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Do Consumers Substitute Opium for Hashish? An Economic Analysis of Simultaneous Cannabinoid and Opiate Consumption in a Legal Regime

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Abstract

Aim—To analyze interrelationships in the consumption of opiates and cannabinoids in a legal regime and, specifically, whether consumers of opiates and cannabinoids treat them as substitutes for each other.

Method—Econometric dynamic panel data models for opium consumption are estimated using the generalized method of moments (GMM). A unique dataset containing information about opiate (opium) consumption from the Punjab province of British India for the years 1907–1918 is analyzed (n=272) as a function of its own price, the prices of two forms of cannabis (the leaf (bhang), and the resin (charas, or hashish)), and wage income. Cross-price elasticities are examined to reveal substitution or complementarity between opium and cannabis.

Results—Opium is a substitute for charas (or hashish), with a cross price elasticity (β_3) of 0.14 ($p < 0.05$), but not for bhang (cannabis leaves; cross price elasticity = 0.00, $p > 0.10$). Opium consumption (β_1 = 0.47 to 0.49, $p < 0.01$) shows properties of habit persistence consistent with addiction. The consumption of opium is slightly responsive (inelastic) to changes in its own price (β_2 = −0.34 to −0.35, $p < 0.05$ to 0.01) and consumer wages (β_4 = 0.15, $p < 0.05$).

Conclusion—Opium and hashish, a form of cannabis, are substitutes. In addition, opium consumption displays properties of habit persistence and slight price and wage income responsiveness (inelasticity) consistent with an addictive substance.

Keywords

Price responsiveness; substitution effect; opium; cannabis; hashish; *bhang*

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1. INTRODUCTION

The role of economic incentives in the decisions of consumers to consume psychoactive substances is well-studied. Economists have formulated models of addiction to study this topic (Becker and Murphy, 1988; Boyer, 1983), and there is a large empirical literature that examines how changes in prices of drugs and incomes of consumers are associated with their consumption (Becker, et al., 1991; Gallet, 2014; Pacula and Lundberg, 2014; Van Ours, 2007; Van Ours and Williams, 2007). The substances that have received the most attention are legal substances, such as nicotine and alcohol, for which product price data are reliable and readily available (Bader et al., 2011; Chaloupka, et al., 2002; Chaloupka, 1999). Contemporary studies of illegal substances, such as opiates, while important for the special regulatory context that they illuminate, are much rarer, because they have been conducted in regimes in which these drugs are illegal. Therefore, data on the prices of these substances are difficult to obtain and, when they are available, are often unreliable because of their illegal status (Caulkins, 2007; Chandra and Barkell, 2013). In order to understand consumer behavior, therefore, researchers have often relied on historical data that were collected in the early 20th century, when these drugs were legal (Liu et al. 1999; Van Ours, 1995; Chandra, 2002; 2000). Such studies are, however, rare, and have focused exclusively on opium. To date there exist no studies that examine the simultaneous consumption of opium and other drugs and their interrelationships in a regime in which they are legal using reliable price data.

The aim of this study is to fill this important gap in the literature with a study of simultaneous opiate and cannabinoid consumption using unique data that were collected when both drugs were legal and tightly regulated by the government of the Punjab Province in British India. Within this broad aim, this study tests (i) how the consumption of opium responds to changes in its own price and those of two forms of cannabis, *bhang* and *charas* (hashish), (ii) whether opium has properties consistent with those of an addictive substance, and (iii) how the consumption of opium is associated with changes in consumer wages. The distinction between the different forms of cannabis is of great importance and demonstrates why they were treated as different products. *Bhang* refers to the dry leaves of the cannabis plant, which were traditionally ingested in liquid or solid (usually cooked) form. *Charas*, on the other hand, refers to the resinous material obtained from the cannabis plant, was usually smoked, and was significantly more potent in terms of THC content than *bhang* (Indian Hemp Drugs Commission, 1894). The analysis utilizes consumption and price data for opium, *bhang* and *charas* from 20th century British India.

Basic economic models of addiction link the consumption of a drug in the present time with its past consumption (Stigler and Becker, 1977; Boyer, 1983; Becker and Murphy, 1988; Becker et al., 1991; Suranovic et al., 1999). The driver of addiction in the economic model is the role that past consumption plays in increasing the reward (i.e., the marginal utility) of consuming the drug in the present (Becker et al., 1991; Becker and Murphy, 1988). Greater consumption in the past increases the reward in the present, leading to higher consumption in the present, all else being equal. This inter-temporal linkage has important implications for the effects that economic incentives, such as changes in the price or the consumer’s income, have on consumption in the present and the future. The inverse relationship between consumption and price of goods is well known in the field of economics. Taking this relationship as a starting point, if the price of an addictive substance rises at a point in time, its consumption at that point in time is likely to fall. Because of the inter-linked nature of past and present consumption described above, this drop in consumption also lowers consumption in subsequent time periods by reducing the reward in the future. Similar logic holds for the relationship between changes in income and changes in short-and long-term drug consumption, with the key difference being that income should have a positive association with consumption. These changes are manifested in the form of short and long-term own-price (i.e., the price of the drug itself) and income elasticities, where an elasticity measures the percentage change in the consumption of the drug in response to a 1% change in the price of the drug, a related drug, or the income of the consumer. A focus of this paper is the estimation of the price and income elasticities of opium.

