Tobacco tax reform and demand-switching effects between the licit and illicit markets in Brazil

Tobacconomics Working Paper Series

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August 2022

Paper No. 22/8/1

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Suggested citation: Divino, J. A., Ehrl, P., Candido, O., Valadão, M., & Rodriguez-Iglesias, G. (2022). Tobacco tax reform and demand-switching effects between the licit and illicit markets in Brazil [Working Paper]. UCB. https://www.tobacconomics.org/tobacco-tax-reform-and-demand-switching-effects-between-the-licit-and-illicit-markets-in-brazil-working-paper-series

Acknowledgments: We are grateful to Frank Chaloupka, Carlos Guerrero-Lopez, Michal Stoklosa, Jeffrey Drope, and Erika Siu for their helpful comments and suggestions. This research (grant number 17409-02) is funded by the University of Illinois Chicago's (UIC) Institute for Health Research and Policy to conduct economic research on tobacco taxation in Brazil. 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 cigarette industry usually claims that cigarette tax increases would only cause a demand-switching effect, pushing consumers towards the illicit market, instead of reducing smoking and increasing tax revenues. While recent research shows that the tobacco industry tends to overestimate the true size of the illicit trade market, there is little reliable evidence on how smokers switch from the licit to the illicit market (and vice versa). This research estimates own- and cross-price elasticities between the licit and illicit markets and provides new evidence to strengthen Brazilian tobacco control policies, including tobacco tax reform efforts and the effectiveness of a binding minimum price.

Methodology

Based on official individual-level survey data, this research estimates own- and cross-price elasticities of cigarette consumption and identifies the illicit market by two distinct criteria: cigarettes sold below the official minimum price and self-declared smoked brands that are officially classified as illicit. We compute kernel density distributions of smokers in order to disentangle how the minimum price might distinguish the legal from the illegal markets and propose a propensity score matching (PSM) model to estimate the own- and cross-price elasticities. The PSM makes the sample of licit- and illicit-cigarette consumers more comparable even in the absence of individuals that smoke both types of cigarettes.

Results

Due to inflation and lack of adjustment since 2016, the minimum price is no longer useful to distinguish between licit and illicit cigarette sales, as both are sold at similar and very low prices. There is a significant one-sided demand-switching effect from the illicit to the licit market whenever illicit cigarettes become more expensive in the pooled sample. Switching demand from the licit to the illicit market, however, is not statistically significant in any of the samples. Accordingly, the matching between the official brand classification by Anvisa and the self-declared smoked brands indicate that legal and illegal cigarettes are indistinguishably traded at very low prices in the market.

Conclusions

Higher cigarette prices due to higher taxes do not switch demand to the illicit market. Therefore, a tax reform with potential to raise cigarette prices, tax burden, and tax revenues would not increase the illicit trade of cigarettes. The current minimum price is no longer an effective policy instrument to assure cigarette price increases. It is important to raise the minimum price to increase the price of low-priced cigarettes in the marketplace to drive down consumption, particularly among those in lower socioeconomic

groups, and to make the tobacco control policy more efficient and traceable against help distinguish better between licit and illicit cigarettes. Finally, fighting cigarette smuggling would not only reduce illicit trade but also make these cigarettes more expensive and cause a demand-switching effect towards the licit market, decreasing consumption and raising tax revenues simultaneously.

JEL Codes: I18, C21, H29
Keywords: Tobacco tax reform, cross-price elasticity, licit cigarette market, illicit cigarette market, public policy

Introduction

Studies from several countries show that increasing tobacco taxes reduces cigarette consumption and increases government revenues (Chaloupka & Warner, 2000; Chaloupka et al., 2012; Shang et al., 2015; WHO, 2021). The cigarette industry, however, usually claims that cigarette tax increases would only induce smokers to switch from the licit to the illicit cigarette market, instead of generating the intended reduction in smoking and increase in tax revenues. That argumentation relies on studies sponsored by the tobacco industry that deliberately overestimate the true size of the illicit cigarette market (Stoklosa & Ross, 2014; van Walbeek & Shai, 2015; Gallagher et al., 2019). To the best of the authors' knowledge, there is little reliable evidence on how smokers are willing to switch from the licit to the illicit market and vice versa.

