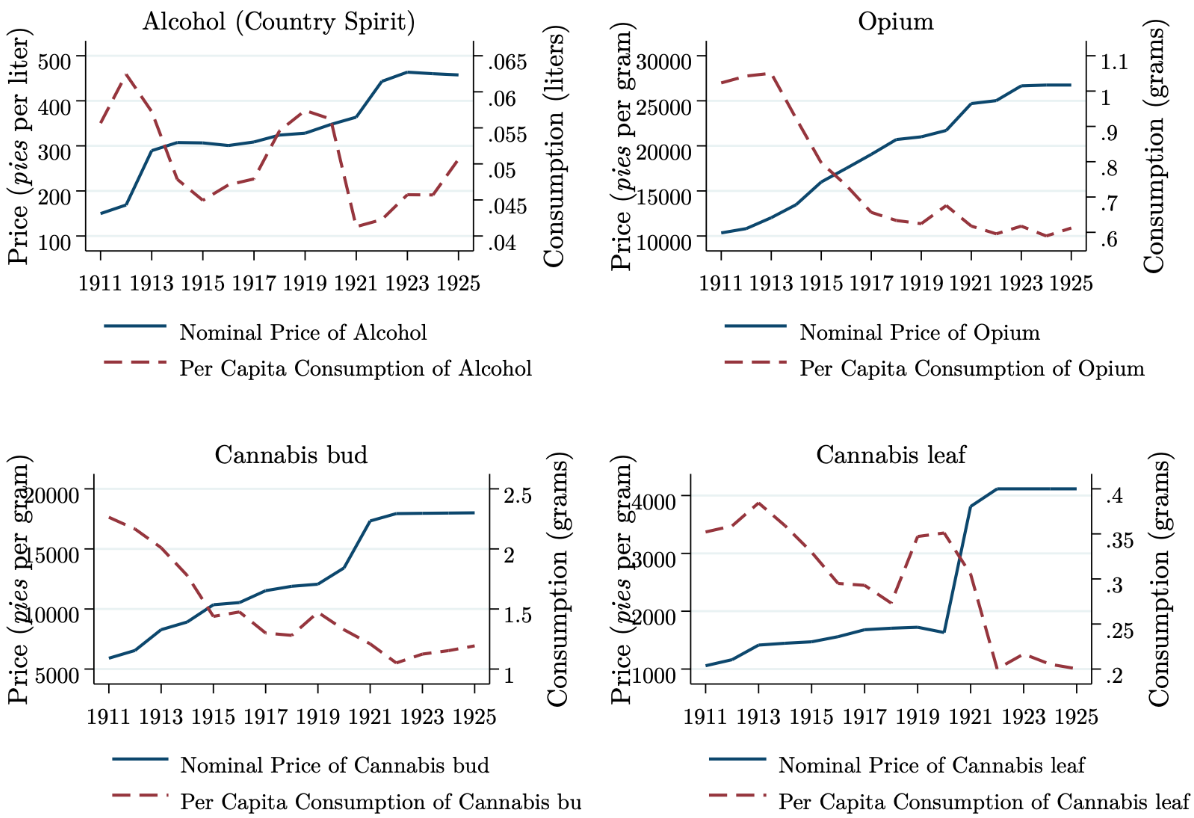
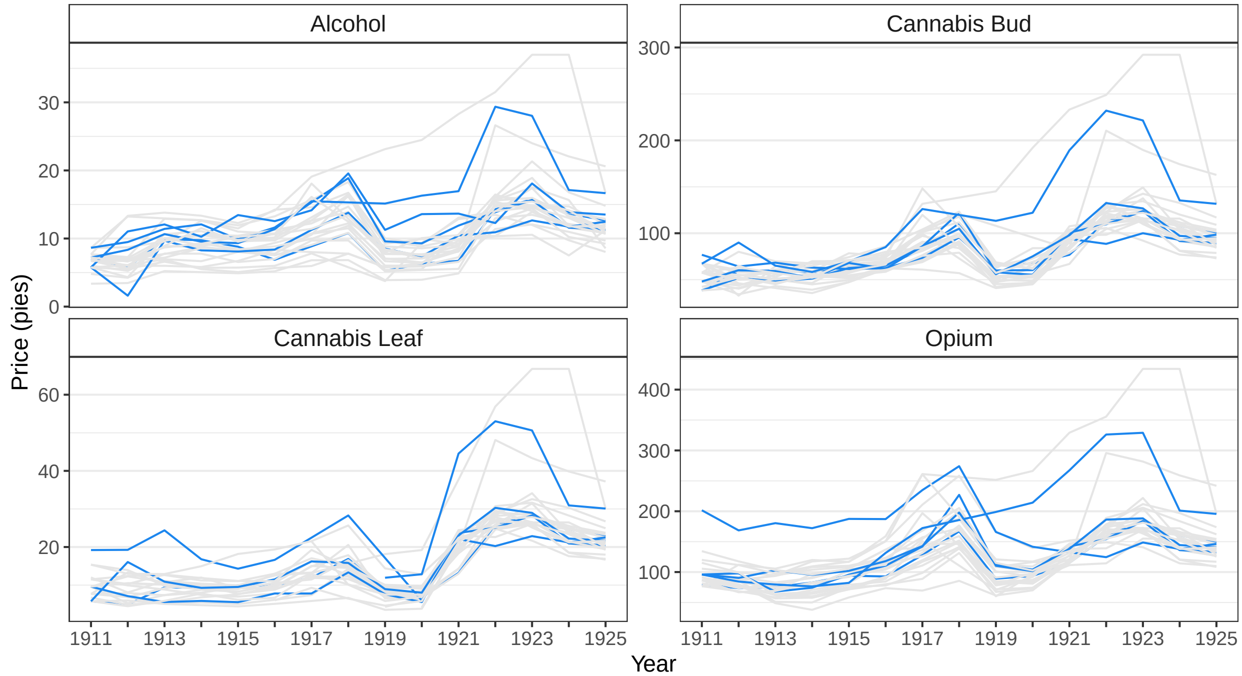
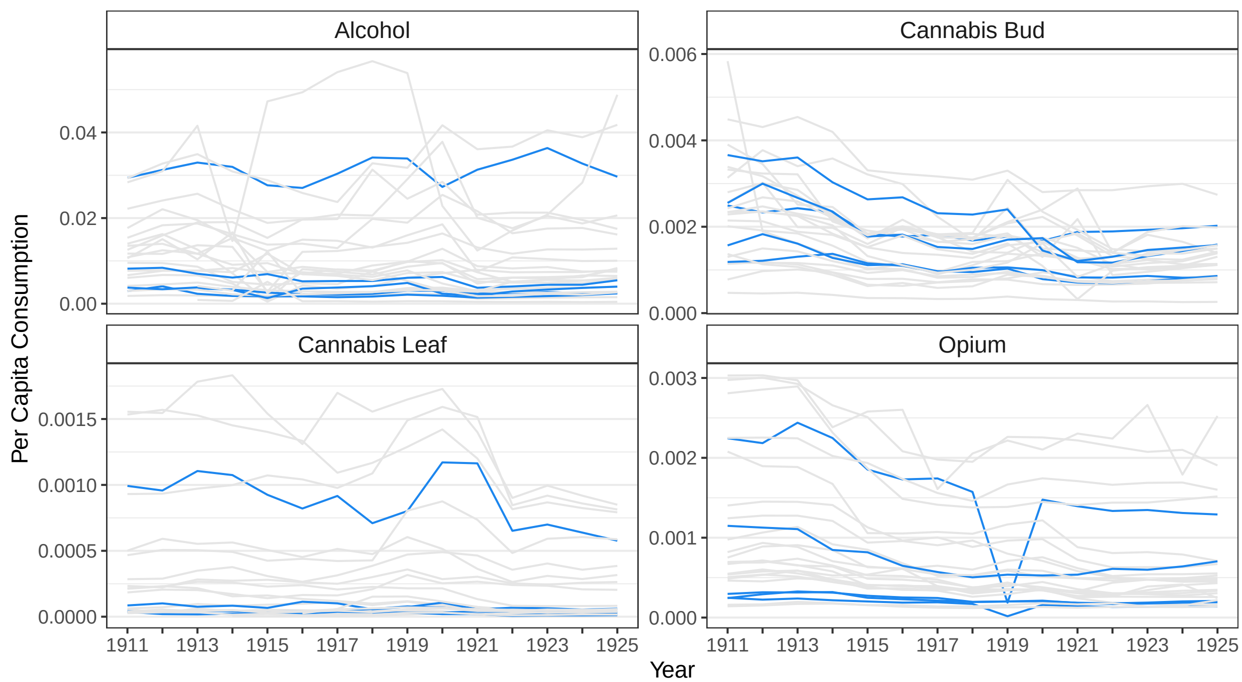