Extant literature on substitution effects for opium and cannabis is very limited due to a lack of reliable population level data suitable to analyze these relationships. Saffer and Chaloupka (1999) is one of the few studies which simultaneously analyzes the consumption of an opiate (heroin) in the context of changes in the cannabis market. However, unlike the present study, the cannabis variable included in those models is not its price, but rather its decriminalization. The empirical literature that focuses only on the price sensitivity of opium consumption is, however, larger (see Chandra, 2002; 2000; Van Luijk and Van Ours, 2002; Van Ours, 1995). Additionally, there are a few studies that focus on the consumption of cannabis in conjunction with other substances, but these studies are limited by unreliable price information based on consumption in an illegal regime (Chaloupka and Laixuthai, 1997; DiNardo and Lemieux, 1992; Pacula, 1998).

Given the scarcity of reliable population-level data to study cannabis and opium consumption and cross-price effects for these substances, this work advances current understanding of multi-drug consumption. Additionally, because cannabis and opium consumption were legally controlled by the government in British India, the data used are reflective of “naturally” occurring behavior instead of behavior that is constrained by an environment of prohibition. This distinction is doubly important because, first, behavior under prohibition might be perceptibly different from naturally occurring behavior and may therefore not accurately reflect cross-price (i.e. substitution or complementarity) effects and second, cannabis consumption is gradually becoming legal in the USA and a number of other countries, making a study of cannabis consumption in a legal regime timely.

1.1 Historical and Regulatory Context

Consumption of opium and cannabis in British Punjab was governed by a different legal regime from the one in effect today. In early 20th century Punjab, the consumption of opium and cannabis in both its forms (*charas* and *bhang*) for recreational purposes was legal. Today opium and *charas* consumption are illegal, while *bhang* remains legal and can be purchased at government-licensed shops. Opium and cannabis were and are part of the traditional Indian medical (Ayurvedic) pharmacopeia. However, the bulk of these substances was being consumed for non-medical purposes. While accurate estimates of the total number of users of opium or cannabis are not available because the government did not collect such data, it is clear that the “occasional use” of bhang in Punjab as a seasonal drink and for social and religious purposes was “very common” but the number of “habitual consumers” was much smaller (Indian Hemp Drugs Commission Report, 1894, Volume 1, p.140). For opium, a plot of per capita consumption is presented in the appendix.

The production and sale of opium and cannabis was largely controlled by the government. While the cultivation of opium was managed through a system of licensing the cultivation of the opium poppy, it was produced in large quantities for domestic consumption across British India as well as for export to destinations across Asia, including but not restricted to the Dutch East Indies, French Indochina, Japanese Taiwan, and British Malaya. The Punjab market, therefore, represented a fraction of the market supplied by opium production controlled by the British India government. Opium was produced in a variety of locations both within and outside the Punjab, from where it was distributed to consumers through a government controlled (wholesale) or licensed (retail) supply distribution network. The wholesale price of government-issued excise opium was set by fiat. In addition, retailers had to pay license fees for the privilege of retailing opium. This two-tier (i.e., wholesale and retail) regulatory system enabled the government to exercise a significant degree of control over the retail price of opium.

While aggregate production of opium (for all British controlled provinces and the much larger worldwide export market) was in effect determined by the government through the licensing system, consumption in the domestic markets was driven by consumers. The system of distribution in the Punjab ensured that demand was filled. When inventories in the warehouses ran low, they were re-supplied by the government. In addition, opium produced from beyond the borders of British-controlled India (the so-called ‘hill opium’) was occasionally imported upon payment of duty into the Punjab to fulfill residual demand. In the event that there was surplus opium in government warehouses, this surplus was carried over into the following accounting period. So, while aggregate production and distribution were controlled by the government, consumption was driven by consumers in response to prices, and the supply side of the market was therefore responsive to demand at the regulated price. The Excise Administration Reports of the Punjab repeatedly bear witness to the phenomenon of price-responsiveness. For example, the covering letter by the Financial Secretary of the Punjab transmitting the 1915–16 report opens with the statement “The year 1915–16 was marked by a further decrease in the consumption … of opium… This is mainly a consequence of the increase in prices arising from the enhanced taxation…” (Punjab Excise Department, 1916).

2. MATERIALS AND METHODS

2.1 Data

The data cover 23 districts of the province of Punjab in British India over the period 1907–1918, spanning 12 years. Depending on the specification of the model, between 229 and 252 observations were used for parameter estimation. The region covered by these data is located in the present-day state of Punjab in India and the province of Punjab in Pakistan. The data were obtained from the annual provincial excise reports of Punjab (Punjab Excise Department, various years), the annual report on Prices and Wages in India (India, Department of Statistics, 1922), the quinquennial wage survey reports of the province of Punjab (Punjab Department of Land Records and Agriculture, 1912; 1917), the provincial season and crop reports for Punjab (Punjab Department of Land Records and Agriculture, various years), and the decennial censuses of Punjab (Rose, 1902; Kaul et al., 1912; Middleton and Jacob, 1922). Because the wage data were published quinquennially, they were interpolated to produce annual estimates. The annual population of each district was obtained from Chandra et al (2012).