In Brazil, smoking prevalence has dropped from 14.9 percent in 2013 to 12.8 percent in 2019 (PNS, 2019). However, more than 20 million Brazilians still use tobacco products, and about 191,000 die every year due to tobacco-related diseases (IHME, 2020). Tobacco taxation is one of the most effective ways to prevent tobacco use, but its potential has not been fully realized yet in Brazil. Despite cigarette tax increases in the last fifteen years, Brazil still has the second-most affordable cigarettes in Latin America after Paraguay (WHO GTCR, 2019), demonstrating that there is certainly room for tax increases.

Since 2019, the Brazilian National Congress has been analyzing two Constitutional Amendment Bills for tax reform (Constitutional Amendments 45/2019 and 110/2019) intended to simplify the tax scheme by unifying different taxes, mostly consumption taxes. In 2020, the Executive presented the Bill no. 3,887 (PL 3887-2020) which replaces the current PIS/COFINS with the CBS (Social Contribution on Operations with Goods and Services), to simplify one of the consumption taxes covered by the Constitutional Amendment Bills. The tax reform bill under consideration in 2022 in Brazil present an opportunity to strengthen the country's tobacco tax policy.

Brazil is a world leader in tobacco control and one of the most successful countries in reducing tobacco use. However, Brazil is also known for the abnormal size of its illicit

cigarette market. In a sample of 36 countries, Brazil ranks second (36 percent) in a ranking of illegal cigarette market share, losing only to Latvia (38 percent) (Goodchild et al., 2020). Both countries are outliers well above the world average of 11.2 percent, which is close to the World Health Organization's (WHO) estimate of 10 percent in total tobacco products being illegal worldwide (WHO, 2015). Goodchild et al. (2020) observe that the illegal products are sold at cheaper prices—on average 65 percent of the legal price.

Szklo et al. (2020) estimated illicit trade in five Brazilian cities using four different criteria. By comparing the methodologies in the cities, they show that personal interviews, litter collection, and household garbage analysis produce similar numbers while the phone-based survey by Vigitel (BHM, 2019, 2020) seems to underestimate illegal cigarette consumption. They also report that 99 percent of the illicit cigarettes come from Paraguay. The neighbor country is known to be the largest provider of illegal cigarettes since production costs are low and regulatory controls are loose (Bate et al., 2020).[1]

Another important finding by Szklo et al. (2020) is that the share of illegally sold medium-price and premium brands is negligible. Instead, cheaper cigarettes account for almost the entire illicit market. Divino et al. (2020a, 2020b) estimated the size of the illicit cigarette market by self-declared cigarette purchases using the National Health Survey (PNS) from 2008 and 2013. Despite using a different data set and approach (PNS involves personal interviews that follow stratified multistage sampling) results are consistent, as illicit-market estimates are quite close to the ones obtained by Szklo et al. (2020). Both studies found heterogeneous measures across the Brazilian states that were in both samples, ranging from 26% in Rio de Janeiro to 79% in Mato Grosso do Sul, for instance. The country's overall illicit market was estimated to be 32.3 percent in 2013 (Szklo et al., 2018), and in 2019 it was estimated at 39.1 percent, using official data (INCA, 2021).

Several recent papers address the determinants and consequences of the illicit cigarette market. Paraje et al. (2020) show that socioeconomic characteristics explain the probability of smoking illicit cigarettes in Chile. The authors report that higher smoking intensity, lower education, and unemployment positively affect the propensity to consume illegal cigarettes, while age, gender, and years of smoking are not significant. Recher (2020) investigated tobacco smuggling in the Western Balkans and found that people with lower income and higher levels of addiction are more likely to buy illicit cigarettes.

Using data from Georgia, Little et al. (2020) demonstrate that when the government is committed to strengthen tax administration and curb corruption, a reduction in illicit cigarette consumption and increase in tax revenues can go hand in hand. In addition, low excise taxes even create the incentive to export illegal cigarettes to other neighboring countries, as illustrated by the Ukrainian experience (Andreeva et al., 2010). The

[1] Following the literature, the terms legal and licit as well as illegal and illicit are used as synonymous throughout the text.

complementarity of these findings is interesting: Georgia has a high smoking prevalence, but when the country raised cigarette excise taxes, the size of the illicit cigarette market was only about 1.5 percent (considerably lower than previously reported by the tobacco industry). Notwithstanding, these studies' estimates of the illicit market are highly reliable because they are derived from rigorous inspection of unique tax stamps and health warnings on cigarette packs from a household survey.