Figure B2: Cross district variation of prices and consumption of substances over time




(a) Prices of substances across districts and over time

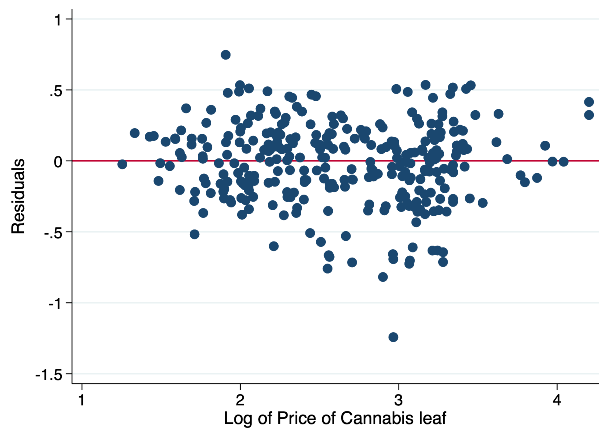



(b) Per-capita consumption of substances across districts and over time

Notes: The sample includes 25 districts over 1911 - 1925. Highlighted districts are Burdwan, Chittagong, Faridpur, Mymensingh, and Pabna.

Figure B3: Scatter plots of residual v.s. excluded variables


(a) Scatter plot of residuals from Cannabis bud consumption specification (excluding price of alcohol) v.s. Log of Price of Alcohol (Country Spirit)




(b) Scatter plot of residuals from Cannabis bud consumption specification (excluding price of cannabis leaf) v.s. Log of Price of Cannabis leaf


(c) Scatter plot of residuals from Opium consumption specification (excluding price of alcohol) v.s. Log of Price of Alcohol

# C Supplementary Tables

Table C1: Summary statistics of prices across the districts over 1911 - 1925

| District | Alcohol | | Cannabis Bud | | Cannabis Leaf | | Opium | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev |
| 24 Parganas | 2.60 | 0.73 | 89.07 | 31.65 | 16.03 | 10.04 | 144.49 | 42.49 |
| Bakarganj | 2.84 | 0.60 | 84.31 | 28.09 | 14.80 | 8.41 | 161.57 | 47.89 |
| Bankura | 1.52 | 0.80 | 87.77 | 26.38 | 17.50 | 7.37 | 127.27 | 41.11 |
| Birbhum | 1.94 | 0.80 | 81.84 | 26.62 | 14.41 | 7.94 | 115.21 | 40.99 |
| Bogra | 1.84 | 0.55 | 71.92 | 30.37 | 21.39 | 9.43 | 100.55 | 46.44 |
| Burdwan | 2.09 | 0.73 | 85.28 | 27.22 | 14.90 | 8.40 | 124.55 | 40.94 |
| Chittagong | 2.07 | 0.68 | 82.83 | 16.89 | 20.74 | 5.67 | 186.03 | 43.34 |
| Dacca | 2.41 | 0.56 | 83.34 | 23.01 | 16.20 | 6.73 | 130.31 | 31.59 |
| Dinajpur | 2.73 | 1.56 | 100.31 | 63.08 | 17.09 | 18.15 | 148.08 | 92.38 |
| Faridpur | 2.65 | 0.62 | 82.43 | 30.19 | 13.88 | 8.88 | 133.78 | 45.06 |
| Hooghly | 2.44 | 1.03 | 92.03 | 35.67 | 16.55 | 9.97 | 146.83 | 47.40 |
| Howrah | 4.58 | 2.10 | 159.79 | 93.18 | 28.09 | 23.64 | 246.32 | 131.51 |
| Jalpaiguri | 1.78 | 0.66 | 76.30 | 23.01 | 17.72 | 8.73 | 108.70 | 35.34 |
| Jessore | 2.46 | 0.73 | 94.93 | 30.43 | 16.91 | 8.85 | 130.36 | 48.51 |
| Khulna | 2.24 | 0.67 | 86.03 | 28.11 | 13.12 | 8.15 | 122.19 | 39.25 |
| Malda | 2.06 | 0.82 | 75.87 | 34.12 | 13.52 | 9.90 | 114.61 | 47.65 |
| Midnapore | 1.59 | 0.56 | 78.40 | 25.52 | 15.66 | 7.18 | 119.47 | 32.32 |
| Murshidabad | 2.15 | 0.77 | 92.19 | 31.88 | 15.53 | 9.29 | 122.09 | 46.14 |
| Mymensingh | 2.86 | 0.70 | 87.16 | 28.83 | 17.02 | 8.32 | 139.97 | 38.76 |
| Nadia | 2.37 | 0.68 | 90.45 | 29.33 | 16.98 | 7.81 | 136.77 | 43.03 |
| Noakhali | 2.27 | 0.73 | 76.62 | 27.20 | 20.30 | 5.31 | 144.19 | 33.33 |
| Pabna | 3.32 | 1.48 | 130.64 | 61.16 | 35.83 | 18.07 | 187.91 | 94.97 |
| Rajshahi | 2.14 | 0.68 | 78.48 | 29.16 | 16.49 | 10.51 | 115.84 | 43.07 |
| Rangpur | 2.34 | 0.55 | 85.29 | 22.72 | 19.03 | 8.65 | 113.18 | 39.84 |
| Tippera | 2.31 | 0.69 | 79.77 | 30.96 | 17.15 | 6.70 | 148.65 | 43.63 |