The dependent and lagged dependent variables were the natural logarithm of per capita opium consumption and its lag, which were calculated by dividing the consumption of opium by the population of the district (Becker et al., 1991; Chaloupka, 1990). The retail prices of the drugs and wages were adjusted for inflation using the price of wheat, the most widely consumed staple in Punjab, a primarily agricultural society, to generate real prices for each of the three drugs and for wages. This is the standard approach for studies of colonial Asia that use price data (see, for example, Dick, 2002, p. 156). Plots of per capita opium consumption and the average annual price across the districts of the Punjab are presented in Figures 1–4. Together, these data provide the information necessary to estimate models of consumption of opium using the economics of addiction framework. Summary statistics on the key variables used in the models described in the next section are presented in Table 1. The real price variables for all three drugs show similar measures of spread across time and across districts. The real prices of the two cannabis products, bhang and charas, show a low-to-moderate correlation of 0.33 ($p < 0.0001$), reducing the possibility of multicollinearity. This is to be expected because both variables are computed using the same measure of inflation for each district and year.

2.2 Empirical Model

Prior to discussion of the empirical model, it should be noted that, because the prices of the drugs sold were determined in large part by a tightly controlled government regime, the standard problem of identification of a demand curve (Wooldridge, 2009, pp.552–558) that can arise when consumption is regressed on price without regard to supply effects is diminished.

Because the data are in the form of a panel (i.e., multiple districts over multiple years) of economic variables, panel data methods developed in the econometrics literature were used to analyze them. Standard econometric dynamic panel data models of opium addiction were estimated. The models were of the general form

$$C_{i,t}=\beta_0+\beta_1 C_{i,t-1}+\beta_2 P_{i,t}+\boldsymbol{\beta_3}\tilde{\mathbf{P}}_{\mathbf{i,t}}+\beta_4 I_{i,t}+\boldsymbol{\beta_5}\mathbf{T_t}+\boldsymbol{\beta_6}\mathbf{D_i}+\varepsilon_{i,t}$$

where $C_{i,t}$ is the log of per capita consumption of opium in district *i* in year *t*, $C_{i,t-1}$ is the lag of the log of per capita consumption of opium, $P_{i,t}$ is the log of the price of opium, $\tilde{\mathbf{P}}_{\mathbf{i,t}}$ is the vector of the log of the prices of *bhang* and *charas*, $I_{i,t}$ is the log of the average wage, and $\mathbf{T_t}$ $\mathbf{D_i}$ are vectors of year-specific and district-specific dummy variables respectively, and $\varepsilon_{i,t}$ is a random error term. The parameters to be estimated are represented by the symbol β_k, and the corresponding parameter estimates by β_k. The presence of the lagged dependent variable in the above specification makes the model a dynamic panel data (DPD) model, necessitating the use of instrumental variables methods to eliminate potential endogeneity resulting from the correlation of the lagged dependent variable with the error term (Baltagi, 1995, 1998; Baltagi and Levin, 1992; Blundell and Bond, 1998). This approach also addresses possible issues with identification of the demand curve briefly discussed above, though these are not expected given the regulated nature of drug prices. Therefore, the models were estimated using the generalized method of moments (GMM; Hansen, 1982; Holtz-Eakin et al., 1988). The process of first differencing variables in the GMM models eliminates the district-specific effect and, if a time-trend variable is included, converts it into a constant. In estimating GMM models, a number of decisions need to be made. The first (‘one-step’ vs. ‘two-step’) choice relates to the method for estimation of the weighting matrix for instruments, with the latter approach usually favored. The second (‘difference’ vs. ‘system’ GMM) relates to the choice and number of instruments to be included in the model (Roodman, 2006). Provided that there is no problem with over-identification due to an excessive number of instruments, the ‘system’ approach to GMM, which involves the use of lags of the first-differences and levels of independent variables as instruments, is favored. Because there was evidence of over-identification using the Sargan test for over-identification in the system GMM model, however, we selected the difference GMM model. Finally, a choice had to be made as to the number of lags for which instruments would be included in the model. Given the problems with over-identification in the system variant of the GMM models, we opted for models with a single lag to minimize the number of instruments.

The above models were estimated using the ‘xtabond2’ function in Stata, version 12 (StataCorp, 2011; Roodman, 2009). For comparison with the estimates obtained using difference GMM, results from an equivalent pair of system GMM models are also presented.