However, it seems that the literature has not reached consensus yet regarding the question of whether legal tobacco prices affect the illegal market. On one hand, tobacco industry-funded research found a link between legal cigarette prices and illicit trade. This is not surprising because the tobacco industry consistently uses a narrative of increased illicit trade from higher prices as a reason to oppose excise tax increases. For example, Prieger and Kulick (2018) use data from Euromonitor in regressions with country and time fixed effects and find a positive relation between a country's illegal market share and the price of legal cigarettes. Calderoni et al. (2017) focus on the European Union using another data set from the University of Trento, Italy (Savona, 2015). Although their unit of observation is the subnational level, including 247 regions, regressions with country fixed effects again suggest that affordability—that is, the price of legal cigarettes—spurs the share of the illegal market. Bate et al. (2020) also come to this conclusion using primary data collected in 13 cities around the world. Yet, their variable of interest—the share of taxes in total prices—only has variation across these 13 cities in their probit regressions with the 361 survey participants.

On the other hand, research not linked with the tobacco industry found no relation between legal cigarette prices and illicit trade. Van der Zee at al. (2020) observe that, a year after a real excise tax increase in South Africa, the price of illicit cigarettes remained statistically unchanged. Indeed, evidence consistently shows that other factors are closely more related to illicit trade. Merriman et al. (2000) ran a cross-country regression, using the amount of cigarette smuggling based on expert's estimates in the World Tobacco File, and found that other factors including the level of corruption have a higher explanatory power than cigarette prices. Similarly, Joossens and Raw (2008) concluded that market forces do not cause smuggling, but rather fraud does. Calderoni et al. (2017) also found that non-price factors, like the extent of the shadow economy and income inequality, are important predictors for cigarette smuggling.

According to Iglesias et al. (2017), nominal licit cigarette prices in Brazil rose by 101 percent between 2008 and 2013, while those in the illicit market grew by 79 percent. Adding more recent data from the 2018 and 2019 Vigitel (BHM, 2019, 2020) surveys implies that prices in the illegal market follow the movement of formal prices with a correlation of 99.7 percent. Brazilian data seem to support that the price-setting strategy of illicit retailers depends on the price of the legal market. That is, the prices of the illicit and licit cigarettes are highly positively correlated, meaning that illicit dealers take the

opportunity to raise their profit margin when the price of licit cigarettes grows after tax increases.

The aim of this paper is to study the responsiveness of the licit and illicit cigarette markets to changes in the cigarette prices in Brazil. This paper focuses on the cross-price elasticity between the licit and illicit cigarette markets and identifies the illicit market by two distinct criteria: cigarettes sold below the official minimum price and self-declared smoked brands that are officially classified as illicit. The paper also investigates how an outdated minimum price might affect both affordability and the illicit trade of cigarettes in Brazil.

To this end, we propose an empirical strategy based on the application of propensity score matching (PSM) to individual-level data from the last two National Health Surveys (PNS), from 2013 and 2019. The PSM is a widely used technique by researchers seeking to estimate treatment effects in a situation where self-selection into treatment may introduce a bias. In general terms, treatment may be understood as any binary, endogenous choice that an individual, firm, etc., makes. Applications of PSM can be found across all fields of social research (Caliendo and Kopeinig, 2008), including tobacco control, for example, regarding the effects of electronic cigarette use (Keller-Hamilton, et al., 2021), smokeless tobacco (Timberlake, et al., 2009), or tobacco smoke (Havstad, et al., 2012). Through PSM's selection of similar individuals in both treatment and control groups, an "observational study design would theoretically mimic what a randomized trial accomplishes through the process of randomization" (Havstad et al., 2012: 1069).

In the present case, treatment is defined as the consumption of illicit cigarettes instead of licit cigarettes. The main novelty of our approach is that, after matching of pairs according to their observable characteristics (the propensity score), we assume that the a given pair of smokers perceive the same prices of illicit and licit cigarettes. In other words, PSM allows us to assign illegal cigarette prices to smokers of legal brands, and the other way round, so as to identify the cross-price elasticities even in the absence of individuals that smoke both types of cigarettes.

Additionally, we compute kernel density distributions of smokers in order to disentangle how the minimum price might distinguish between the legal and illegal markets and be used as an effective Tobacco control policy.

Methodology

Data

The estimations in this study utilize secondary data from the two most recent editions—2013 and 2019—of the nationally representative National Health Survey (PNS), s conducted by the Brazilian Institute of Geography and Statistics (IBGE). Another major advantage of the PNS over commonly used household surveys is that, in line with the

nature of the inquiry, questions are answered by each individual, instead of on behalf of other family members.