Notes: This table shows the mean and standard deviation of real prices of alcohol (country spirit), cannabis bud, cannabis leaf, and opium for each district in the sample. Units are pies per litre for alcohol and pies per gram for cannabis bud, cannabis leaf, and opium.

Table C2: Summary statistics of per-capita consumption across the districts over 1911 - 1925

| District | Alcohol | | Cannabis Bud | | Cannabis Leaf | | Opium | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev |
| 24 Parganas | 0.10 | 0.02 | 3.16 | 0.61 | 1.32 | 0.32 | 2.18 | 0.36 |
| Bakarganj | 0.01 | 0.00 | 0.84 | 0.17 | 0.07 | 0.02 | 0.44 | 0.12 |
| Bankura | 0.09 | 0.03 | 0.76 | 0.11 | 0.34 | 0.06 | 0.63 | 0.12 |
| Birbhum | 0.03 | 0.01 | 1.42 | 0.32 | 0.42 | 0.11 | 0.93 | 0.29 |
| Bogra | 0.04 | 0.01 | 1.85 | 0.54 | 0.01 | 0.01 | 0.30 | 0.11 |
| Burdwan | 0.14 | 0.01 | 1.86 | 0.26 | 0.82 | 0.18 | 1.51 | 0.52 |
| Chittagong | 0.01 | 0.00 | 0.97 | 0.17 | 0.07 | 0.02 | 0.68 | 0.21 |
| Dacca | 0.03 | 0.01 | 1.84 | 0.66 | 0.25 | 0.03 | 0.36 | 0.07 |
| Dinajpur | 0.04 | 0.02 | 1.59 | 0.51 | 0.03 | 0.02 | 0.43 | 0.14 |
| Faridpur | 0.01 | 0.00 | 1.00 | 0.33 | 0.04 | 0.01 | 0.22 | 0.05 |
| Hooghly | 0.15 | 0.03 | 2.22 | 0.83 | 1.00 | 0.24 | 2.25 | 0.40 |
| Howrah | 0.08 | 0.01 | 1.79 | 0.28 | 1.14 | 0.26 | 1.69 | 0.24 |
| Jalpaiguri | 0.16 | 0.07 | 1.74 | 0.72 | 0.04 | 0.02 | 0.40 | 0.10 |
| Jessore | 0.01 | 0.00 | 0.78 | 0.20 | 0.05 | 0.01 | 0.38 | 0.09 |
| Khulna | 0.02 | 0.00 | 0.91 | 0.25 | 0.17 | 0.07 | 0.57 | 0.15 |
| Malda | 0.06 | 0.02 | 2.06 | 0.71 | 0.03 | 0.02 | 1.13 | 0.42 |
| Midnapore | 0.06 | 0.01 | 0.78 | 0.17 | 0.52 | 0.13 | 1.69 | 0.55 |
| Murshidabad | 0.04 | 0.01 | 1.25 | 0.31 | 0.11 | 0.06 | 0.79 | 0.29 |
| Mymensingh | 0.02 | 0.00 | 2.15 | 0.81 | 0.03 | 0.01 | 0.16 | 0.05 |
| Nadia | 0.03 | 0.01 | 1.43 | 1.14 | 0.20 | 0.04 | 0.63 | 0.22 |
| Noakhali | 0.00 | 0.01 | 0.33 | 0.07 | 0.02 | 0.01 | 0.13 | 0.02 |
| Pabna | 0.03 | 0.01 | 1.70 | 0.52 | 0.02 | 0.01 | 0.21 | 0.05 |
| Rajshahi | 0.03 | 0.01 | 1.89 | 0.46 | 0.07 | 0.05 | 0.37 | 0.10 |
| Rangpur | 0.03 | 0.02 | 1.38 | 0.53 | 0.02 | 0.01 | 0.42 | 0.17 |
| Tippera | 0.02 | 0.01 | 1.39 | 0.48 | 0.04 | 0.01 | 0.15 | 0.02 |

Notes: This table shows the mean and standard deviation of per-capita consumption of alcohol (country spirit), cannabis bud, cannabis leaf, and opium for each district in the sample. Units are litres for alcohol and gram for cannabis bud, cannabis lead, and opium.

# D Robustness Checks

Table D3: Estimates from the Dynamic Panel Data Models: One-Step GMM

| | *Dependent variable:* Log of Consumption | | | |
|---|---|---|---|---|
| | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) | (4) |
| Lagged Log of Consumption | 0.298** | 0.380*** | 0.626** | 0.567*** |
| | (0.110) | (0.108) | (0.243) | (0.105) |
| Log of Price of Alcohol | -0.674** | 0.0981 | -0.271 | 0.0453 |
| | (0.284) | (0.071) | (0.232) | (0.069) |
| Log of Price of Cannabis bud | 0.756** | -0.237 | 0.571 | 0.073 |
| | (0.358) | (0.238) | (0.484) | (0.166) |
| Log of Price of Cannabis leaf | -0.185 | -0.109 | -0.462* | -0.052 |
| | (0.163) | (0.104) | (0.251) | (0.037) |
| Log of Price of Opium | -0.232 | -0.226 | 0.141 | -0.535*** |
| | (0.308) | (0.161) | (0.185) | (0.103) |
| Log of Wage | 0.269 | 0.452** | -0.176 | 0.432*** |
| | (0.408) | (0.198) | (0.332) | (0.088) |
| Constant | -3.542*** | -1.752** | -4.788 | — |
| | (0.948) | (0.622) | (3.182) | |
| Arellano-Bond test for AR(2) | 1.42 | 0.85 | 0.62 | 1.14 |
| $(Pr > z)$ | 0.16 | 0.40 | 0.54 | 0.25 |
| Hansen Test for Overidentification ($\chi^2$) | 2.50 | 0.11 | 2.10 | 0.00 |
| $(Pr > z)$ | 0.29 | 0.74 | 0.35 | — |
| Observations | 306 | 312 | 309 | 287 |
| Number of Groups | 25 | 25 | 25 | 25 |
| Number of Instruments | 9 | 8 | 9 | 6 |