3. RESULTS

Table 1 contains four sets of estimates for the models of opium consumption. Both sets of GMM models (one-step and two-step) generate substantively similar results for the difference and system specifications. An addictive drug should exhibit a positive association between consumption in the past and consumption today. The coefficients on the lagged log of consumption (consumption in a previous time period) of opium in the difference GMM models are positive, significant, and less than 1 in value, showing evidence of addictive properties ($\beta_1 = 0.47$ to 0.49, $p < 0.01$). While the system GMM models corroborate this finding ($\beta_1 = 0.83$ to 0.89, $p < 0.01$), those estimates are much closer to 1 with a p-value of the Sargan test for over-identification of less than 0.10, suggesting a problem with over-identification (or too many instruments). The results for own-price and wage elasticity between the one-step and two-step difference GMM models are similarly consistent, and are much more similar to the system GMM models as well.

The coefficient on the log of the real price of opium is negative and small ($\beta_2 = -0.34$ to -0.35, $p < 0.05$) showing that opium is own-price inelastic. We also see evidence of wage/income inelasticity for opium ($\beta_5 = 0.15$, $p < 0.05$). With respect to the cross-price elasticities of between opium and cannabis, we find that opium ($\beta_3 = 0.14$, $p < 0.05$) shows evidence of substitution with *charas*. An increase in the price of *charas* is associated with an increase in the consumption of opium.

4. DISCUSSION

The key new finding of this paper is that of a substitution effect between a form of cannabis, *charas* (or hashish) and opium. In other words, a change (say an increase) in the price of *charas* is associated with a change in opium consumption in the same direction (i.e., also an increase). Interestingly, this finding is corroborated by anecdotal evidence about substitution between opium and cannabis. For example, we know from the Indian Hemp Drugs Commission Report (1894; Vol. 1, Chapter 10, p. 177, for example), that “hemp drugs are used as a substitute for opium.”

Other findings of this study include the influence of past opium consumption on present consumption and its slightly price- and wage-responsive nature (i.e., inelasticity), as evidenced by price and wage elasticities that are less than 1 in absolute value (with the appropriate signs). These results are in keeping with earlier work on the subject which also finds the habit-persistence property, which is consistent with addiction, and own-price and income inelasticity of opium in the short run (Van Ours, 1995; Liu et al, 1999), though not in models that incorporate a substitute like cannabis.

Limitations of this study include, first, possible context-specificity. The finding on substitution (i.e., between opium and *charas*) may be specific to the cultural context (i.e., early 20th century Punjab). However, the findings on habit persistence and own-price and income responsiveness match findings from other very different contexts [i.e., the Dutch East Indies in Van Ours (1995) and Japanese Taiwan in Liu et al (1999)], suggesting that they may be broadly robust to variations in locational and temporal context. In addition, even within the context of India, today’s drug regime differs from that of the early 20th century. The only form of cannabis that can be legally consumed in India today is ‘bhang.’ Charas (hashish) and opium are now illegal. Likewise, while opium is now illegal in India, it is refined for medicinal use as morphine, codeine, and other by-products. Bhang is often consumed during festivals in India today just as it was in the early 20th century. A second limitation, insofar as understanding individual-level behavior is concerned, is the aggregate nature of the data. While the interpretation of the findings as reflective of individual behavior should be made with great caution and only under very strong assumptions about consumer behavior [including but not restricted to homogeneity across all consumers, which is usually not justifiable (Stoker, 1993)], the results are a true reflection of market-level phenomena, which may not be easily derived from small-sample individual-level data. A third limitation, which applies specifically to the inclusion of the price of *bhang*, is the presence of ‘wild’ *bhang* in the Punjab. There is evidence that *bhang* was cultivated in the wild and outside the system of strict government control, and could have been used as a substitute for government issued *bhang*, thereby weakening any relationship between the price of the officially sold bhang and the consumption of opium. However, because this ‘wild’ *bhang* tended to be of inferior quality compared to the *bhang* supplied in government licensed stores (Indian Hemp Drugs Commission Report, 1894), the degree to which the existence of a ‘free’ (albeit poor) substitute for government-issued *bhang* affects the results of the opium consumption model is probably limited.

Despite the aforementioned limitations, the results of this study should be of interest to researchers working on drug use and drug dependence for a variety of reasons. First, they represent the first population-level results of a study of simultaneous opium- and cannabis-consuming populations at a time when the recreational use of both drugs was legal. This enables us to analyze interrelationships between consumption of the different drugs in an environment in which consumer behavior is not constrained by considerations of illegality. Second, the distinction between two major categories of cannabis products [*charas* (hashish/cannabis resin, strong) and *bhang* (leaf, weak)] enables us to understand differences in the treatment of the same drug when served as different products --- the relationship between the stronger *charas* and opium is different from that between the weaker *bhang* and opium. Finally, the fact that the parameter estimates in the opium models are within reasonable ranges as evidenced by earlier studies suggests that the data obtained from the British India reports contain reliable information about consumer behavior.

