Estimating Own- and Cross-price Elasticity of Cigarette Consumption by Price Tiers in Bangladesh

Tobacconomics Working Paper Series

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No. 22/3/1

March 2022

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Suggested citation: Shimul, S., & Hussain, A. K. M. (2022). *Estimating own- and cross-price elasticity of cigarette consumption by price tiers in Bangladesh*. www.Tobacconomics.org

Acknowledgments: This study is funded by the University of Illinois Chicago's (UIC) Institute for Health Research and Policy to conduct economic research on tobacco taxation in Bangladesh. UIC is a partner of the Bloomberg Philanthropies' Initiative to Reduce Tobacco Use. The views expressed in this document cannot be attributed to, nor can they be considered to represent, the views of UIC, the Institute for Health Research and Policy, or Bloomberg Philanthropies.

Abstract

Background

The overall price elasticity of cigarette consumption in Bangladesh has been studied extensively. Although overall price elasticity can explain aggregate effects, this measure cannot provide brand-specific effects of tax-induced price increases on cigarette consumption. This is especially true in the presence of a wide range of prices and cigarette brands within a differential tax structure based on price and product characteristics. Tiered price and tax systems induce brand substitution when tax and prices increase and undermine the intended effect of a price increase. It is, therefore, necessary to estimate brand-specific price elasticities, both own- and cross-price elasticities, by price tiers for an effective tax and price policy formulation aimed at reducing cigarette smoking. Studies that estimate price elasticity by price tiers are very few. To the authors' best knowledge, there are no such studies for Bangladesh, a country that has a more than three-decade long history of tiered price and tax structures for cigarettes.

Methodology

Using a cohort survey of nearly 6,000 individuals from the International Tobacco Control (ITC) Policy Evaluation Project in Bangladesh, this study estimates the own- and cross-price elasticity and income elasticity of cigarette demand by price tiers in Bangladesh. The elasticities are estimated in three stages of consumer decisions: first, whether to smoke (price elasticity of smoking prevalence); second, which brand to smoke (price elasticity of brand choice); and third, how many cigarettes to smoke per day (price elasticity of smoking intensity). Elasticities estimated from these stages are combined to estimate total elasticity. The elasticities of smoking prevalence and brand choice in the first and second stages are estimated using probit regressions. The elasticity of smoking intensity is estimated using ordinary least squares regression. In addition, to separate regressions in the three stages, the second and third stages of consumer decision making on brand choice and consumption per day (CPD) are combined in a seemingly unrelated regression (SUR) model, considering the simultaneity of decisions on brand choice and CPD. To test for and address the endogeneity of prices in cigarette consumption decisions, the instrumental variable approach was used in all three stages.

Results

The price elasticity of cigarette smoking prevalence with respect to the price of low-price cigarettes is -0.0487. The total elasticity for low-price cigarette consumption with respect to its

own price is -0.1678, which is the sum of the elasticity of smoking prevalence of -0.0487 and the elasticity of smoking intensity of -0.1191.

While smoking prevalence is not sensitive to increases in the price of high-price brands, smoking intensity is: the own-price elasticity of smoking intensity of high-priced brands is -0.2512. The cross-price elasticity of low-price cigarette consumption with respect to high-price brand prices is 0.2643, suggesting that increases in the price of high-price cigarettes may induce smokers to switch to low-price cigarettes.

The results also suggest that income growth can lead to reduction in the intensity of smoking low-price cigarettes and increase in the intensity of smoking high-price cigarettes. The income elasticity of smoking prevalence overall is 0.0564. The income elasticity of daily consumption of low-price cigarettes is -0.1934 and for high-price cigarettes it is 1.4044, which likely indicates that smokers are trading up from low-price to high-price brands as their income increases. The total income elasticity is negative for low-price cigarettes, as the negative effect of income growth on smoking intensity is greater than the positive effect on smoking prevalence. The total income elasticity is 1.4608 for high-price cigarettes, signifying that higher income enables smokers to purchase more expensive brands and therefore increases the demand for high-price cigarettes.

Conclusion

Increasing the price of low-price cigarette brands can effectively reduce smoking prevalence and smokers' daily cigarette consumption, thereby reducing overall cigarette consumption in Bangladesh. Increasing the price of high-price cigarette brands without increasing the price of low-price brands may encourage smokers to switch to low-price brands instead of quitting. Moreover, as income growth contributes to higher smoking prevalence, increases in cigarette prices need to outpace income growth. A cigarette tax policy that raises the prices of both low-price and high-price brands—but increases prices in the low-price tier at a faster rate than in the high-price tier and increases prices of all brands at a pace faster than income growth—can effectively reduce cigarette consumption in Bangladesh.

JEL Codes: H29, L66, I18
Keywords: Elasticity by price-tiers, brand-switching, total elasticity

Introduction

Background

Bangladesh is one of the signatories of the international health treaty, the World Health Organization Framework Convention on Tobacco Control (WHO FCTC), which aims at reducing tobacco use significantly by adopting a comprehensive set of provisions to limit production, distribution, sale, promotion, and advertisement. Since the WHO FCTC came into force in 2005, Bangladesh has made some progress in terms of measures taken to reduce tobacco use, such as banning advertisement and promotion of tobacco products, implementing text and graphic health warnings on packs, increasing tax and prices, and mass media campaigns to raise public awareness about the harms of tobacco use. However, many challenges remain. The prevalence of smoking in Bangladesh is still very high at around 18%. Including smokeless tobacco (SLT) use, overall tobacco use prevalence is 35.3% (GATS, 2017). Youth tobacco use is also high in Bangladesh: nearly 7% of 13–15-year-old youths used tobacco products in 2012 (Barkat et al., 2012)

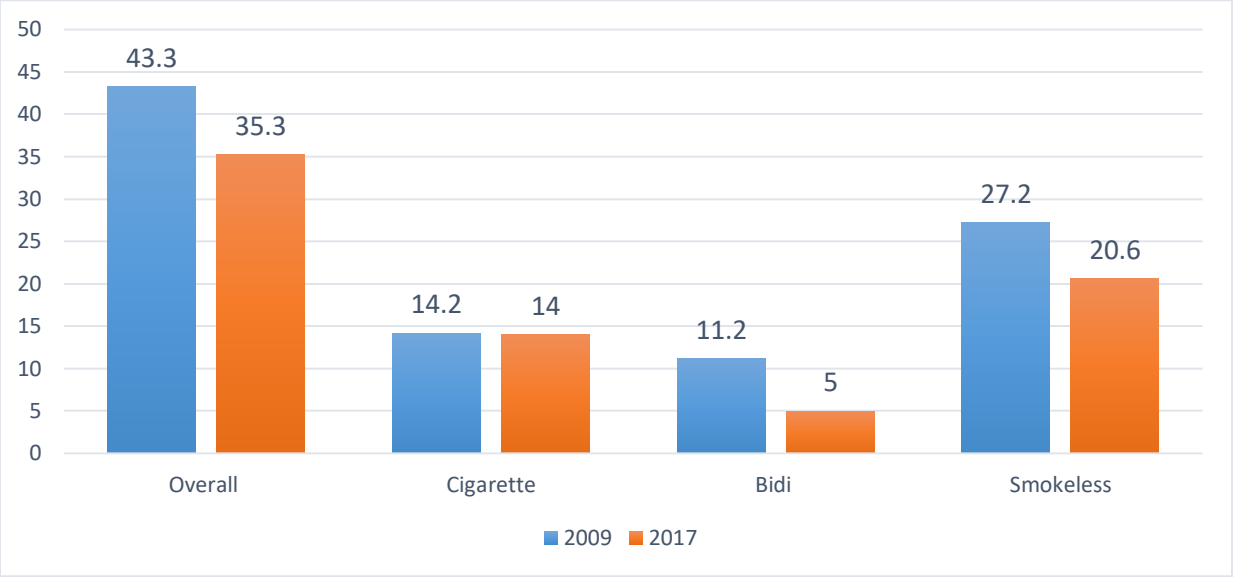
Raising taxes on tobacco products is a proven measure to curb tobacco consumption worldwide. Moreover, this policy instrument can help raise extra tax revenue since demand for tobacco products is price inelastic. Higher tax on tobacco products induces higher price and reduces their affordability, which in turn reduces consumption and improves people's health. Even though Bangladesh nearly reaches the minimum international tobacco tax benchmark set by the WHO with a total tax share above 70% of the retail price of the most popular brand of cigarettes, the prices of tobacco products in Bangladesh are among the lowest in the world (WHO, 2021) and the second lowest (after Myanmar) in the South-East Asia Region (WHO, 2017, as cited in World Bank, 2019). High tax share can be misleading as a stand-alone performance measure of tobacco taxation (Nargis et al., 2019a). A cigarette tax scorecard developed by Chaloupka and colleagues (2021) scores countries based on four components: cigarette price, changes in the affordability of cigarettes over time, the share of taxes in retail cigarette prices, and the structure of cigarette taxes. On a five-point scale, Bangladesh scores 2.63, pulled down particularly by low scores on tax structure and price, and it has a long way to go to reach a high-performance level that would score above 4.0.