The PNS data reports the number of daily cigarette consumption as well as the amount of cigarettes and total price the interviewee paid in his/her last purchase, which allows us to calculate the price per unit. Individual socioeconomic characteristics, such as age, gender, personal income, household size, and years of smoking are used to refine the estimations. PNS only reports data for people aged 15 years or older.

Previous studies used the minimum price as a threshold to distinguish between the illicit and licit cigarette markets (Divino et al., 2020b; Szklo et al., 2018). Since the minimum price per 20-cigarette pack is binding in the entire national territory without exceptions, cigarette purchases below that price are, by definition, illegal.[2] For the 2019 PNS data, in addition to the minimum price, we can also use a dummy variable that classifies the cigarette purchased as licit or illicit. The IBGE included this novel dummy variable that classifies the cigarette purchased by the individual as licit or illicit, based on an unpublished question about the cigarette brand declared by the interviewee.[3] This question and the accompanying indicator variable, however, are not available in the PNS 2013 survey.

The definition of illicit cigarettes based purely on self-declared cigarette brand has some weaknesses. By the rule of law, it is not feasible to observe legal cigarettes sold below the minimum price. First of all, monetary discounts below the minimum price are strictly prohibited. Second, the price is printed on the cigarette pack once it comes out of production. Since this value serves as the basis for tax collection, the producer loses the incentive to undercut this fixed price. Notwithstanding, 3.9% of prices in our sample are registered as being legal despite having a pack value below the minimum price. It is most likely (and visual inspection of the data confirms this impression) that these observations are due to misreporting, above all by individuals who bought more than one pack; instead of correctly reporting the total price paid, they report the value per pack. So when the price per pack is calculated, its value becomes artificially low. In this analysis we exclude the observations where a legal cigarette brand is declared to be below the minimum price.

Data on cigarette prices are only collected for smokers, but a price measure is also required for non-smokers to estimate cigarette demand. Cigarette prices vary considerably between federal states due to differences in the state-level tax ICMS, transportation costs, logistic costs, and other demand- and supply-related factors. Using

[2] Note that the present definition is likely to underestimate the true size of the illegal market, because high-price cigarettes may still be sold illegally but at prices above the minimum price.

[3] There is a publicly available directory of illicit cigarette brands sold in the country maintained by the Brazilian National Health Agency (ANVISA), available at https://saude.abril.com.br/bem-estar/anvisa-detecta-90-marcas-ilegais-de-cigarro-sendo-vendidas-no-brasil/

the average price per state also mitigates concerns of endogeneity and biased estimates, as explained in Deaton (1988), John et al. (2019), and Divino et al. (2020).

Estimation of cross-price elasticity requires that the same person smoke both legal and illegal cigarettes and that they report exactly how much of each type of cigarette they consumed at the reported price. Yet, the PNS data only report one purchase of cigarettes. Consequently, individuals consume either legal or illegal cigarettes and only one associated price is observed. To identify a hypothetical situation in which the same individual can be attributed consumption and prices of both legal and illegal cigarettes, we apply the technique of propensity score matching (PSM).

PSM was developed by Rosenbaum and Rubin (1983) and is frequently applied in social sciences to compare counterfactual situations (Ehrl, 2018, Caliendo and Kopeing, 2008). As these authors explain, in nonrandomized studies direct comparison between two groups (treated and control) can be biased because the individuals in each group can be systematically different. In other words, the PSM was designed to overcome the problem of selection into treatment. The idea of PSM is to estimate a so-called score that indicates which individuals possess similar socioeconomic characteristics—such as gender, income, Federal State of residence, education, and others—where the main difference is whether they consume legal or illegal cigarettes. The original sample is then balanced based on the propensity score, so that both groups are alike and "direct comparisons are more meaningful" (Rosenbaum & Rubin, 1983: 42).

The identification assumption of PSM is that, after conditioning on the set of observed variables, treatment assignment is independent of potential outcomes. If this conditional independence assumption holds, PSM estimates have a causal interpretation. The advantage of PSM in the present setting is thus to address the endogeneity of cigarette prices due to the selection of individuals into either more expensive legal or cheaper illegal cigarettes. Based on the observed characteristics of federal state, income, years of smoking, age, education and gender, we expect that smokers for which we found a counterpart through PSM have a very similar consumption pattern. Whether this assumption is likely to hold can be seen from the post PSM mean differences regarding the observable control variables.