The results of this study may have important implications as we seek to understand how populations of drug users respond to economic incentives in a legal regime. The gradual progression of the status of cannabis in the USA from illegal to legal can also be informed by this study. For example, the finding that consumption of opium responds differently to changes in the prices of the different cannabis products suggests that the present-day approach of treating cannabis as a homogeneous product in early studies on price elasticity in the USA may not be as fruitful as one that purposefully distinguishes between the different available products. Additionally, the finding of a substitution effect between hashish and opium suggests that attempts to tax cannabis, especially in its more potent forms, may drive consumers to consume other substances. The increasing trend in THC-potency of cannabis products in the USA (Mehmedic et al., 2010; Burgdorf et al., 2011; ONDCP, 2014) makes this finding all the more significant.

This study also lays out a path for future studies on consumer behavior of multiple drugs in a legal regime by providing a first set of benchmark population-level own-price, cross-price, and wage elasticity estimates. The different properties of the two cannabis products suggest that further research to discern how the biological differences in the action of opium and the two cannabis products translate into consumer behavior may also yield valuable insights into how to manage drug consumption in a legal regime so as to minimize detrimental health outcomes.

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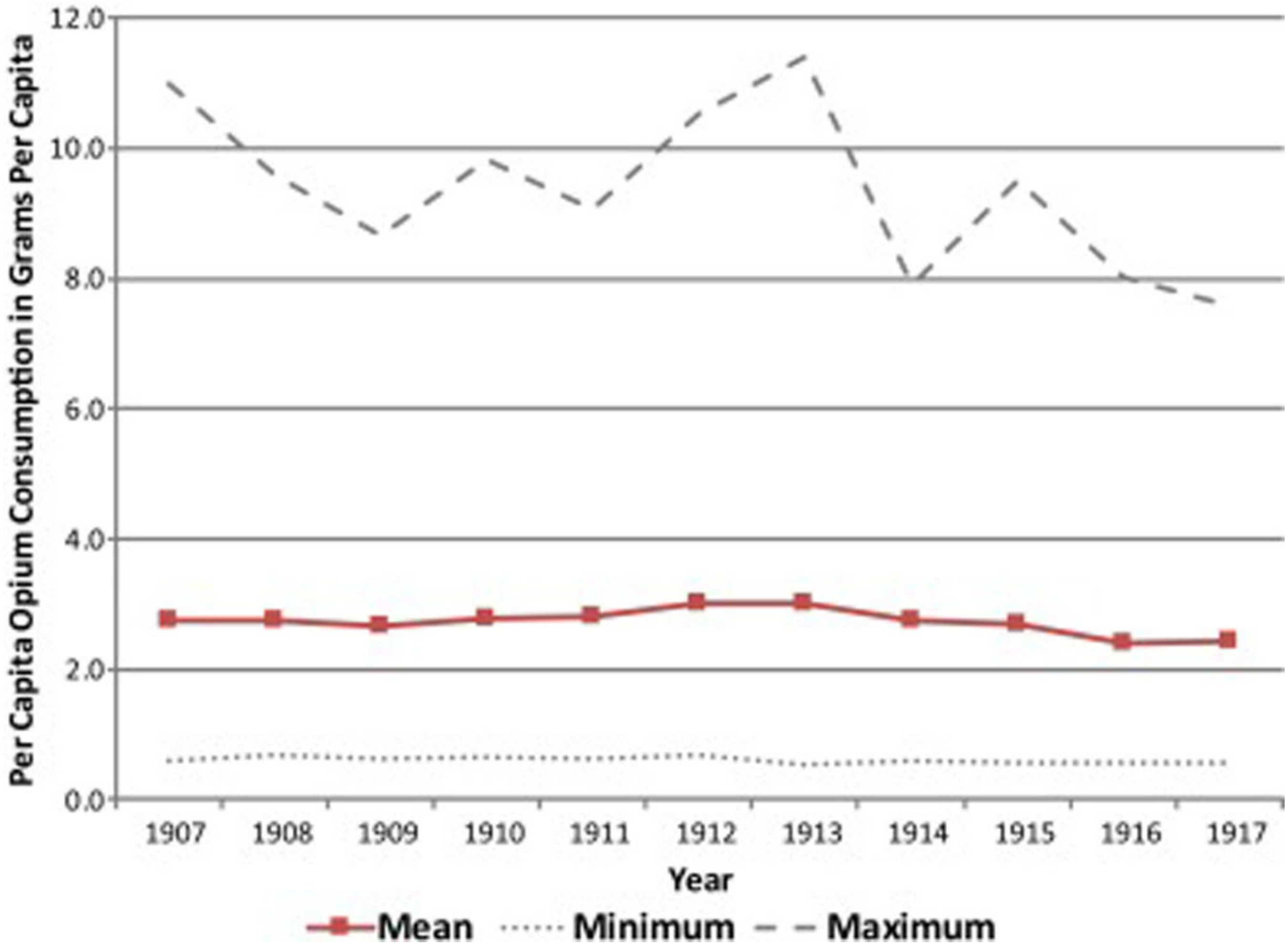