Moreover, Bangladesh experienced relatively high rates of inflation (5.56–12.30%) in the last two decades (Bangladesh Economic Review, 2021) and this inflation was not reflected in higher tobacco product prices. Hence, the real price of tobacco products decreased. In sum, high income growth in the recent past, coupled with decreasing real price of tobacco products, increased the affordability of tobacco products (Nargis et al., 2019b).

Cigarette tax policy changes in Bangladesh have not been adequate to induce significant increases in cigarette price that can outpace income growth and inflation. The effectiveness of any tax increase in Bangladesh is further marred by the presence of a tiered tax system that likely has at least two inadvertent consequences: (i) the reduction in consumption may be less than intended since tax and price increases may induce smokers to switch to lower-price brands (Nargis et al., 2019b) and (ii) government may not be able to realize the full revenue potential as tobacco companies are induced to reposition brands with concomitant marketing strategies to drive up sales of lower-tax brands to avoid higher tax payments (Hossain at al., 2021). Complex tax systems thus tend to generate gains for producers—in lower tax liability and higher profits—at the expense of a reduced impact on consumption, health, and tax revenue.

It is evident that tobacco industry pricing induces higher cigarette consumption in the low-price tier and undermines the effectiveness of higher taxes in Bangladesh (Nargis et al., 2020). Therefore, even though overall tobacco consumption in Bangladesh has been declining (Figure 1), having widely differential prices has kept the option open to brand switching from high- to low-priced cigarettes, especially by those in lower income groups that may make the target of achieving tobacco free country by 2040 as envisioned by the government of Bangladesh.

Figure 1. Prevalence of tobacco use in Bangladesh, overall and by type of tobacco product, 2009 and 2017



Source: Global Adult Tobacco Survey (GATS), Bangladesh, 2009, 2017

One major concern is that, in the last few years, the number of adult cigarette smokers and intensity increased (as shown in Table 1). This increase is primarily driven by increases in cigarette consumption in the lowest price tier. Besides, the prevalence of tobacco consumption is much higher among the poorest segment of the population, where the tendency of brand-switching to cheaper cigarettes is strong, which is evident from the GATS 2009 and 2017 survey data. For instance, while the prevalence of bidi consumers declined from 2009 to 2017 (Figure 1) the prevalence of cigarette consumers remained almost steady, which may indicate that many users switched from bidi to low-price cigarettes over this period. While an increase in the prices of high-price cigarettes may induce people to switch to low-price brands, income increase may encourage people to switch to factory made tobacco products from bidi. Therefore, switching between products or brands of the same product may slow the pace of reducing the overall prevalence of tobacco consumption, especially among the poorest segments of the population. In this connection, it is imperative to understand the brand-choice[1] behavior and price elasticity specific to different price tiers for better and evidence-based policy making.

[1] Even though the switching behavior especially from bidi to low-price cigarettes appear to be pertinent, the current analysis is restricted to cigarettes only to understand the price responsiveness of cigarette consumption between the price tiers of cigarettes.

Table 1. Number of adult cigarette smokers, cigarettes per adult, and cigarettes per smoker in Bangladesh, 2009 and 2017

	Number of adult cigarette smokers (millions)	Number of cigarettes per adult person per year (sticks)	Number of cigarettes per smoker per year (sticks)
2009	21.90	498	6,028
2017	22.35	586	7,544

Source: Authors' calculations from total cigarette sales data obtained from the National Board of Revenue, Ministry of Finance, Government of Bangladesh, and number of adult smokers calculated by multiplying total adult population (from the Bangladesh Bureau of Statistics) and adult smoking prevalence (from Global Adult Tobacco Surveys, Bangladesh, 2009 and 2017).

In a recent study, Huq et al. (2019) used ITC survey data from Bangladesh to model the transition to or from different price tiers of cigarettes. They observed significant movement of smokers across price tiers from one wave to another. The study also investigated the reasons for switching, although no estimation of price elasticity was undertaken for different price tiers. The price responsiveness can be significantly different across price tiers, which may call for different policy suggestions than those based on uniform price elasticity estimates for all tiers. While overall price elasticity estimates are available for cigarette consumption in Bangladesh (e.g., Nargis et al., 2014; Ahmed et al., 2021), the estimates are not yet available by price tiers.

In the absence of estimates of price elasticity by price tiers with differential tax rates, tax simulation analysis, which is necessary to understand the impact of tax policy changes on revenue and consumption, falls short of accuracy in its predictions. This study seeks to fill that knowledge gap by estimating price elasticity by price tiers of cigarette brands.

Methodology

The data

The data set used in this study comprises cohort data of tobacco users and non-users in Bangladesh. Four waves of data were collected from January 2009 to April 2016 by the International Tobacco Control Policy Evaluation Project in Bangladesh by the University of Waterloo in collaboration with the University of Dhaka. All four waves of data were used in the current study. The sizes of overall and cigarette smoker samples for each of the four waves of the

survey are provided in Table 2. Further details of the sampling methods and survey design are available elsewhere (ITC Project, 2020a, 2020b, 2020c, 2020d).

Table 2. Sample information of the International Tobacco Control (ITC) Policy Evaluation Project in Bangladesh: Waves 1–4

Wave	Time	Observations	% Cigarette smokers
Wave 1	January 21 to May 11, 2009	5,771 (1,925 cigarette smokers)	33.36%
Wave 2	March 18 to June 5, 2010	5,795 (1,971 cigarette smokers)	34.01%
Wave 3	November 16, 2011, to June 5, 2012	5,522 (1,723 cigarette smokers)	31.20%
Wave 4	October 12, 2014, to April 16, 2015	4,236 (1,287 cigarette smokers)	30.38%

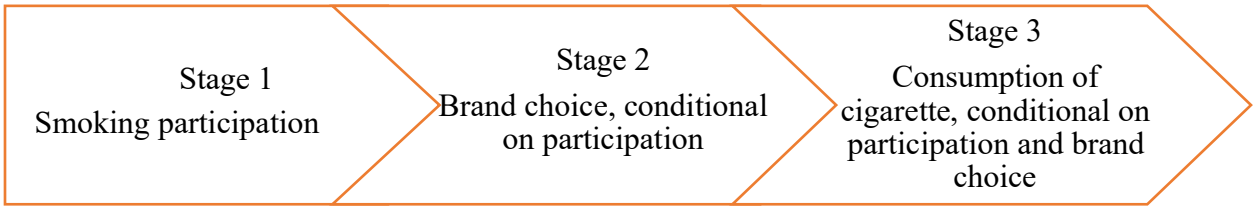
Some variations are observed in the sample size of different waves due to sample attrition and subsequent replenishment. Altogether, 3,245 households responded in all four waves. For 5,668 households, data are not available for all waves. The analysis is restricted to male respondents aged 18 and above, as female smoking prevalence is very low in Bangladesh (less than 2%) and the number of female cigarette smokers in the sample is negligible. The final analytical sample size pooled over the four waves is 8,148 observations in an imbalanced panel.

The data set includes measures on smoking behavior of individuals, their socio-demographic characteristics (e.g., age, sex, household income, education, occupation, and urban/rural area of residence), and purchasing behavior of tobacco products, including the amount purchased and prices paid. The price and income variables reported in waves 1, 2, and 3 are adjusted for inflation and converted to 2014–15 constant prices as in wave 4.

Analytical framework

Three components of own- and cross-price elasticity are estimated based on three stages of consumer decision making depicted in Figure 2: (i) the decision to smoke; (ii) choosing low- or high-price brands, conditional on the decision to smoke; and (iii) the number of cigarettes smoked per day, conditional on the decision to smoke and the choice of low- or high-price brands.

Figure 2. Stages of consumer decision making in analytical framework



First, elasticity of smoking prevalence is estimated from the information on whether the individual is a cigarette smoker or not. As self-reported price data are only available for those who are smokers, it is necessary to impute the price for non-smokers. These estimates are produced using out-of-sample prediction of prices from a random effects panel regression of smoker-reported prices per pack of 20 cigarette sticks, using their individual characteristics and primary sampling areas as independent variables.