Notes: This table shows results for Dynamic Panel Data models in Equation 1 for Alcohol, Cannabis bud, Cannabis leaf, and Opium. One-Step System GMM for Alcohol, Cannabis bud, and Cannabis leaf; and One-Step Difference GMM for Opium. Difference GMM results for Opium are preferred since System GMM is overidentified. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Observations differ across the specification due to different optimal number of lag variables. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table D4: Estimates from 2SLS model with district fixed effects

| | *Dependent variable:* Log of Consumption | | | |
|---|---|---|---|---|
| | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) | (4) |
| Lagged Log of Consumption | 0.304 | 0.286* | 0.534*** | 0.629*** |
| | (0.366) | (0.149) | (0.071) | (0.194) |
| Log of Price of Alcohol | -0.116 | 0.099* | -0.049 | 0.039 |
| | (0.112) | (0.052) | (0.065) | (0.058) |
| Log of Price of Cannabis bud | -0.489* | -0.637*** | 0.305** | 0.092 |
| | (0.273) | (0.161) | (0.146) | (0.199) |
| Log of Price of Cannabis leaf | 0.021 | 0.023 | -0.442*** | -0.043 |
| | (0.060) | (0.048) | (0.086) | (0.038) |
| Log of Price of Opium | -0.011 | -0.121 | -0.060 | -0.496*** |
| | (0.128) | (0.094) | (0.150) | (0.111) |
| Log of Wage | 0.709*** | 0.516*** | 0.0877 | 0.382** |
| | (0.187) | (0.176) | (0.115) | (0.147) |
| Constant | -0.780 | -1.460** | -3.939*** | -0.620 |
| | (1.163) | (0.600) | (0.641) | (0.481) |
| First Stage F-Stat | 3.85 | 35.99 | 10.04 | 24.02 |
| District Fixed Effect | ✓ | ✓ | ✓ | ✓ |
| Observations | 295 | 301 | 301 | 301 |
| Number of Groups | 25 | 25 | 25 | 25 |
| Number of Instruments | 9 | 9 | 9 | 9 |

Notes: This table shows results for 2SLS models for Equation 1 for Alcohol, Cannabis bud, Cannabis leaf, and Opium. Lagged consumption is instrumented with lagged prices. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Robust standard errors clustered at the district level are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table D5: Estimates from the Dynamic Panel Data Models without cross-price effects

| | *Dependent variable:* Log of Consumption | | | |
|---|---|---|---|---|
| | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) | (4) |
| Lagged Log of Consumption | 0.203*** | 0.475*** | 0.641*** | 0.624*** |
| | (0.068) | (0.122) | (0.093) | (0.081) |
| Log of Price of Alcohol | -0.796*** | | | |
| | (0.148) | | | |
| Log of Price of Cannabis bud | | -0.419*** | | |
| | | (0.145) | | |
| Log of Price of Cannabis leaf | | | -0.255*** | |
| | | | (0.087) | |
| Log of Price of Opium | | | | -0.477*** |
| | | | | (0.072) |
| Log of Wage | 0.623*** | 0.352** | 0.078 | 0.426*** |
| | (0.187) | (0.144) | (0.237) | (0.050) |
| Constant | -1.852*** | -1.496*** | -2.531*** | — |
| | (0.401) | (0.489) | (0.891) | |
| Arellano-Bond test for AR(2) | 0.51 | 0.21 | 1.02 | 1.09 |
| $(Pr > z)$ | 0.61 | 0.83 | 0.31 | 0.27 |
| Hansen Test for Overidentification ($\chi^2$) | 0.21 | 1.27 | 3.44 | 0.00 |
| $(Pr > z)$ | 0.89 | 0.26 | 0.18 | — |
| Observations | 339 | 343 | 311 | 320 |
| Number of Groups | 25 | 25 | 25 | 25 |
| Number of Instruments | 6 | 5 | 6 | 3 |

Notes: This table shows results for Dynamic Panel Data models without cross-price elasticity terms in Equation 2 for Alcohol, Cannabis bud, Cannabis leaf, and Opium. Two-Step System GMM for Alcohol, Cannabis bud, and Cannabis leaf; and Two-Step Difference GMM for Opium. Difference GMM results for Opium are preferred since System GMM is overidentified. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Observations differ across the specification due to different optimal number of lag variables. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table D6: Results including Number of Licensed Opium and Cannabis shops

| | *Dependent variable:* Log of Consumption | | |
|---|---|---|---|
| | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) |
| Lagged Log of Consumption | 0.403*** | 0.627*** | 0.633*** |
| | (0.116) | (0.101) | (0.100) |
| Log of Price of Alcohol | 0.025 | -0.171** | 0.039 |
| | (0.071) | (0.074) | (0.065) |
| Log of Price of Cannabis bud | -0.198 | 0.463** | 0.086 |
| | (0.193) | (0.183) | (0.187) |
| Log of Price of Cannabis leaf | -0.083 | -0.480*** | -0.061 |
| | (0.074) | (0.097) | (0.047) |
| Log of Price of Opium | -0.124 | 0.190 | -0.432*** |
| | (0.112) | (0.135) | (0.098) |
| Log of Wage | 0.350** | -0.211 | 0.346*** |
| | (0.157) | (0.189) | (0.095) |
| Number of Shops | 0.006** | 0.028*** | 0.010*** |
| | (0.002) | (0.008) | (0.003) |
| Constant | -2.522 | -5.041 | — |
| | (0.765) | (1.577) | |
| Arellano-Bond test for AR(2) | 0.49 | 1.02 | 1.19 |
| $(Pr > z)$ | 0.63 | 0.31 | 0.23 |
| Hansen Test for Overidentification ($\chi^2$) | 0.01 | 1.21 | 0.00 |
| $(Pr > z)$ | 0.93 | 0.55 | — |
| Observations | 287 | 284 | 262 |
| Number of Groups | 25 | 25 | 25 |
| Number of Instruments | 9 | 10 | 7 |