Figure 1.
Annual Per Capita Opium Consumption Punjab, India, 1907–17

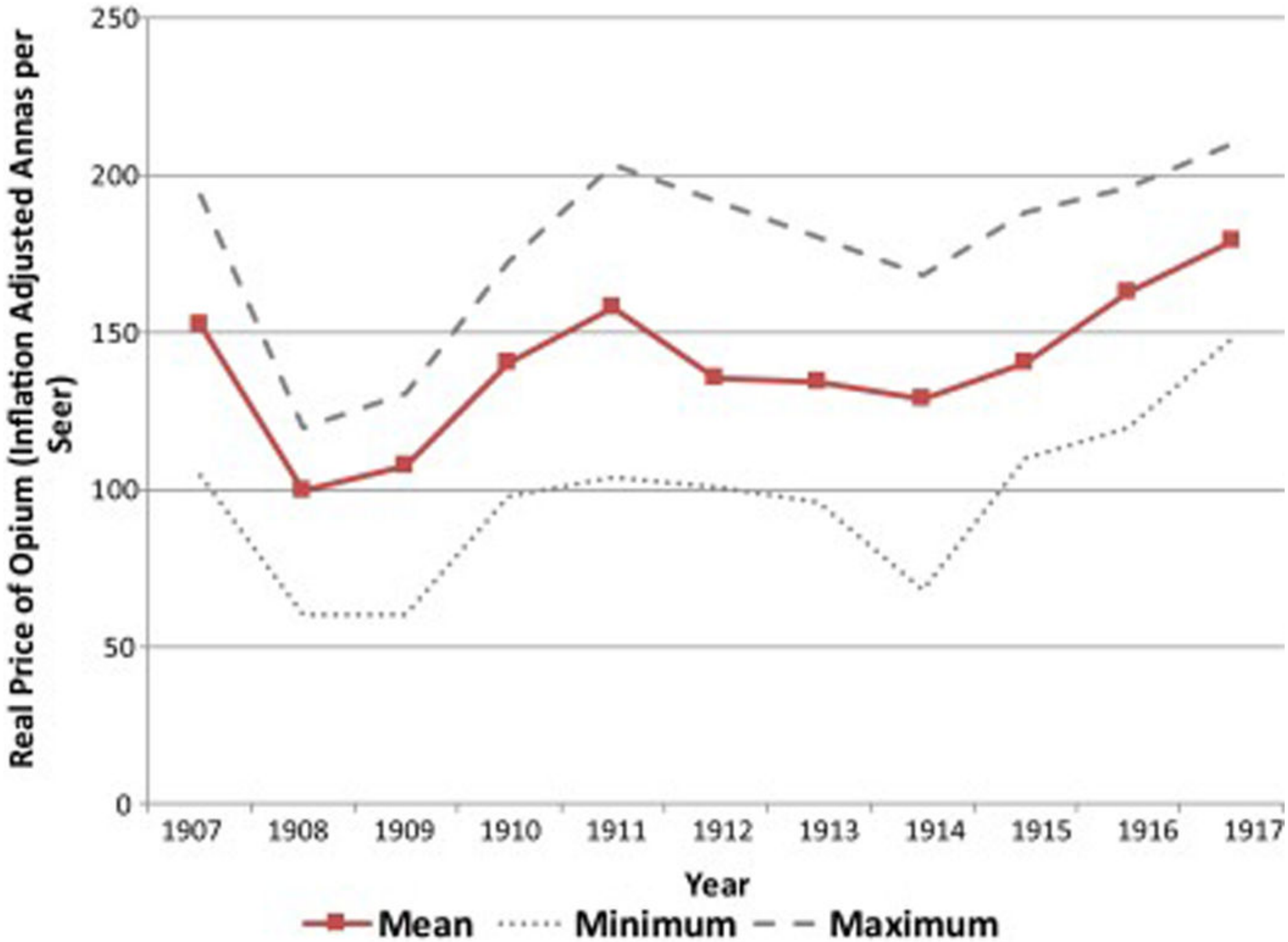

Figure 2.
Real Price of Opium Punjab, India, 1907–17