In the second stage the elasticity of choice of low- versus high-price brands is estimated, conditional on smoking participation. In Bangladesh, four types of brands—low, medium, high, and premium— are available according to four price tiers. The bottom two tiers (low and medium) are combined into the low-price brand category (henceforth denoted as LM) and the top two tiers (high and premium) are combined into the high-price brand category (henceforth denoted as HP). There are two reasons to make this separation.

First, the majority of cigarette consumption in Bangladesh takes place in the low- and medium-price tiers. Over the period from 2009 to 2015, cigarette sales in the low- and medium-price tiers accounted for 80–85% of total tax-paid cigarette sales, according to the National Board of Revenue data. This dichotomy in brand choice is reflected in the ITC survey data, with far fewer observations on HP brands than on LM brands. Separate analysis for each of the four tiers is not possible due to a lack of representative samples in each category.

Second, the price variation within each price category is not wide enough to identify the tier-specific effect of price changes on cigarette consumption.

In the third stage, elasticity of smoking intensity (cigarette consumption per day, or CPD) is estimated, conditional on smoking participation and choice of brand.

Empirical models

Three sets of empirical models are applied for each of the three decision stages.

Stage 1: Smoking prevalence

To estimate the elasticity of smoking prevalence, a regression of the probability of being a cigarette smoker is first run on the potential determinants of cigarette demand including price, income, individual socio-demographics, and other factors. The models are specified as follows:

$$\Pr(Smoker_{it} = 1|P_{it}, Z_{it}, \in_{it}) = \alpha_i + \beta_o P_{it} + \beta_i Z_{it} + \in_{it} \quad \text{(Model 1)}$$

$$\Pr\left(Smoker_{it} = 1\middle|P_{it}^{LM}, P_{it}^{HP}, Z_{it}, \in_{it}\right) = \alpha'_i + \beta_{LM} P_{it}^{LM} + \beta_{HP} P_{it}^{HP} + \beta'_i Z_{it} + \in'_{it} \quad \text{(Model 2)}$$

where P is price and Z is a vector of the other control variables of income, age, education level, occupation, rural/urban resident status, marital status, and the number of friends who are smokers. The suffix i stands for individual respondent and t stands for waves 1, 2, 3, and 4. While model (1) controls for a single price, model (2) includes prices of LM and HP brands (P_{it}^{LM}, P_{it}^{HP}) separately. Model (1) shows whether overall price matters for the decision to smoke. Model (2) captures the effect of prices on smoking prevalence at different price segments. In both models, the other control variables remain the same.

Since individuals can also choose by price, the endogeneity of self-reported prices can bias the estimated effect of price. Therefore, prices are instrumented using a composite housing index that summarizes characteristics of housing of respondents to represent their socioeconomic status. This composite index was developed in the ITC Bangladesh survey and was categorized into low, medium, and high socioeconomic status based on terciles. More details of the housing index are available in the *ITC Project Technical Reports* (ITC Project, 2020a, 2020b, 2020c, 2020d). The housing index is a broad measure of affordability of housing by households and is expected to be highly correlated with the affordability of other household goods and services. Thus, it is expected to reflect the affordability of tobacco products—that is, the price they pay to purchase tobacco products given their household income. Considering that the "number of friends" variable may be endogenous, the regression is also run without the variable. No changes are observed in the statistical significance of other variables. Although the magnitude of the estimates changes to some extent, they are not statistically different from the estimates obtained from the regression that includes the "number of friends who are a smoker" variable.

The abovementioned models are estimated using logit, probit, panel logit, panel probit, and instrumental variable probit (IV probit) regressions. In panel logit and probit estimation, random

effects models are used instead of fixed effects models because: (i) the fixed effects models would lose observations for those respondents who appear only once in the panel and (ii) the fixed effects model would not allow for the identification of the effect of any variable with no within-person variation (e.g., residence) or little within-person variation (e.g., completed education) over time. As the purchase price of cigarettes was not reported by non-smokers, their price is imputed using predicted price from the following random effects regression models of self-reported price for all brands and for LM and HP separately:

$$P_{it} = \gamma_o + \gamma_1 Z''_{it} + v_i + wave_t + psu_{is} + \varepsilon''_{it} \quad (I_o)$$

$$P^{LM}_{it} = \gamma^{LM}_0 + \gamma^{LM}_1 Z''_{it} + v_i + wave_t + psu_{is} + \varepsilon''_{it} \quad (I_1)$$

$$P^{HP}_{it} = \gamma^{HP}_0 + \gamma^{HP}_1 Z''_{it} + v_i + wave_t + psu_{is} + \varepsilon''_{it} \quad (I_2)$$

where P_{it} is the self-reported price of smokers, which is categorized into P^{LM}_{it} and P^{HP}_{it} based on the brand names reported by smokers and corresponding price tiers specified in the cigarette tax data provided by the National Board of Revenue. v_i is the random effect corresponding to individual i and ε''_{it} is the random error term. The variable wave stands for the time effect in each wave. The dummy variables *psu* stand for the primary sampling unit s representing the location of respondent i. Z''_{it} is the vector of exogeneous variables that include income, age, education level, occupation, rural/urban resident status, marital status, and the number of friends who are smokers.

As the price regression is used for out-of-sample prediction of price for non-smokers that cannot be carried out with fixed effects regression, equations (I_o), (I_1), and (I_2) are estimated using random effects estimation.

The predicted prices $\widehat{P_{it}}$, $\widehat{P^{LM}_{it}}$, $\widehat{P^{HP}_{it}}$, from equations (I_o), (I_1), and (I_2), respectively, are then imputed to non-smokers in the regression of smoking prevalence in models (1) and (2).

Stage 2: Brand choice (BC)

The brand choice regression model used in this study is specified as follows:

$$P(BC^{LM}_{it} = 1 | P^{LM}_{it}, P^{HP}_{it}, Z_{it}, \in^{LM}_{it}) = a^{LM}_i + \beta_{LM} P^{LM}_{it} + \beta_{HP} P^{HP}_{it} + \beta'_i Z_{it} + \in^{LM}_{it} \quad \text{(Model 3)}$$

where BC_{it}^{LM} = 1 if an individual smoker reported smoking a low-price brand (LM) and 0 if an individual smoker reported smoking a high-price brand (HP). The control variables (Z_{it}) include income, age, education level, occupation, rural/urban resident status, marital status, and the number of friends who are smokers. Model (3) is estimated using logit, probit, panel logit, panel probit, and finally IV probit (based on composite housing index as an instrument) estimation.

Stage 3: Number of cigarettes smoked per day (CPD)

The smoking intensity of smokers is modeled using the following four regression equations:

$$\text{CPD}_{it} = \alpha''_i + \beta''_o P_{it} + \beta''_i Z_{it} + \in''_{it} \quad \text{(Model 4)}$$

$$\text{CPD}_{it} = \alpha''_i + \beta''' P_{it}^{LM} + \beta''' P_{it}^{HP} + \beta''_i Z_{it} + \in''_{it} \quad \text{(Model 5)}$$

$$CPD_{it}^{LM} = \alpha_i^{LM} + \beta^{LM} P_{it}^{LM} + \beta^{HP} P_{it}^{HP} + \beta'_{LM} Z_{it} + \in^{LM}_{it} \quad \text{(Model 6)}$$

$$CPD_{it}^{HP} = \alpha_i^{HP} + \beta'^{LM} P_{it}^{LM} + \beta'^{HP} P_{it}^{HP} + \beta''_{HP} Z_{it} + \in^{HP}_{it} \quad \text{(Model 7)}$$

The right-hand-side variables in each model are the same as in stage 2. Models (4) and (5) do not distinguish between the CPD of LM and HP brands for all smokers. In model (4) a single price variable is included, and in model (5) the prices of both LM and HP brands are included. Models (6) and (7) are used to run separate regressions for LM and HP brand categories. Both models (6) and (7) use the prices of LM and HP separately. To circumvent potential endogeneity of self-reported prices, along with pooled ordinary least squares regression and panel regressions, two-stage least squared regression models are used.

CPD_{it}^{LM} and CPD_{it}^{HP} are likely to be correlated, as the consumption of one type will reduce the likelihood of using the other type, and hence the error terms of these regressions ($\in^{LM}_{it}$ and $\in^{HP}_{it}$) are likely to be correlated. Therefore, a seemingly unrelated regression is also estimated that incorporates both the choice of brands (LM versus HP) and CPD corresponding to each brand type. This step combines the decisions of brand choice and CPD in one regression and compares the results with the regressions run independently in stages 2 and 3 above. A similar approach was taken in Stoklosa et al. (2017), based on the ITC survey data for Zambia, to estimate the price elasticity of smoking prevalence. That study found the price elasticity of smoking prevalence for machine-made cigarettes was -0.20, and for roll-your-own cigarettes it was -0.03 when they were estimated taking the simultaneity of smoking both types of cigarettes into account.