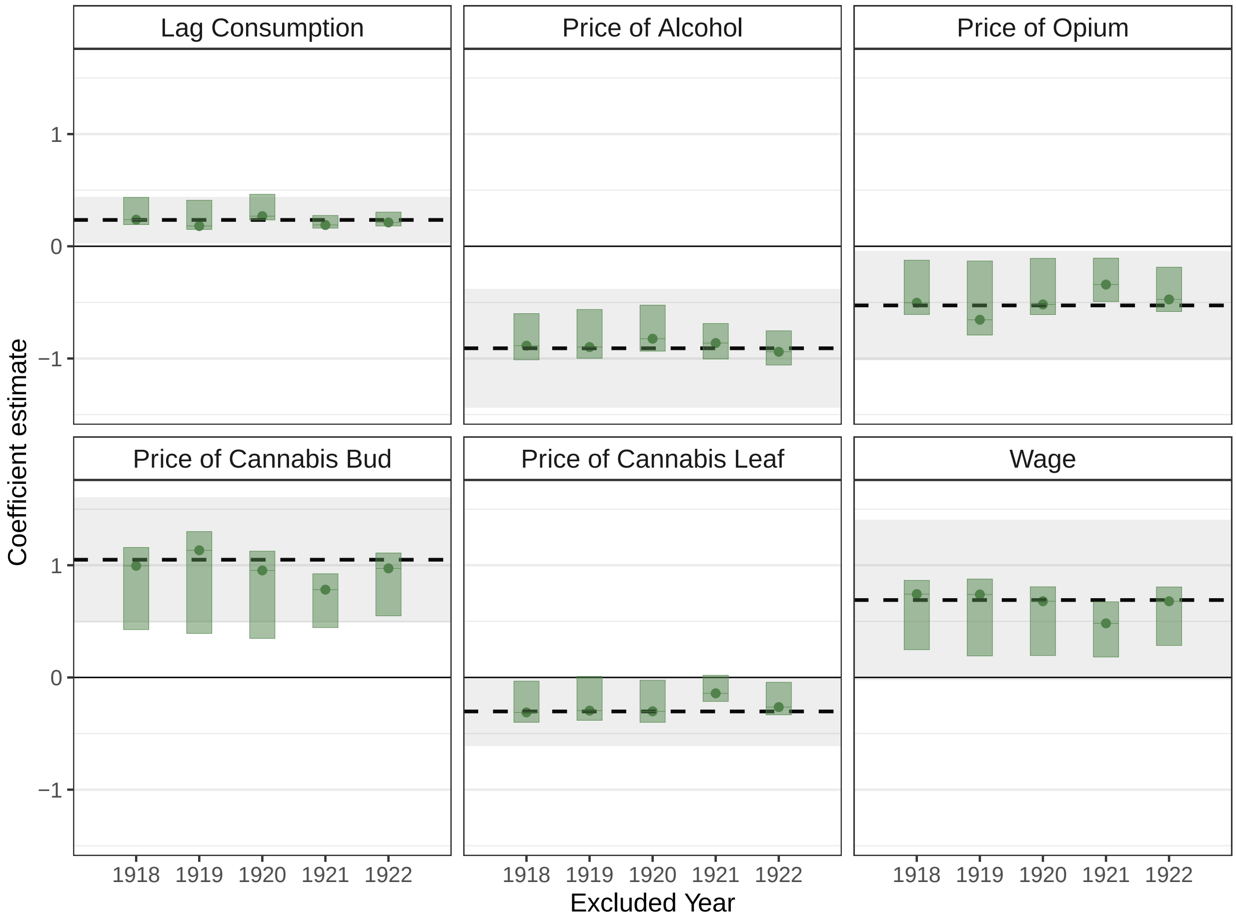
Notes: This table shows results for Dynamic Panel Data models in Equation 1 for Alcohol, Cannabis bud, Cannabis leaf, and Opium, controlling for the number of licensed shops in each district. Two-Step System GMM for Alcohol, Cannabis bud, and Cannabis leaf; and Two-Step Difference GMM for Opium. Difference GMM results for Opium are preferred since System GMM is overidentified. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Observations differ across the specification due to different optimal number of lag variables. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Table D7: Estimates from the Rational Addiction Model

| | *Dependent variable:* Log of Consumption | | | |
|---|---|---|---|---|
| | Alcohol (Country Spirit) | Cannabis bud | Cannabis leaf | Opium |
| | (1) | (2) | (3) | (4) |
| Lagged Log of Consumption | 0.340*** | 0.341*** | 0.511*** | 0.394*** |
| | (0.110) | (0.111) | (0.070) | (0.072) |
| Lead Log of Consumption | 0.367 | 0.438* | 0.129 | 0.198 |
| | (0.272) | (0.254) | (0.212) | (0.161) |
| Log of Price of Alcohol | -0.169 | 0.048 | -0.306** | 0.064 |
| | (0.299) | (0.048) | (0.139) | (0.085) |
| Log of Price of Cannabis bud | 0.270 | -0.233 | 0.659* | -0.088 |
| | (0.417) | (0.143) | (0.342) | (0.145) |
| Log of Price of Cannabis leaf | -0.088 | 0.004 | -0.473* | -0.031 |
| | (0.158) | (0.0627) | (0.261) | (0.0275) |
| Log of Price of Opium | -0.181 | -0.047 | 0.047 | -0.427** |
| | (0.208) | (0.087) | (0.0911) | (0.158) |
| Log of Wage | 0.109 | 0.134 | -0.0565 | 0.429*** |
| | (0.330) | (0.154) | (0.190) | (0.117) |
| Constant | -1.053 | -0.268 | -4.438** | — |
| | (1.220) | (0.639) | (2.138) | |
| Arellano-Bond test for AR(2) | 1.83 | 1.76 | 0.90 | 1.45 |
| $(Pr > z)$ | 0.068 | 0.079 | 0.366 | 0.146 |
| Hansen Test for Overidentification ($\chi^2$) | 8.78 | 4.22 | 8.36 | 6.61 |
| $(Pr > z)$ | 0.118 | 0.121 | 0.137 | 0.037 |
| Observations | 306 | 312 | 309 | 287 |
| Number of Groups | 25 | 25 | 25 | 25 |
| Number of Instruments | 13 | 10 | 13 | 9 |