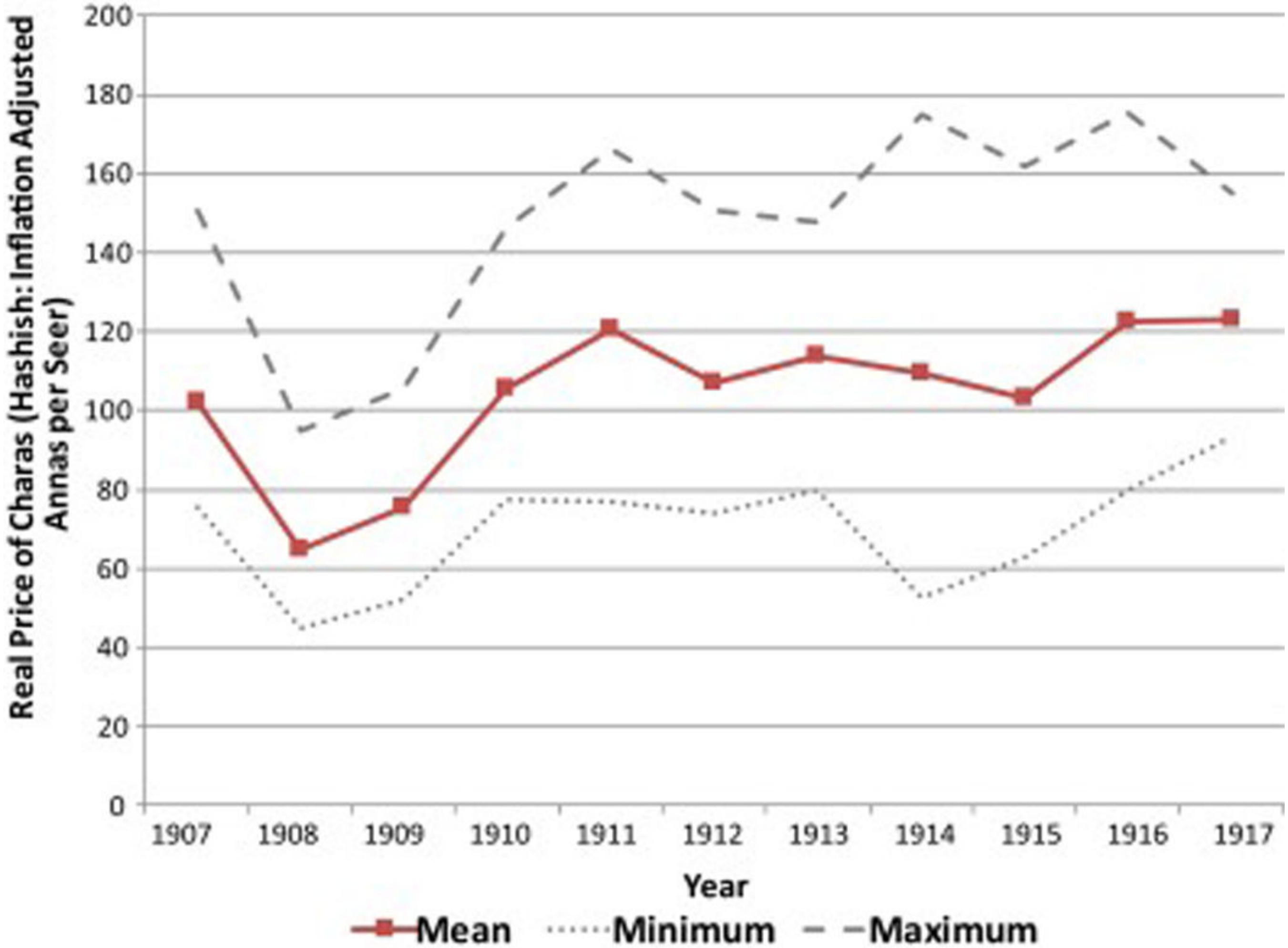

Figure 3.
Real Price of Charas (Hashish) Punjab, India, 1907–17

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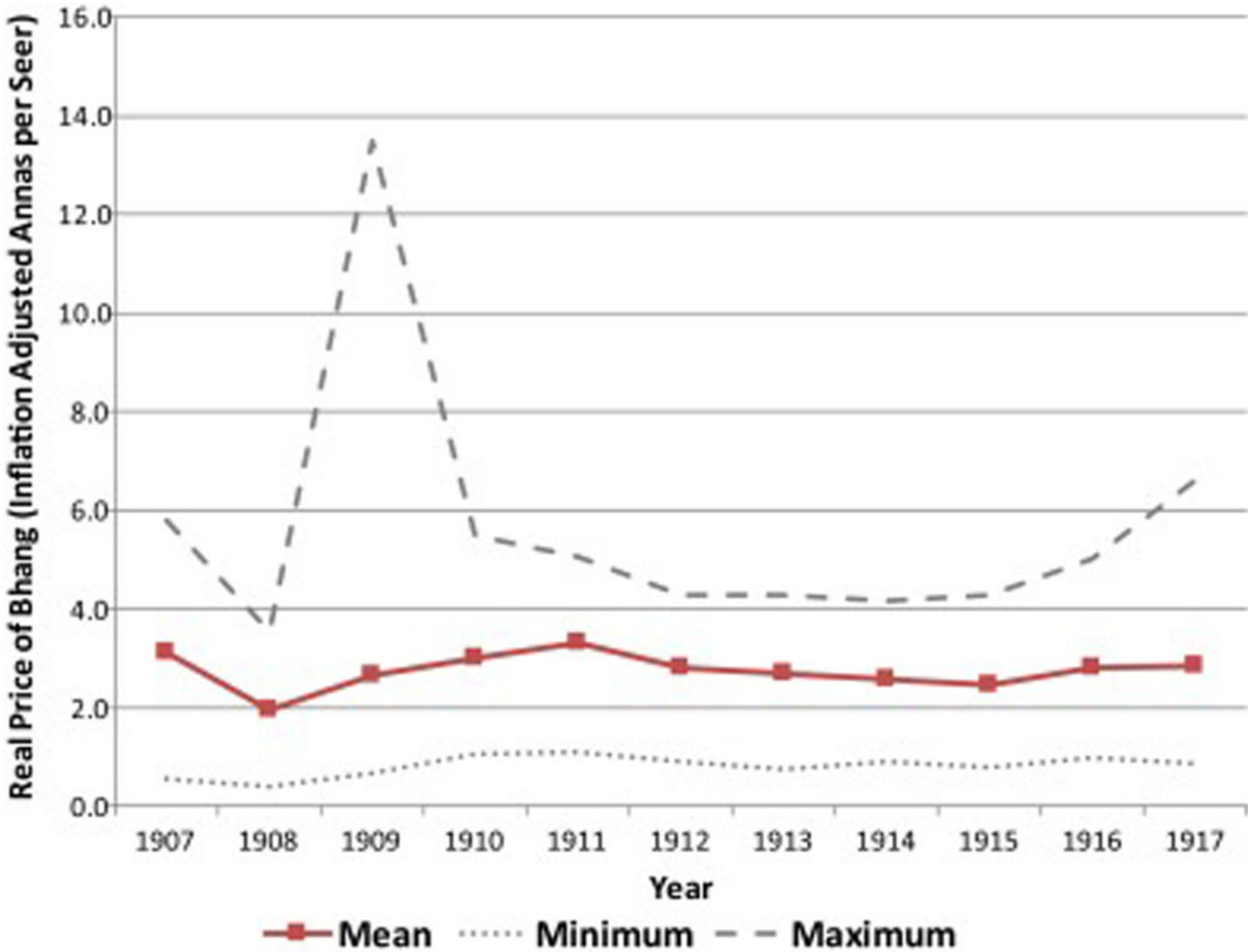