To make the estimates nationally representative, all regressions are weighted based on cross-sectional sampling weights that allow for complex multi-stage probability sampling design. Since smoking prevalence cannot be separated for low-price and high-price cigarette smoking, own-price elasticity of smoking prevalence is only estimated with respect to the prices of low-price and high-price brands and income elasticity of smoking prevalence. It is not possible to estimate cross-price elasticity of smoking prevalence. From the models of smoking intensity, both own- and cross-price elasticity and income elasticity of low-price and high-price cigarette brands are estimated. The elasticities are calculated at the mean prices and income, based on the most reliable set of estimates of marginal effects of price and income on cigarette demand.

Results

Tables 3a and 3b present the summary statistics of the key variables in the analytical sample. The statistics on cigarette consumption, prices, and brands are reported for an estimation subsample of cigarette smokers. The statistics on other variables are reported for the full sample of smokers and non-smokers. On average, the results show that cigarettes smokers in Bangladesh smoke 10 cigarettes per day, with a high standard deviation.

The average price per pack of 20 cigarettes is 60 Bangladeshi taka in 2015 prices. However, the price gap between the low-price and high-price cigarette brands is significant—the average price of high-price brands is 122 taka, which was nearly three times as high as the average price of low-price brands (Table 3a). The regressions of self-reported prices of smokers used for imputing prices to non-smokers are shown in the Appendix Table A1. According to the results from these regressions, smokers with higher income reported higher prices, and prices in later waves are higher than the prices in previous waves.

Two-thirds of the sample is located in the rural areas and more than three quarters of smokers report smoking low-price brands (Table 3b).

Table 3a. Summary statistics of analytical sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Income (taka in 2015 prices)	8,148	41,510	2,328	14,750	108,840
Age (years)	8,148	40.52	15.72	15.00	108.00
Number of friends who are smokers	8,148	3.80	1.46	0.00	5.00

Cigarette consumption per day (sticks)	5,847	10.10	10.98	1.00	99.00
Price per pack of 20 cigarette sticks (taka in 2015 prices)	5,795	60.44	46.47	10.43	469.03
Price per pack of 20 sticks of low-price cigarettes (taka in 2015 prices)	5,795	46.21	14.92	11.76	96.00
Price per pack of high-price cigarettes (taka in 2015 prices)	5,795	122.22	32.49	58.56	469.03

Table 3b. Summary statistics of analytical sample

Variable	Observations	%
Place of residence		
Urban	2,177	37.57
Rural	3,618	62.43
Price tier		
Low-price brands	4,384	75.65
High-price brands	1,411	24.34
Marital status		
Unmarried	1,015	17.52
Married	4,780	82.48
Educational status		
Illiterate	1,042	17.98
1 to 8 years	3,150	54.36
9 years or more	1,603	27.66
Occupation		
Owner farmer	818	14.12
Tenant farmer	129	2.23
Self-employed in non-farm agricultural activity	1,067	18.41
Self-employed in non-agricultural activity	380	6.56
Farm wage laborer	116	2
Non-farm agricultural wage laborer	769	13.27
Non-agricultural wage laborer	89	1.54
Professional (e.g., physician, engineer)	286	4.94
Managerial, administrative or clerking	111	1.92
Student	268	4.62
Unemployed	69	1.19
Housewife/Housekeeper/ Household manager	1,693	29.21

The IV probit model for the decision to smoke is estimated applying the maximum likelihood estimation method to model (2) that includes the prices of low-price and high-price brands separately. The results of this regression of the decision to smoke presented in Table 4 indicate that a 1 taka higher price of low-price cigarettes lowers the probability of smoking by 0.09 percentage points and the number of cigarettes smoked per day by -0.02 for low-price brands. The changes in the price of low-price cigarettes do not significantly affect the daily consumption of high-price brands. Higher price of high-price cigarettes does not significantly affect the decision to smoke. However, daily cigarette consumption of low-price brands tends to increase with higher prices of high-price brands, which can be attributed to downward substitution from high-price to

low-price brands. Daily cigarette consumption of high-price cigarettes does not appear to be sensitive to change in the prices of high-price brands themselves.

Both the decision to smoke and the number of cigarettes smoked per day are sensitive to income changes. Higher income leads to higher smoking probability overall and greater amount of daily cigarette consumption for high-price brands. However, higher income tends to lower the daily consumption of low-price cigarettes indicating the possibility of upward substitution to higher-price brands as more expensive brands become more affordable with higher income.

Table 4. Results of regression of the decision to smoke and the number of cigarettes smoked per day

	Decision to smoke	Number of cigarettes smoked per day	
	IV Probit	Seemingly unrelated regression	
	Smoker	Low-price brands	High-price brands
Price of low-price brands per pack of 20 pieces (taka in 2015 prices)	-0.091*** (0.012)	-0.022** (0.009)	0.005 (0.006)
Price of high-price brands per pack of 20 pieces (taka in 2015 prices)	-0.003 (0.008)	0.018*** (0.004)	-0.003 (0.003)
Household income (taka in 2015 prices)	0.018*** (0.004)	-0.039*** (0.007)	0.056*** (0.004)
Age (years)	-0.005** (0.002)	0.045*** (0.010)	-0.028*** (0.006)
Education (Reference: illiterate)			
1 to 8 years	0.202*** (0.055)	-0.756** (0.356)	0.435* (0.224)
9 years or more	0.457** (0.193)	-3.309*** (0.424)	2.138*** (0.268)
Occupation (Reference: owner farmer)			
Tenant farmer	0.173 (0.259)	-1.371 (0.922)	0.227 (0.582)
Self-employed in non-farm agricultural activity	0.194** (0.090)	-0.529 (0.471)	0.487 (0.297)
Self-employed in non-agricultural activity	-0.132 (0.309)	-0.507 (0.620)	0.039 (0.391)
Farm wage laborer	0.100 (0.176)	0.585 (0.967)	-0.653 (0.610)
Non-farm agricultural wage laborer	0.076 (0.117)	0.138 (0.504)	0.186 (0.318)
Non-agricultural wage laborer	0.829*** (0.132)	-2.748** (1.113)	1.568** (0.702)
Professional (e.g., physician,	0.609***	-1.608**	2.632***

engineer)	(0.114)	(0.708)	(0.447)
Managerial, administrative or clerking	0.635 (0.469)	-0.835 (1.057)	-0.371 (0.667)
Student	0.144 (0.118)	-0.333 (0.696)	0.094 (0.439)
Unemployed	-0.059 (0.308)	-2.980** (1.220)	-0.083 (0.770)
Housewife/Housekeeper/ Household manager	0.270*** (0.061)	-0.220 (0.426)	0.655** (0.269)
Resident of urban area (Reference: rural area)	0.311*** (0.075)	-2.556*** (0.295)	1.526*** (0.186)
Married	-0.159 (0.189)	0.903** (0.379)	-0.188 (0.239)
Number of friends who are smokers	-0.020 (0.339)	0.654*** (0.107)	0.074 (0.067)
Number of observations	8,148	5,832	5,832

Notes:
1. The z statistics of the coefficients are in parentheses.
2. The level of significance used is : $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
3. The $\chi^2(2)$ statistics from the Wald test of exogeneity in the IV probit model using prices of low-price and high-price brands instrumented with composite housing index is 6.65 (p-value = 0.0360), which rejects the null hypothesis of exogeneity of cigarette prices at a 5% level of significance. The full set of results including the instrumental variable estimation of cigarette prices is provided in the Appendix Table A2.
4. The validity of the instruments is tested using the *F*-statistic of the reduced form regression of cigarette prices of low-price and high-price brands on composite housing index and all other regressors in the IV probit model. The overall F-statistics is greater than 10, indicating that the instruments are strong and identifies the effect of the prices of low-price and high-price brands. The results of these regressions are provided in the Appendix Table A3.

Older adults tend to have lower smoking probability overall and lower smoking intensity for high-price brands. The smoking intensity of low-price brands tends to get higher at older age. Overall smoking probability is higher among more educated persons. Smoking intensity tends to be lower among higher-educated smokers for low-price brands and higher for high-price brands. Compared to owner farmers, persons self-employed in non-farm agricultural activity, non-agricultural wage laborers, professionals and household managers show higher probability of smoking. The intensity of smoking low-price brands is lower among non-agricultural wage laborers, professionals, and the unemployed, while the intensity of smoking high-price brands is higher among non-agricultural wage laborers, professionals, and household managers compared to owner farmers. Residents of urban areas tend to have higher smoking probability and intensity of smoking high-price brands and lower intensity of smoking low-price brands. Smokers who are married and have more friends who are smokers demonstrate higher intensity of smoking low-price cigarettes.