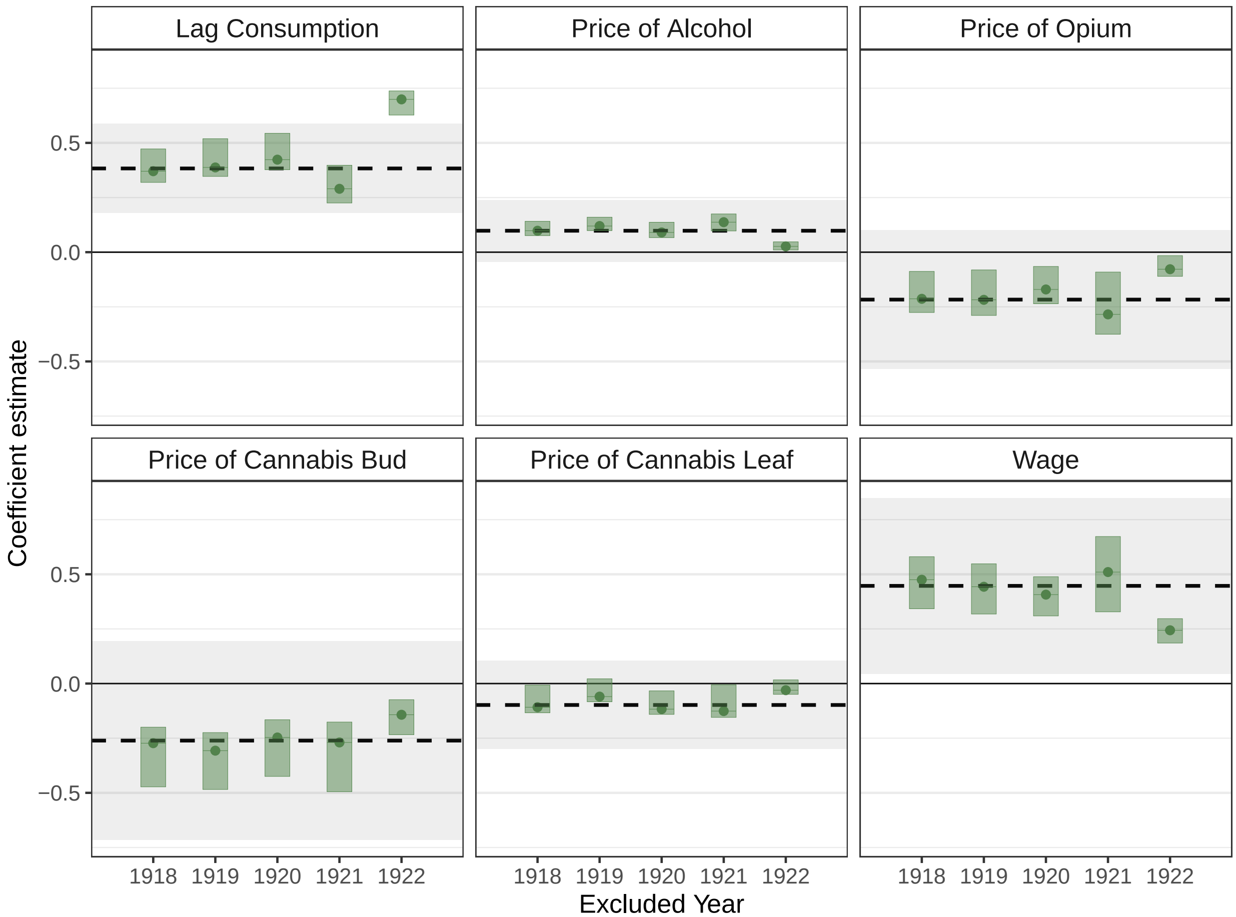
Notes: This is a Dynamic Panel Data model for the specification in Equation 1 including lagged lead of consumption for Alcohol, Cannabis bud, Cannabis leaf, and Opium. This is a rational addiction model similar in spirit to Chaloupka (1991) and Becker et al. (1994). Two-Step System GMM for Alcohol, Cannabis bud, and Cannabis leaf; and Two-Step Difference GMM for Opium. Difference GMM results for Opium are preferred since System GMM is overidentified. Sample is 25 districts of Bengal from 1911/12 to 1925/26. Observations differ across the specification due to different optimal number of lag variables. Windmeijer-Corrected cluster robust standard errors are reported in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

Figure D4: Coefficient estimates from leave-one-out analysis for Alcohol (Country Spirit)