Figure 4.
Real Price of Bhang Punjab, India, 1907–17.

Table 1

Descriptive Statistics on Variables Used in Dynamic Panel Data Models (n=252)

Variable	Mean	Standard Deviation	Minimum	Maximum
Per Capita Opium Consumption (grams per capita)	2.8750	2.5071	0.5160	12.2092
Real Price of Opium (Inflation Adjusted Annas per Seer)	145.94	39.62	60.00	283.28
Real Price of Charas (Hashish; Inflation Adjusted Annas per Seer)	108.10	30.53	44.76	196.50
Real Price of Bhang (Inflation Adjusted Annas per Seer)	2.73	1.39	0.41	13.47
Real Wage (Inflation Adjusted Pies Per Day)	0.11	0.04	0.03	0.20

Table 2

GMM Estimates for Opium Consumption Models†

Variable ↓Model→	Difference (1-Step)	GMM (2-Step)	System (1-Step)	GMM (2-Step)
Intercept	---	---	0.19 (0.58)	0.12 (0.50)
Lagged Log of Consumption	0.49*** (0.17)	0.47*** (0.16)	0.83*** (0.09)	0.89*** (0.05)
Log Real Price Opium	−0.34*** (0.11)	−0.35*** (0.09)	−0.31*** (0.10)	−0.23** (0.11)
Log Real Price Charas	0.14** (0.05)	0.14** (0.05)	0.14* (0.08)	0.13* (0.07)
Log Real Price Bhang	0.00 (0.02)	0.00 (0.02)	0.01 (0.03)	0.01 (0.04)
Log Real Wage	0.14** (0.07)	0.15** (0.06)	0.16** (0.07)	0.14* (0.07)
Arellano-Bond test (AR 2)	0.00	−0.04	0.30	0.32
Pr > z	1.00	0.97	0.76	0.75
Hansen Test	0.48	0.48	7.72	7.72
Pr > χ^2	0.79	0.79	0.10	0.10
Number of observations	229	229	252	252
Number of instruments	17	17	20	20

Notes:

1) Significance Level <0.10 =*, <0.05=**,< 0.01=***

2) SE in parentheses

†Year-specific fixed effects included but not reported; Windmeijer-corrected cluster-robust standard errors adjusted for small sample size; 'collapse' option used to reduce number of instruments. See Roodman (2009) for details.

Table 3

Summary of Results for Opium Consumption

Phenomenon		GMM Model Specification			
		Difference		System	
		One-Step	Two-Step	One-Step	Two-Step
Habit persistence (possible addictiveness)		✓	✓	✓	✓
Own-price Responsiveness	Very ('elastic')/slightly ('inelastic')	Slightly	Slightly	Slightly	Slightly
	Short-term elasticity	−0.34	−0.35	−0.31	−0.23
	Long-term elasticity	−0.67	−0.66	−1.82	−2.09
Wage Responsiveness	Very ('elastic')/slightly ('inelastic')	Slightly	Slightly	Slightly	Slightly
	Short-term elasticity	0.14	0.14	0.14	0.13
	Long-term elasticity	0.27	0.26	0.82	1.18
Relationship to Cannabis		Substitute for *charas* (hashish)	Substitute for *charas* (hashish)	Substitute for *charas* (hashish)	Substitute for *charas* (hashish)
Technical Issues	Autocorrelation	None	None	None	None
	Overidentification	None	None	Present	Present