The results of estimation of the decision to smoke using model (1) that includes the cigarette price variable for all brands are provided in Appendix Table A4. Due to statistically insignificant estimates of the coefficients of cigarette price of all brands in the logit, panel logit, probit, panel

probit, and IV probit estimations, these estimates are not used for further analysis. Similarly, the coefficients of cigarette price in the regressions using the prices of low-price and high-price brands separately are not statistically significant except for the IV probit regression, as shown in Appendix Table A5. Hence, only the price coefficients estimated from the IV probit regression are used in the estimation of own- and cross-price elasticity of cigarette smoking prevalence presented in Table 5.

The independent regressions of the choice of low-price versus high-price brands using logit, panel logit, probit, panel probit, and IV probit estimations do not provide any statistically significant estimates of the effects of price on brand choice (Appendix Table A6). However, higher income tends to lower the probability of choosing low-price brands. Similarly, the independent regressions for CPD for low-price and high-price brands using pooled ordinary least squares (OLS) regression, panel regression, or two-stage least squares regression do not provide any statistically significant estimate of the effects of cigarette price on daily cigarette consumption (Appendix Table A7). However, combining the choice of brands and number of cigarettes smoked for each type of brand in the SUR model does provide meaningful estimates of the relationship of own- and cross-price elasticity of low-price and high-price brands with the intensity of smoking each type of brands, as indicated in the discussion of the results in Table 4. It suggests that the choice of brand and daily consumption may be done simultaneously as opposed to independently in two successive stages. The SUR estimates are therefore used for estimating the price elasticity of cigarettes smoked per day in Table 5.

Table 5 shows estimates of price and income elasticities based on the coefficients of price and income variables in the IV probit and SUR regressions for the decision to smoke and cigarettes smoked per day. The elasticities are calculated at the sample mean values of price and income. The total elasticity is given by the sum of the elasticity of smoking prevalence and the elasticity of smoking intensity.

The price elasticity of smoking prevalence with respect to the price of low-price brands is estimated at -0.0487. The total elasticity for low-price cigarette consumption with respect to its own price is -0.1678, which is the sum of the elasticity of smoking prevalence of -0.0487 and the elasticity of smoking intensity of -0.1191. This implies that a 10% increase in the price of low-price cigarettes is expected to lead to 0.487% reduction in cigarette smoking prevalence and a 1.191% decrease in daily consumption of low-price cigarettes, with a total of 1.678% reduction in the consumption of low-price cigarettes. As higher prices of low-price brands lead to lower smoking

prevalence overall, it is expected to reduce the likelihood of smoking across all brands including low-price and high-price brands.

Table 5. Own- and cross-price elasticity and income elasticity estimates of cigarette demand by low- and high-price tiers

	Smoking prevalence	Smoking intensity		Total elasticity (low-price brands)	Total elasticity (high-price brands)
		Low-price brands	High-price brands		
Price of low-price brands	-.0487*** (.0150)	-.1191*** .0489)	.1335 (.1551)	-0.1678	-
Price of high-price brands	-.0318 (.1567)	.2643*** (.0619)	-.2512 (.1994)	0.2643	-.2512
Income	.0564# (.0780)	-.1934*** (.0334)	1.4044*** (.1066)	-0.1370	1.4608

Notes:
1. The standard errors are in parentheses. The level of significance using two-tailed test is : * $p < .10$, ** $p < .05$, *** $p < .01$.
2. Total elasticities are estimated by summing only significant coefficients across smoking prevalence and smoking intensity.
3. For smoking prevalence, IV probit regression model coefficients are used.
4. For smoking intensity, SUR regression coefficients are used.
5. The coefficients that were not statistically significant are not used for the calculation of total elasticity.
6. # indicates that even though income coefficient was significant in the IV probit regression in Table 4, the marginal effect at the mean income is found to be insignificant. Nevertheless, it is considered in overall elasticity calculation.

Smoking prevalence is not sensitive to increases in the price of high-price brand cigarettes. Smoking intensity of high-price cigarette smokers is not sensitive to the changes in its own price upon consideration of the statistical significance of the price elasticity estimate of -0.2512 at a 10% level using a two-tailed test. With a one-tailed test, this estimate can, however, be considered significant at the 10% level. This estimate indicates that a 10% increase in the price of high-price brands leads to a reduction in the smoking intensity of high-price brand smokers by 2.512%. Increases in the price of high-price cigarettes by 10% may induce smokers to switch to low-price cigarettes increasing low-price cigarette consumption by 2.643%, as indicated by the cross-price elasticity of low-price cigarette consumption with respect to high-price brand prices at -0.2643.

The income elasticity of smoking prevalence overall is 0.0564, suggesting that a 10% increase in income may lead to a 0.564% increase in cigarette smoking prevalence. The income elasticity of daily consumption of low-price cigarettes is -0.1934 and for high-price cigarettes it is 1.4044, which indicate that income growth can lead to reduction in the intensity of smoking low-price cigarettes and increase in the intensity of smoking high-price cigarettes. The total income elasticity is negative for low-price cigarettes as the negative effect of income growth on smoking intensity is greater than the positive effect on smoking prevalence. The total income elasticity is 1.4608 for high-price cigarettes, signifying that higher income enables smokers to purchase more expensive brands and therefore increases the demand for high-price cigarettes.

Discussion and Conclusions

Discussions and policy implications

Using data from four waves of a cohort survey, the International Tobacco Control (ITC) Policy Evaluation Project in Bangladesh, this study examines the decision to smoke cigarettes, the selection of low-price or high-price brands, and the number of cigarettes smoked per day as determined by own- and cross-brand prices, household income, individual-level demographics, and socioeconomic factors. The price elasticity of smoking prevalence with respect to the price of low-price brands is estimated at -0.0487. Although this estimate is relatively low compared to the estimates available from previous studies in Bangladesh (e.g., Nargis et al., 2014; Ahmed et al., 2021), it is not comparable to earlier estimates due to differences in estimation methods. Most of the studies estimating price sensitivity of cigarette consumption focus on overall price elasticity of cigarette demand. The price elasticity estimate based on the prices of low-price brands is expected to be lower than the estimate based on all brand prices because of the large price difference between low- and high-price brands (46.21 taka versus 122.22 taka, as shown in Table 3a). Differentiating price sensitivity of smoking decisions by brands or price tiers is nearly absent in the existing literature, apart from Liu et al. (2015) for China. The current study makes an important contribution by filling this gap.

The elasticity of smoking intensity of low-price and high-price cigarettes with respect to own prices are -0.1191 and -0.2512, respectively, suggesting that both low-price and high-price brand smokers respond to price increases by reducing daily consumption. Increasing price in the low-price tier is crucial for reducing smoking prevalence, as smoking prevalence is sensitive to low-price brand price changes only, which is expected given the high volume and market share (80–85%) of low-price cigarettes in Bangladesh.

The positive cross-price elasticity of daily cigarette consumption of low-price cigarettes with respect to high-price brands at 0.2643 provides evidence of downward substitution from high-price tiers to low-price tiers. The existence of a high price differential and the tiered tax structure in Bangladesh are favorable to downward substitution and can undermine the effectiveness of tax and price increases in reducing overall cigarette consumption. The findings of this study are relevant and timely for Bangladesh, which has been burdened with a tiered tax and price structure for cigarettes for decades, thereby inhibiting the tremendous potential of

cigarette taxation, which is proven to be one of the most effective tobacco control measures worldwide.

The income elasticity of smoking prevalence overall is 0.0564, indicating that income growth can induce more people to smoke. However, the negative income elasticity of daily consumption of low-price cigarettes and positive income elasticity of daily cigarette consumption of high-price cigarettes indicate that higher income may lead smokers to substitute upward and purchase more expensive brands. This finding is consistent with a previous study by Huq et al. (2019) that observed upward substitution in Bangladeshi smokers.