Technically, PSM is implemented in the following way. In the first step the propensity score is derived from a probit model where the dependent variable is the indicator variable for illicit cigarette consumption and the explanatory variables are the characteristics in X and federal state fixed effects. Then, based on the propensity score, a one-to-one nearest neighbor matching is applied, without replacement, where successful pairing is restricted to observations on the common support of the propensity score distribution of both illicit and licit cigarette smokers. Additionally, the propensity scores of a pair may not be further apart than 0.1 (caliper matching). These adjustments guarantee that the pairs are as comparable as possible.

Once pairs of highly similar smokers are identified, cigarette prices are "exchanged." This means, for smokers of illegal cigarettes a hypothetical price of legal cigarettes is assigned based on the choice of his/her counterfactual pair, and vice versa for smokers of legal products. Thus, the estimation of price and cross-price elasticities proceeds only with matched pairs of smokers. Note also that the implemented exchange of prices across matched pairs is conceptually similar to exchanging the individually observed prices for the average state-level price, which is the common solution of the endogeneity bias in case of a simple conditional price elasticity estimation. Another check for the accuracy of our novel PSM cross-price identification is the comparison between their value and the simple conditional price elasticity for both the legal and illegal cigarette market where we can apply state-level prices in order to avoid the endogeneity bias. As will be clear from Tables 3 and 4, the estimates are indeed relatively close to each other.

The matching reduces the number of observations with valid cigarette price information from 11,870—of which 4,033 consume illegal cigarettes—to 2,744 smokers in each of the two groups. Table A1 in the Appendix illustrates that PSM is capable of balancing the two groups of cigarette consumers—that is, the distribution of socioeconomic characteristics for smokers of illicit and licit cigarettes after PSM are much more similar than in the unconstrained sample. For example, Table A1 shows that PSM reached an exact matching regarding the variable year, such that all individual pairs were observed in the same year.

Estimation of overall price elasticity

We estimate the conditional and unconditional price elasticity of demand for cigarettes. Unconditional price elasticity indicates the percent decrease in smoking prevalence due to a one-percent increase in cigarette prices. Conditional price elasticity refers only to current smokers and measures the percent decrease in cigarette consumption that is induced by a one-percent increase in cigarette prices. Both the conditional and unconditional elasticities are combined as in Divino et al. (2020a, 2020b) to yield the total price elasticity.[4]

Unconditional price elasticity is estimated by the following probit model

$$\Pr(S_{i,t}) = \Phi(\gamma + \xi \mathrm{P}_{s,t} + \delta \mathrm{X}_{i,t} + D_r + D_t) \quad (1)$$

[4] As explained in Divino et al. (2020), the total price elasticity is not simply the sum of the conditional and unconditional elasticities because it reflects adjustments along two dimensions: (1) the consumption quantity (smoking intensity), or the intensive margin; and (2) the smoking prevalence, or the extensive margin. Since both dimensions change at the same time, the total effect of a price increase is not simply the algebraic sum of the conditional and the unconditional elasticity.

where $S_{i,t}$ is an indicator of whether individual i in year t is a smoker or not, and $P_{s,t}$ is the average price in federal state s. $X_{i,t}$ contains the observable individual characteristics, such as age, gender, personal income, household size, and years of smoking. D_r represents fixed effects for the five geographical regions of Brazil to control for unobservable differences between the population in these regions. Similarly, D_t denotes the year fixed effects. The nonlinear nature of the probit model permits us to identify how the prevalence elasticity varies across the federal states and price categories (low, medium, and high). That is, upon evaluating the marginal effect of prices on the probability of smoking, we use the specific average values of the control variables in X_i and the average prices of cigarettes in three price categories in each state.

We also estimate conditional tobacco demand following the methodology described in Divino et al. (2021). To increase the number of observations, this estimation is based on the full sample of smokers in the pooled regression using the PNS from 2013 and 2019. The estimated conditional demand equation is given by

$$\ln(Q_{i,t}) = \alpha + \sum_{c=1}^{3} \gamma_{c,r} \ln(\mathrm{P}_{c,s,t}) \times D_r + \xi \mathrm{P}_{s,t} + \delta \mathrm{X}_{i,t} + D_r + D_t) + \varepsilon_{i,t} \quad (2)$$

where $Q_{i,t}$ is the number of cigarettes consumed daily, $P_{c,s,t}$ is the cigarette prices (per pack) averaged by state along categories $c = 1, 2, 3$ and the respective coefficients $\gamma_{c,r}$ are the conditional price elasticities. The price category 1 represents the illegal market, while price categories 2 and 3 account for the legal market, and the threshold separating them is the median value. Monetary variables like cigarette prices and income are deflated to 2019 price levels using the tobacco-specific component of the consumer price index obtained from the IBGE. Finally, as defined before, D_r and D_t are year and regional fixed effects, respectively, and $X_{i,t}$ are control variables for individual characteristics (Divino et al., 2021). Equation (2) thus yields conditional price elasticities for each price class and federal state.