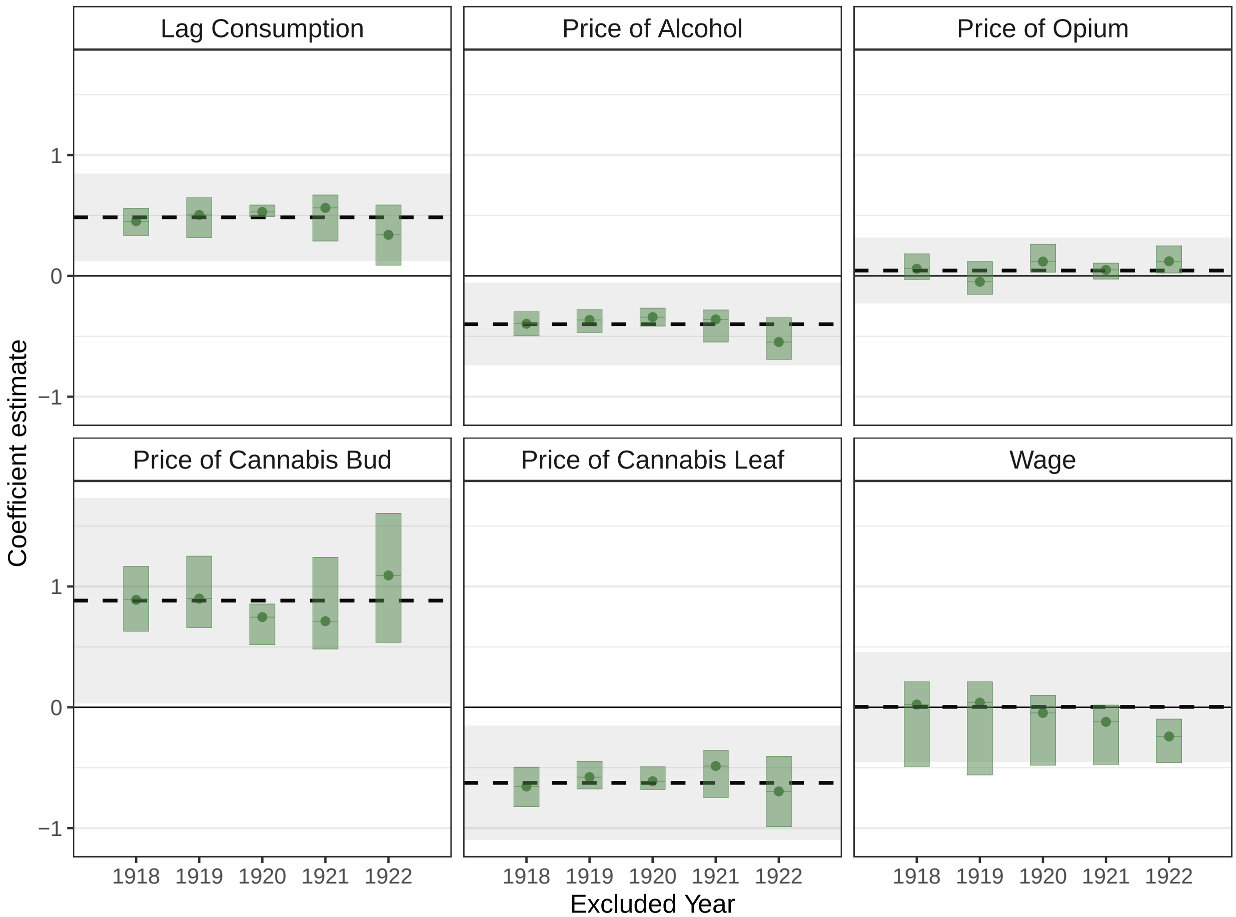

Notes: This figure shows coefficient estimates from leave-one-out robustness check for alcohol where each regression leaves out one year and one district at a time. We specifically focus on high inflation years between 1918 to 1922. Coefficient estimates are organized by the excluded year. Each of the green vertical bar shows range of estimates from 28 regressions for each excluded year and the green solid point shows the average of these estimates. Therefore, each panel shows the elasticity estimate from 140 regressions. Black dashed line shows the baseline elasticity estimates from Table 2 and grey shaded region is the associated 95% Confidence Interval. The figure shows that the range of estimates from leave-one-out regressions lies within the 95% CI of the baseline estimates. Further the average of these estimates is close to the baseline coefficient estimates.

Figure D5: Coefficient estimates from leave-one-out analysis for Cannabis Bud



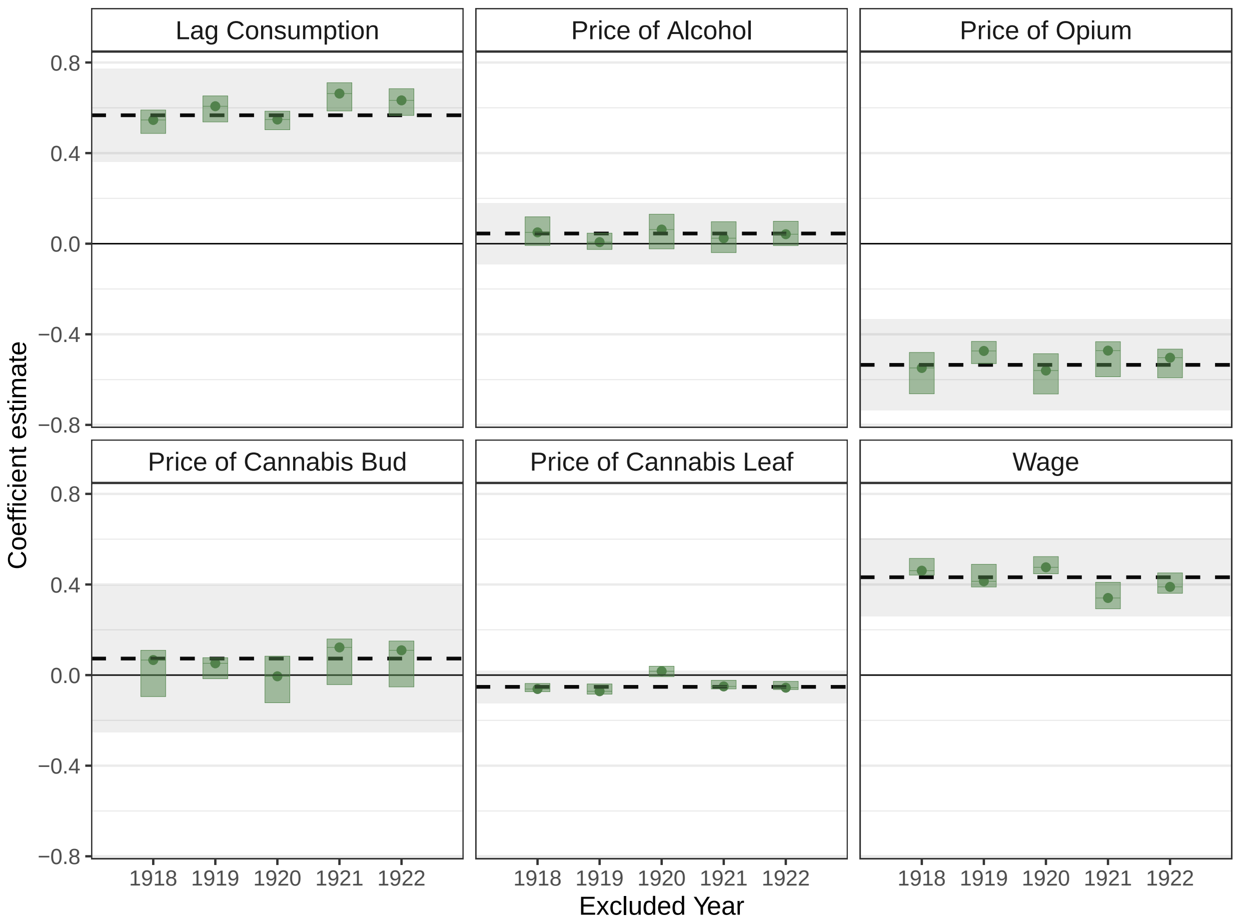

Notes: This figure shows coefficient estimates from leave-one-out robustness check for Cannabis Bud where each regression leaves out one year and one district at a time. We specifically focus on high inflation years between 1918 to 1922. Coefficient estimates are organized by the excluded year. Each of the green vertical bar shows range of estimates from 28 regressions for each excluded year and the green solid point shows the average of these estimates. Therefore, each panel shows a specific coefficient estimate from 140 regressions. Black dashed line shows the baseline elasticity estimates from Table 2 and grey shaded region is the associated 95% Confidence Interval. The figure shows that the range of estimates from leave-one-out regressions lies within the 95% CI of the baseline estimates. Further the average of these estimates is close to the baseline coefficient estimates.