The current study findings have strong policy implications. First, a price increase only in the high-price tier will not reduce the prevalence of smoking or daily cigarette consumption of high-price cigarettes. Instead, it will induce smokers to switch to lower-price brands. Therefore, if policy makers intend to reduce overall consumption, the prices of lower-price cigarettes need to be increased concurrently. In the budget announcement for fiscal year 2020–2021, cigarette prices were increased only in the high-price tiers from 2019–2020 prices (from 128 taka to 135 taka per pack of 10 sticks of premium brand cigarettes and from 97 taka to 103 taka per pack of 10 sticks of high-price brand cigarettes), while the prices in the low-price tiers remained unchanged (63 taka per pack of 10 sticks of medium-price brand cigarettes and 39 taka per pack of 10 sticks of low-price brand cigarettes). From 2019–2020 to 2020–2021, total cigarette sales increased by 5.2%, largely driven by an 11.1% increase in the sales of low-price cigarette brands. This increase was partially offset by decreases in sales in high- (-0.2%) and medium-price tiers (-25.8%), while sales in the premium tier continued to increase (5.6%). These patterns of change in sales in different price tiers are consistent with a positive and significant cross-price elasticity of low-price brand cigarettes and price insensitivity of high-price brands.

Second, the price gap between low- and high-price tiers should be narrowed down over time to minimize the incentive to substitute to cheaper brands when prices increase. This would require increases in cigarette prices in the low-price tier that are faster than increases in the high-price tier for gradual convergence of prices. Introduction of specific taxes and simplification of the current four-tiered tax structure into a uniform specific system would also help reduce the price gap.

Third, income growth can induce higher smoking prevalence unless cigarette prices are increased significantly to outpace income growth and reduce the affordability of cigarettes. Nargis et al. (2019) observed that the affordability of cigarettes increased in Bangladesh over 2009–2015, due to fast income growth and modest increases in cigarette prices. While formulating cigarette tax policy changes, it is important to increase taxes and prices enough to exceed income growth after adjustment for inflation.

Fourth, like many other developing countries, the revenue collection organ of the government (NBR in Bangladesh) typically hesitates to increase taxation on cigarettes, fearing that it would have a significant effect on their revenue collection. However, from the current estimates, it is evident that this situation will not emerge for Bangladesh. The price elasticity of cigarette consumption in the low-price tier is less than one and very small, meaning that the percentage decrease in cigarette sales will be far less than the percentage increase in price and tax, and total revenue is expected to increase significantly following a tax-induced price increase.

One major limitation of the study is that the analytical sample used for the estimation of price sensitivity of cigarette consumption is limited to adult males aged 18 and above and may not necessarily represent the price responsiveness of youth and women. However, global evidence suggests that youth are more price sensitive than adults and youths are more likely to smoke lower-price cigarettes (IARC, 2011). As such, one would expect greater reduction in cigarette consumption at the population level from a given price increase of cigarettes. Since smoking prevalence is insignificant among women (less than 2%) in Bangladesh, the estimates from this study do not lose national representation of the adult population by excluding women respondents. The second major limitation of the study is that due to an insufficient number of observations in the premium and high-price tiers of cigarette brands and a lack of sufficient variation in self-reported prices within each tier, it is not possible to run the analysis for each of the four price tiers of cigarettes. This limitation can be addressed in future research with new data sets.

Conclusions

Increasing the price of low-price cigarette brands can effectively reduce smoking prevalence and the daily cigarette consumption of smokers, thereby reducing overall cigarette consumption in Bangladesh. Increasing the price of high-price cigarette brands without increasing the prices of low-price brands may encourage smokers to switch to low-price brands instead of quitting. As

income growth contributes to higher smoking prevalence, increases in cigarette prices need to outpace income growth and inflation. A cigarette tax policy that raises the prices of both low-price and high-price brands increasing prices in the low-price tier at a faster rate than in the high-price tier and increasing prices of all brands at a pace faster than income growth can effectively reduce cigarette consumption in Bangladesh.

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Appendix

Table A1. Results of random effects regressions of cigarette price for all, low-price brands, and high-price brands

	Price	Price of low-price brands	Price of high-price brands
Income (in thousand taka in 2015 prices)	0.404*** (0.025)	0.129*** (0.014)	0.170*** (0.051)
Age (years)	-0.286*** (0.040)	-0.094*** (0.018)	-0.048 (0.110)
Education (Reference: illiterate)			
1 to 8 years	4.816*** (1.423)	2.835*** (0.635)	4.035 (5.641)
9 years or more	21.566*** (1.739)	5.175*** (0.838)	8.152 (5.710)
Occupation (Reference: owner farmer)			
Tenant farmer	4.695 (3.247)	1.080 (1.670)	-3.045 (8.693)
Self-employed in non-farm agricultural	4.610*** (1.731)	2.523*** (0.841)	-0.160 (6.131)
Self-employed in non-agricultural activity	0.536 (2.121)	-1.305 (0.985)	27.312** (12.829)
Farm wage laborer	-5.139 (3.377)	2.153 (1.582)	-1.272 (15.034)
Non-farm agricultural wage laborer	-2.674 (1.861)	1.112 (0.892)	-6.160 (6.621)
Non-agricultural wage laborer	23.976*** (4.067)	7.677*** (2.969)	6.759 (7.779)
Professional (e.g., physician, engineer)	17.706*** (2.570)	4.886*** (1.627)	4.823 (6.557)
Managerial, administrative, or clerking	7.909** (3.796)	6.972*** (2.696)	-5.559 (7.720)
Student	1.145 (2.464)	2.623** (1.234)	-7.578 (7.360)
Unemployed	-4.206 (4.104)	-0.916 (2.020)	-3.252 (13.642)
Housewife/Housekeeper/Household manager	6.526*** (1.593)	3.898*** (0.752)	-0.665 (6.015)
Resident of urban area (Reference: rural area)	8.089*** (1.897)	-0.234 (0.830)	-2.675 (6.102)
Married	-4.742*** (1.401)	-2.156*** (0.731)	0.074 (2.926)
Number of friends who are smokers	-0.122 (0.372)	0.149 (0.196)	0.345 (0.856)
Wave (Reference: wave 1)			
Wave 2	0.863 (1.155)	3.002*** (0.623)	-3.263 (2.844)
Wave 3	13.387***	8.836***	39.453***

	(1.234)	(0.649)	(3.150)
Wave 4	15.343***	9.138***	45.368***
	(1.289)	(0.677)	(3.130)
Observations	6,115	4,552	1,474

Notes:
1. Standard errors in parentheses.
2. * $p < .10$, ** $p < .05$, *** $p < .01$.
3. The coefficients for primary sampling unit location variables are omitted for brevity of presentation.

Table A2. Results of IV probit estimation for the decision to smoke

	IV probit: Decision to smoke	First stage: Low-price brands	First stage: High-price brands
Price of low-price brands per pack of 20 cigarettes (taka in 2015 prices)	-0.091*** (0.012)		
Price of high-price brands per pack of 20 cigarettes (taka in 2015 prices)	-0.003 (0.008)		
Household income (taka in 2015 prices)	0.018*** (0.004)	0.181*** (0.008)	0.581*** (0.026)
Age (years)	-0.005** (0.002)	-0.053*** (0.013)	0.069 (0.049)
Education (Reference: illiterate)			
1 to 8 years	0.202*** (0.055)	2.165*** (0.518)	-0.086 (1.839)
9 years or more	0.457** (0.193)	4.978*** (0.592)	5.290** (2.160)
Occupation (Reference: owner farmer)			
Tenant farmer	0.173 (0.259)	1.853 (1.242)	9.361*** (3.006)
Self-employed in non-farm agricultural activity	0.194** (0.090)	1.928*** (0.678)	4.262* (2.429)
Self-employed in non-agricultural activity	-0.132 (0.309)	-2.375*** (0.768)	28.380*** (2.060)
Farm wage laborer	0.100 (0.176)	1.009 (1.405)	6.645* (3.616)
Non-farm agricultural wage laborer	0.076 (0.117)	0.694 (0.731)	1.047 (1.917)
Non-agricultural wage laborer	0.829*** (0.132)	8.906*** (1.139)	4.779 (3.951)
Professional (e.g., physician, engineer)	0.609*** (0.114)	6.213*** (0.902)	12.155*** (2.496)
Managerial, administrative, or clerking	0.635 (0.469)	7.447*** (0.982)	-5.428 (4.236)
Student	0.144 (0.118)	1.844* (0.945)	-10.487*** (2.590)
Unemployed	-0.059 (0.308)	-0.282 (0.929)	-2.567 (3.030)
Housewife/Housekeeper/ Household manager	0.270*** (0.061)	2.961*** (0.586)	-1.389 (1.912)
Resident of urban area (Reference: rural area)	0.311*** (0.075)	3.399*** (0.415)	-3.261** (1.473)

Married	-0.159 (0.189)	-1.927*** (0.501)	1.486 (1.475)
Number of friends who are smokers	-0.020 (0.339)	-0.461*** (0.108)	-2.863*** (0.356)
Composite housing index (Reference: low)			
Moderate		0.012 (0.319)	-1.516 (1.433)
High		0.142 (0.427)	-5.689*** (1.476)
Observations	8148	8148	8148
Wald test of exogeneity: chi2(2) Prob > Chi²	 6.65 0.0360		

Notes:
1. Standard errors in parentheses.
2. $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.