Estimation of the demand-switching effect between the licit and illicit markets

To estimate the demand-switching effect between the licit and illicit markets, the conditional price elasticities are estimated by two linear regression models:

$$\ln(\tilde{Q}_{m,t,licit}) = \alpha_{licit} + \delta_{licit}^{own} \ln \tilde{P}_{m,t,licit} + \delta_{illicit}^{cross} \ln \tilde{P}_{m,t,illicit} + \beta \tilde{X}_{m,t} + D_{r,licit} + D_t + \tilde{\varepsilon}_{m,t} \quad (3a)$$

$$\ln(\tilde{Q}_{m,t,illicit}) = \alpha_{illicit} + \delta_{illicit}^{own} \ln \tilde{P}_{m,t,illicit} + \delta_{licit}^{cross} \ln \tilde{P}_{m,t,licit} + \beta \tilde{X}_{m,t} + D_{r,illicit} + D_t + \tilde{\varepsilon}_{m,t} \quad (3b)$$

where $\tilde{Q}_{m,t,}$ is the number of cigarettes smoked per day by PSM matched individual m, $\tilde{P}_{m,t,}$ is the price per 20-cigarette pack paid by PSM matched individual m, $\tilde{X}_{m,t}$ contains the same control variables defined above but for the PSM matched individual m, and $D_{r,}$ represents federal state fixed effects. Because the variables of interest—cigarette

consumption and prices—are transformed into logarithm, the coefficients δs can be interpreted as elasticities.

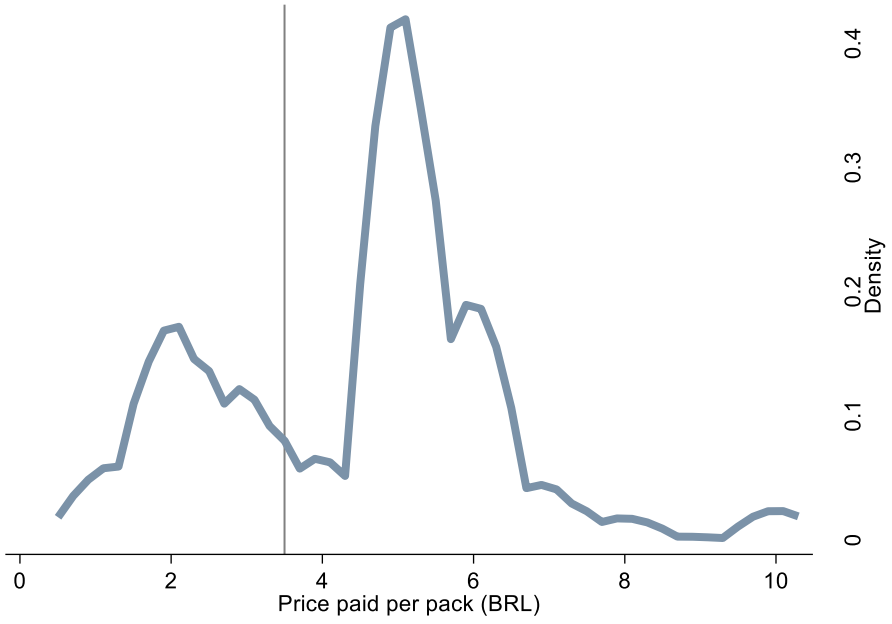
The novelty in equations (3a) and (3b) is the distinction between prices of illegal and legal cigarettes. These two specifications render the own-price and the cross-price elasticities of cigarette demand in the legal market (eq. 3a) and the illegal market (eq. 3b). Thus, these two equations are only distinguished by the type of cigarettes the matched individual m consumes. For example, the coefficient δ_{licit}^{own} indicates how sensitive consumers of legal cigarettes are to increases in the price of their legal brand. The cross-price elasticity in equation (3a) $\delta_{illicit}^{cross}$ shows how much smokers would adjust the consumption of legal cigarettes in case the price in the illegal market changes.