Figure D6: Coefficient estimates from leave-one-out analysis for Cannabis Leaf




Notes: This figure shows coefficient estimates from leave-one-out robustness check for Cannabis Leaf where each regression leaves out one year and one district at a time. We specifically focus on high inflation years between 1918 to 1922. Coefficient estimates are organized by the excluded year. Each of the green vertical bar shows range of from 28 regressions for each excluded year and the green solid point shows the average of these estimates. Therefore, each panel shows a specific coefficient estimate from 140 regressions. Black dashed line shows the baseline elasticity estimates from Table 2 and grey shaded region is the associated 95% Confidence Interval. The figure shows that the range of estimates from leave-one-out regressions lies within the 95% CI of the baseline estimates. Further the average of these estimates is close to the baseline coefficient estimates.

Figure D7: Coefficient estimates from leave-one-out analysis for Opium




Notes: This figure shows coefficient estimates from leave-one-out robustness check for Opium where each regression leaves out one year and one district at a time. We specifically focus on high inflation years between 1918 to 1922. Coefficient estimates are organized by the excluded year. Each of the green vertical bar shows range of estimates from 28 regressions for each excluded year and the green solid point shows the average of these estimates. Therefore, each panel shows a specific coefficient estimate from 140 regressions. Black dashed line shows the baseline elasticity estimates from Table 2 and grey shaded region is the associated 95% Confidence Interval. The figure shows that the range of estimates from leave-one-out regressions lies within the 95% CI of the baseline estimates. Further the average of these estimates is close to the baseline coefficient estimates.

# E Anecdotal evidence from archives

This appendix contains selected excerpts from two sets of reports that provide evidence for the own-price, wage, and cross-price responsiveness of the consumption of alcohol, cannabis bud, cannabis leaf, and opium in India. These include Volume 1 of the *Indian Hemp Drugs Commission Report* of 1893-94 (henceforth *IHDCR*) and annual issues of the *Report on the Administration of the Excise Department in the Presidency of Bengal* from 1911 to 1925 (henceforth *ER*).

## E.1 Anecdotal Evidence of Own-Price Responsiveness of Consumption of Alcohol, Cannabis Leaf, Cannabis Bud, and Opium

> "In districts where the consumption has decreased, there are witnesses who say that the enhanced cost of ganja has reduced, and is reducing, the habit. . . ." *IHDCR*, v.1, p.134

> "The higher prices operated in more ways than one to reduce the consumption of country spirit." *ER*, 1913-14, p.9

> "Coming as it did in a year of economic depression, the general increase in the retail price of opium naturally resulted in a decrease in local consumption." *ER*, 1915-16, p.18

> "The general decrease [in consumption of alcohol] was, however, mainly due to the . . . high prices caused by the war ...." *ER* 1915-16, p.8

## E.2 Anecdotal Evidence of Wage Responsiveness of Consumption of Alcohol, Cannabis Leaf, Cannabis Bud, and Opium

"The general decrease [in consumption of alcohol] was, however, mainly due to the continuance of the economic depression .... caused by the war..." *ER* 1915-16, p.8

"The better wages earned by the labouring classes, who are the principal consumers of [cannabis bud], is sometimes held to account for the increase." *IHDCR*, v.1, p.134

"He is also of the opinion that the use has spread among the labouring classes, whose wages have greatly risen in recent years." *IHDCR*, v.1, p.150

"In Bankura and Midnapur the greater part of the increase [in consumption of alcohol] took place in the old outstill area and was largely due to an improvement in the condition of the labouring classes, who are the principal consumers, owing to a rise in wages." *ER*, 1913-14, p.8

"The increase of 1 maund 37 seers [of opium] in Mymensingh is less than the decrease in the preceding year and may be attributed to the conditions of prosperity which caused an increase in the consumption of excisable articles of every description." *ER*, 1913-14, pp.20-21

## E.3 Anecdotal Evidence of the Presence or Absence of Substitution or Complementarity Effects between Alcohol, Cannabis Leaf, Cannabis Bud, and Opium:

**Alcohol as a substitute for Cannabis Bud:**

"other causes also may have been at work to produce the result. The growing taste for liquor is one of the principal causes mentioned." *IHDCR*, v.1, p.134

“The principal cause of decrease is the change .... in the direction of liquor.” *IHDCR*, v.1, p.138

“...rise in the price of spirits, many people who formerly drank spirits have taken to drugs as a substitute.” *IHDCR*, p.366.

“The principal cause of decrease is the change ... in the direction of liquor.” *IHDCR*, v.1, p.138

“...rise in the price of spirits, many people who formerly drank spirits have taken to drugs as a substitute.” *IHDCR*, v.1, p.366.

**Cannabis Bud as a substitute for Alcohol:**

“...the great cost of the liquor habit and its deleterious effects are making the same classes go back to ganja.” *IHDCR*, v.1, p.134

“He shows pretty conclusively that the hemp drug revenue has risen when the price of liquor has been raised, and that it has fallen when ... liquor has been made more plentiful and more cheap.” *IHDCR*, v.1, p. 137.

“The preponderance of testimony is in favor of increasing consumption and the high price of liquor is more frequently alleged as the cause than anything else.” *IHDCR*, v.1, p.137.

“The Collector of Pabna reports that the ganja habit is spreading among the upper classes, and that ganja is sometimes used by prostitutes as a cheap substitute for liquor." *ER*, 1912-13, p.14

“From the 24-Parganas it has been reported that the increase in consumption was due to a certain extent to the fact that many of the consumers of liquor indulged in the smoking of ganja owing to the high price of country spirit." *ER*, 1919-20, p. 15

> “From Howrah it has been reported that the increase in consumption [of ganja] was due to a certain extent to the fact that many of the liquor consumers indulge in the smoking of ganja owing to the high price of country spirit." *ER*, 1921-22, p. 14

Finally, in a few instances, there is evidence of effects not observed in our models, for example, cannabis leaf as a substitute for cannabis bud and alcohol:

> “...if ... bhang ... is left untouched by the prohibitory measure of the Government, consumers of ganja or charas will get in it a substitute. . . ” *IHDCR*, v.1, p.375

> “The increase [in consumption of Cannabis leaf] in Calcutta was partly due to the influx of up-country men in the town and party to higher price of ganja. . . . The increase in the other districts was also due to higher price of ganja." *ER*, 1920-21, p. 15