Table A3. Results of reduced-form regressions of the prices of low-price and high-price cigarette brands

	First stage of low-price brands	First stage of high-price brands
Household income (taka in 2015 prices)	0.181*** (0.008)	0.581*** (0.026)
Age (years)	-0.053*** (0.013)	0.068 (0.049)
Education (Reference: illiterate)		
1 to 8 years	2.164*** (0.519)	-0.089 (1.840)
9 years or more	4.979*** (0.592)	5.325** (2.161)
Occupation (Reference: owner farmer)		
Tenant farmer	1.853 (1.243)	9.370*** (3.009)
Self-employed in non-farm agricultural activity	1.928*** (0.679)	4.246* (2.428)
Self-employed in non-agricultural activity	-2.375*** (0.770)	28.398*** (2.059)
Farm wage laborer	1.010 (1.407)	6.660* (3.623)
Non-farm agricultural wage laborer	0.695 (0.734)	0.981 (1.917)
Non-agricultural wage laborer	8.905*** (1.140)	4.751 (3.955)
Professional (e.g., physician, engineer)	6.214*** (0.903)	11.934*** (2.502)
Managerial, administrative, or clerking	7.448*** (0.983)	-5.456 (4.241)
Student	1.845* (0.946)	-10.473*** (2.591)
Unemployed	-0.282 (0.930)	-2.588 (3.033)
Housewife/Housekeeper/ Household manager	2.960*** (0.587)	-1.395 (1.912)
Resident of urban area (Reference: rural area)	3.398*** (0.416)	-3.255** (1.474)
Married	-1.925*** (0.501)	1.514 (1.475)
Number of friends who are smokers	-0.461*** (0.108)	-2.878*** (0.357)
Composite housing index (Reference: low)		
Moderate	0.010 (0.417)	-1.475 (1.470)
High	0.142	-5.677***

	(0.448)	(1.485)
Observations	8,151	8,166
F-statistic (overall with p-value)	105 (0.000)	65 (0.000)
F-statistic (for instruments with p-value in parentheses)	0.06 (0.93)	8.06 (0.003)

Notes:
1. Standard errors in parentheses.
2. $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.

Table A4. Results of regressions of the decision to smoke based on the cigarette price variable for all brands

	Logit	Panel-logit	Probit	Panel-probit	IV probit
Price per pack of 20 cigarettes (taka in 2015 prices)	-0.001 (0.002)	0.000 (0.002)	-0.001 (0.001)	0.000 (0.002)	-0.003 (0.037)
Income (taka in 2015 prices)	0.006* (0.003)	-0.001 (0.003)	0.003* (0.002)	-0.001 (0.003)	0.004 (0.023)
Age (years)	-0.005 (0.005)	-0.021*** (0.005)	-0.003 (0.003)	-0.021*** (0.005)	-0.003 (0.006)
Education (Reference: illiterate)					0.000 (.)
1 to 8 years	0.107 (0.187)	0.347** (0.164)	0.068 (0.110)	0.347** (0.164)	0.075 (0.152)
9 years or more	-0.282 (0.231)	0.190 (0.200)	-0.167 (0.135)	0.190 (0.200)	-0.131 (0.777)
Occupation (Reference: owner farmer)					0.000 (.)
Tenant farmer	-0.573 (0.412)	0.508 (0.350)	-0.332 (0.242)	0.508 (0.350)	-0.319 (0.340)
Self-employed in non-farm agricultural	0.138 (0.230)	0.548*** (0.189)	0.083 (0.133)	0.548*** (0.189)	0.096 (0.276)
Self-employed in non-agricultural activity	0.100 (0.216)	0.009 (0.221)	0.063 (0.128)	0.009 (0.221)	0.063 (0.122)
Farm wage laborer	-0.298 (0.350)	0.787** (0.393)	-0.180 (0.213)	0.787** (0.393)	-0.186 (0.255)
Non-farm agricultural wage laborer	0.215 (0.207)	0.851*** (0.207)	0.127 (0.123)	0.851*** (0.207)	0.129 (0.113)
Non-agricultural wage laborer	0.076 (0.381)	-0.353 (0.429)	0.043 (0.226)	-0.353 (0.429)	0.092 (1.025)
Professional (e.g., physician, engineer)	0.184 (0.284)	0.484* (0.289)	0.113 (0.165)	0.484* (0.289)	0.152 (0.818)
Managerial, administrative, or clerking	-0.752** (0.326)	-1.023*** (0.379)	-0.449** (0.185)	-1.023*** (0.379)	-0.432 (0.384)
Student	0.090 (0.282)	0.101 (0.254)	0.065 (0.162)	0.101 (0.254)	0.070 (0.180)
Unemployed	-0.628** (0.282)	-1.045*** (0.342)	-0.382** (0.157)	-1.045*** (0.342)	-0.386** (0.177)
Housewife/Housekeeper/ Household manager	0.072 (0.185)	0.253 (0.168)	0.049 (0.110)	0.253 (0.168)	0.063 (0.309)
Resident of urban (Reference: rural area)	0.240 (0.153)	0.639*** (0.167)	0.141 (0.091)	0.639*** (0.167)	0.164 (0.519)
Married	0.325** (0.164)	0.608*** (0.159)	0.191** (0.096)	0.608*** (0.159)	0.183 (0.195)
Number of friends who are smokers	0.756*** (0.040)	0.863*** (0.038)	0.448*** (0.022)	0.863*** (0.038)	0.445*** (0.074)
Observations	8,148	8,150	8,148	8,150	8,148
Pseudo R^2	0.213		0.213		

Notes:
1. The *z* statistics of the coefficients are in parentheses.
2. * $p < .10$, ** $p < .05$, *** $p < .01$
3. The Wald statistics from IV probit regression using composite housing index as an instrument for the cigarette price for all brands are not statistically significant. Hence, the exogeneity of price is not rejected.

Table A5. Results of regressions of the decision to smoke based on the cigarette price variable for low-price and high-price brands

	Logit	Panel-logit	Probit	Panel-probit	IV probit
Price of low-price brands per pack of 20 cigarettes (taka in 2015 prices)	0.005 (0.004)	-0.001 (0.004)	0.003 (0.002)	0.005 (0.004)	-0.091*** (0.012)
Price of high-price brands per pack of 20 cigarettes (taka in 2015 prices)	-0.001 (0.002)	-0.002 (0.002)	-0.000 (0.001)	-0.001 (0.002)	-0.003 (0.008)
Household income (taka in 2015 prices)	0.004 (0.003)	0.000 (0.003)	0.003 (0.002)	0.004 (0.003)	0.018*** (0.004)
Age (years)	-0.004 (0.005)	-0.021*** (0.005)	-0.002 (0.003)	-0.004 (0.005)	-0.005** (0.002)
Education (Reference: illiterate)					
1 to 8 years	0.089 (0.187)	0.356** (0.164)	0.058 (0.110)	0.089 (0.187)	0.202*** (0.055)
9 years or more	-0.338 (0.228)	0.209 (0.198)	-0.201 (0.133)	-0.338 (0.228)	0.457** (0.193)
Occupation (Reference: owner farmer)					
Tenant farmer	-0.583 (0.418)	0.535 (0.352)	-0.339 (0.245)	-0.583 (0.418)	0.173 (0.259)
Self-employed in non-farm agricultural activity	0.124 (0.232)	0.568*** (0.190)	0.073 (0.134)	0.124 (0.232)	0.194** (0.090)
Self-employed in non-agricultural activity	0.144 (0.223)	0.062 (0.229)	0.085 (0.131)	0.144 (0.223)	-0.132 (0.309)
Farm wage laborer	-0.287 (0.351)	0.805** (0.394)	-0.174 (0.213)	-0.287 (0.351)	0.100 (0.176)
Non-farm agricultural wage laborer	0.214 (0.208)	0.862*** (0.208)	0.125 (0.124)	0.214 (0.208)	0.076 (0.117)
Non-agricultural wage laborer	-0.002 (0.379)	-0.312 (0.429)	-0.006 (0.226)	-0.002 (0.379)	0.829*** (0.132)
Professional (e.g., physician, engineer)	0.133 (0.285)	0.521* (0.289)	0.080 (0.165)	0.133 (0.285)	0.609*** (0.114)
Managerial, administrative, or clerking	-0.805** (0.325)	-1.013*** (0.380)	-0.481*** (0.184)	-0.805** (0.325)	0.635 (0.469)
Student	0.070 (0.285)	0.092 (0.255)	0.053 (0.164)	0.070 (0.285)	0.144 (0.118)
Unemployed	-0.622** (0.284)	-1.034*** (0.343)	-0.378** (0.158)	-0.622** (0.284)	-0.059 (0.308)
Housewife/Housekeeper/ Household manager	0.047 (0.188)	0.259 (0.169)	0.033 (0.112)	0.047 (0.188)	0.270*** (0.061)
Resident of urban area (Reference: rural area)	0.199 (0.154)	0.641*** (0.165)	0.116 (0.092)	0.199 (0.154)	0.311*** (0.075)
Married	0.344**	0.615***	0.202**	0.344**	-0.159