Results

Minimum legal price and the illicit cigarette market

Figure 1 illustrates the distribution of reported cigarette prices using the PNS 2013 data, which clearly shows a bimodal distribution with peaks at about BRL 2 and BRL 5. The first peak is far below the minimum price of BRL 3.50 and the second peak is around the average of legally priced cigarettes, equal to BRL 5.00. Note also that the proportion of legal cigarette consumers is much larger and the distribution of those prices wider than those of illegal cigarettes.

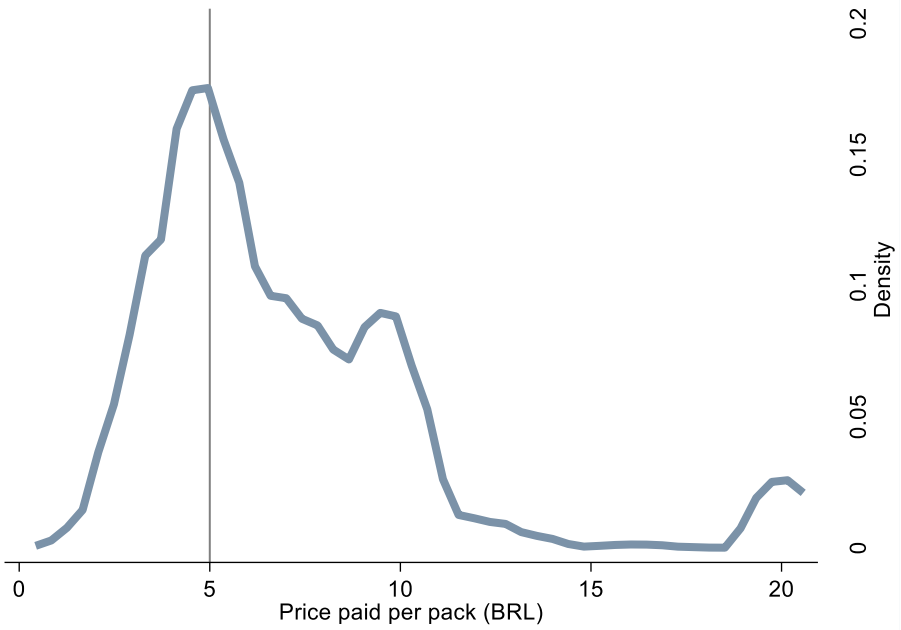
Figure 1. Distribution of cigarette smokers and minimum price (PNS 2013)



Notes: The figure shows the kernel density distribution of 20-cigarette pack nominal prices in the entire sample of smokers in the PNS 2013. The vertical straight line at BRL 3.5 separates the legal and illegal markets based on the official minimum price in 2013.

Figure 2 illustrates the distribution of smokers using the PNS 2019 data. Data no longer show a bimodal distribution, as was the case for the PNS 2013 data. The minimum price thus seems no longer to be binding and does not clearly separate the licit and illicit cigarettes in the country because both types of cigarettes are sold at similar prices, around BRL 5.00 per pack.

Figure 2. Distribution of cigarette smokers and minimum price (PNS 2019)



Notes: The figure shows the kernel density distribution of 20-cigarette pack nominal prices in the entire sample of smokers in the PNS 2019. The vertical straight line at BRL 5.00 separates the legal and illegal markets based on the official minimum price in 2019.

While PNS surveys are only available for 2013 and 2019, other indicators such as cigarette price, exchange rate, and cigarette affordability provide additional insights into the evolution of the (licit and illicit) cigarette market in Brazil (Table 1). Brazil introduced a minimum price for cigarette sales in 2011 (art. 7º of the Decree nº 7.555/2011) as part of a series of changes in the tobacco excise tax. Despite several updates over the years, there has been no change in the minimum price of BRL 5.00 per pack since May 2016. However, over the same years the minimum legal price in USD shows a clear reduction. This reduction is associated with the increasing exchange rate between BRL and USD (this increase may be seen as an increase in production costs). One hypothesis is that exchange rate devaluation created a significant increase in production costs, such that illicit sellers may have had to increase their price from around BRL 2.20 in 2013 to BRL 5.00 in 2019.