	(0.164)	(0.159)	(0.096)	(0.164)	(0.189)
Number of friends who are smokers	0.757*** (0.040)	0.857*** (0.039)	0.448*** (0.022)	0.757*** (0.040)	-0.020 (0.339)
Number of observations	8,148	8,150	8,148	8,148	
Pseudo R^2	0.213		0.214	0.213	

Note:
1. The *z* statistics of the coefficients are in parentheses.
2. * $p < .10$, ** $p < .05$, *** $p < .01$

Table A6. Results of regression of choice of low-price versus high-price brands

	Logit	Panel-logit	Probit	Panel-probit	IV probit
Price of low-price brands per pack of 20 cigarettes (taka in 2015 prices)	0.001 (0.003)	-0.001 (0.004)	0.000 (0.001)	-0.000 (0.002)	0.018 (0.136)
Price of high-price brands per pack of 20 cigarettes (taka in 2015 prices)	0.001 (0.002)	0.002 (0.002)	0.000 (0.001)	0.001 (0.001)	0.004 (0.011)
Household income (taka in 2015 prices)	-0.028*** (0.003)	-0.035*** (0.003)	-0.016*** (0.001)	-0.020*** (0.002)	-0.021 (0.022)
Age (years)	0.031*** (0.004)	0.039*** (0.005)	0.016*** (0.002)	0.021*** (0.003)	0.017*** (0.002)
Education (Reference: illiterate)					0.000 (.)
1 to 8 years	-0.540*** (0.196)	-0.755*** (0.200)	-0.249** (0.098)	-0.410*** (0.109)	-0.303 (0.336)
9 years or more	-1.610*** (0.213)	-2.328*** (0.219)	-0.856*** (0.109)	-1.297*** (0.120)	-0.950** (0.401)
Occupation (Reference: owner farmer)					0.000 (.)
Tenant farmer	-0.908*** (0.345)	-1.063*** (0.365)	-0.447** (0.187)	-0.584*** (0.202)	-0.436 (0.368)
Self-employed in non-farm agricultural activity	-0.742*** (0.205)	-0.793*** (0.225)	-0.345*** (0.109)	-0.415*** (0.122)	-0.382** (0.166)
Self-employed in non-agricultural activity	0.532 (0.371)	0.275 (0.379)	0.270 (0.173)	0.134 (0.197)	0.190 (0.303)
Farm wage laborer	0.866* (0.469)	0.796 (0.525)	0.463** (0.230)	0.421 (0.279)	0.418 (0.516)
Non-farm agricultural wage laborer	-0.355 (0.231)	-0.330 (0.243)	-0.121 (0.121)	-0.157 (0.132)	-0.136 (0.143)
Non-agricultural wage laborer	-1.806*** (0.425)	-2.193*** (0.429)	-0.978*** (0.246)	-1.216*** (0.241)	-1.130 (0.715)
Professional (e.g., physician, engineer)	-1.573*** (0.275)	-1.862*** (0.287)	-0.857*** (0.153)	-1.031*** (0.159)	-0.935*** (0.245)
Managerial, administrative, or clerking	-0.937** (0.370)	-1.493*** (0.408)	-0.489** (0.206)	-0.818*** (0.226)	-0.590 (0.780)
Student	-0.713*** (0.267)	-1.021*** (0.295)	-0.359** (0.151)	-0.559*** (0.163)	-0.340* (0.189)
Unemployed	-0.031	-0.420	0.030	-0.229	-0.016

	(0.410)	(0.556)	(0.235)	(0.303)	(0.343)
Housewife/Housekeeper/ Household manager	-0.879*** (0.201)	-0.990*** (0.213)	-0.434*** (0.106)	-0.535*** (0.115)	-0.472** (0.220)
Resident of urban area (Reference: rural area)	-0.852*** (0.117)	-1.696*** (0.145)	-0.470*** (0.066)	-0.954*** (0.082)	-0.489*** (0.119)
Married	0.383*** (0.141)	0.506*** (0.149)	0.226*** (0.078)	0.292*** (0.084)	0.236** (0.097)
Number of friends who are smokers	-0.017 (0.037)	0.019 (0.042)	-0.006 (0.021)	0.012 (0.023)	0.011 (0.091)
Number of observations	5,961	5,962	5,942	5,962	5,942
Pseudo R^2	0.256		0.254		

Notes:
1. The *z* statistics of the coefficients are in parentheses.
2. * $p < .10$, ** $p < .05$, *** $p < .01$
3. The Wald statistics from IV probit regression using composite housing index as an instrument for the cigarette price for all brands are not statistically significant. Hence, the exogeneity of price is not rejected.

Table A7. Results of regressions of the number cigarettes smoked per day

	OLS for low-price brands	OLS for high-price brands	2SLS for low-price brands	2SLS for low-price brands
Price of low-price brands per pack of 20 cigarettes (taka in 2015 prices)	-0.014 (0.016)	0.018 (0.065)	0.320 (0.292)	-0.125 (1.229)
Price of high-price brands per pack of 20 cigarettes (taka in 2015 prices)	0.041*** (0.010)	-0.011* (0.006)	0.088 (0.076)	-0.164 (0.290)
Household income (taka in 2015 prices)	-0.006 (0.014)	0.025 (0.018)	-0.090 (0.086)	0.132 (0.117)
Age (years)	0.024 (0.019)	0.006 (0.029)	0.042 (0.027)	0.026 (0.103)
Education (Reference: illiterate)				
1 to 8 years	-0.961* (0.553)	-1.024 (1.253)	-1.105 (0.871)	0.806 (2.463)
9 years or more	-1.573** (0.637)	-1.563 (1.198)	-3.344* (1.813)	1.367 (4.736)
Occupation (Reference: owner farmer)				
Tenant farmer	0.032 (1.132)	0.930 (1.426)	-2.329 (1.722)	1.674 (3.085)
Self-employed in non-farm agricultural activity	0.123 (0.686)	1.335 (1.231)	-1.351 (1.482)	1.820 (3.349)
Self-employed in non-agricultural activity	-0.576 (0.922)	-1.036 (1.392)	-1.888 (2.262)	2.208 (9.276)
Farm wage laborer	0.463 (1.072)	2.443 (1.695)	-0.827 (1.228)	-0.056 (3.309)
Non-farm agricultural wage laborer	0.424 (0.805)	2.537 (2.085)	-0.210 (0.846)	1.578 (3.606)
Non-agricultural wage laborer	0.459 (1.329)	0.041 (1.360)	-5.082 (3.689)	1.782 (8.016)
Professional (e.g., physician, engineer)	-0.741 (0.945)	2.063 (1.350)	-1.801 (2.631)	3.741 (6.002)
Managerial, administrative, or clerking	-0.969 (1.188)	-0.472 (1.410)	-2.732 (3.085)	-1.353 (11.838)
Student	0.019 (0.872)	0.976 (1.283)	0.337 (1.145)	-2.299 (6.420)
Unemployed	-2.713*** (1.007)	1.415 (2.278)	-4.310*** (1.600)	-0.253 (3.061)
Housewife/Housekeeper/Household manager	1.137 (0.719)	1.908* (1.060)	-0.680 (1.362)	1.633 (6.629)
Resident of urban area (Reference: rural area)	-1.689*** (0.385)	-1.176 (0.916)	-1.762** (0.811)	0.372 (4.594)
Married	-0.025 (0.771)	0.900 (0.968)	0.711 (0.676)	0.997 (3.070)
Number of friends who are smokers	0.944*** (0.179)	0.217 (0.330)	1.231*** (0.345)	-0.091 (0.558)
Number of observations	4,404	1,427	4,405	1,427