The price of legal cigarettes, however, is less influenced by the exchange rate, as licit cigarettes are produced domestically. Therefore, other factors such as the prolonged economic crisis in Brazil may have influenced domestic legal producers to avoid price increases. Moreover, the observed increase in minimum wages in Brazil seems to have increased the affordability of legal cigarettes between 2013 and 2019.

Table 1. Minimum legal price of 20-cigarette pack and affordability

Year	Min. price (BRL)	Exch. rate (BRL/USD)	Min. price (USD)	Min. wage (BRL)	MWage/MPrice (# packs)
2012	3.00	1.95	1.53	622	207
2013	3.50	2.16	1.62	678	194
2014	4.00	2.35	1.70	724	181
2015	4.50	3.33	1.35	788	175
2016	5.00	3.49	1.43	880	176
2017	5.00	3.19	1.57	937	187
2018	5.00	3.65	1.37	954	191
2019	5.00	3.95	1.27	998	200
2020	5.00	5.16	0.97	1045	209
% change 2019/2013	42.9	82.8	-21.9	47.2	3.0

The confluence of all these factors resulted in a more concentrated overall cigarette price distribution between BRL 4 and BRL 10 (including illegal and legal markets), as reported in Figure 2.

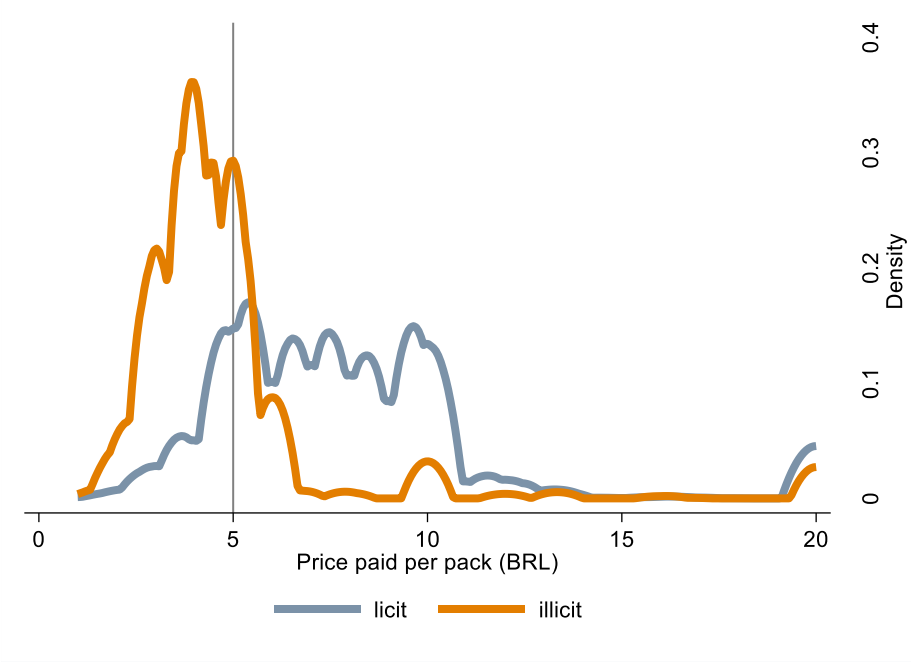
The positive effects of setting a minimum price and regularly revising its accuracy as part of an effective tobacco control policy are well known.[5,6] The factors depicted in Table 1 show that the current minimum price of BRL 5 is outdated, and its intended effect of reducing cigarette consumption by making legal cigarettes more expensive is losing momentum. Thus, the minimum legal price in 2019 is no longer a useful threshold to distinguish between the licit and illicit markets as it was in 2013. Note further that in 2013, the overall illicit market was estimated in 32.3% and in 2019 it was estimated in 39,1%, using official data (Szklo et al., 2007, INCA, 2021).

[5] For instance, see Boettiger et al., 2021; Golden et al., 2020; Doogan et al., 2018; Huang et al., 2016; Golden et al.; 2016; McLaughlin et al., 2014.

[6] It is important to note that the minimum price policy, which sets a floor price at the retail level, (adopted in Brazil) is more effective than those that impose a percent markup on retail prices.

PNS 2019 data also report a dummy variable that distinguishes between licit and illicit cigarette purchases as declared by the smokers (interviewees) in the PNS survey. Figure 3 illustrates that both legal and illegal cigarettes are sold at prices around the minimum floor price.

Figure 3. Distribution of cigarette smokers by brand type and minimum price (PNS 2019)



The peak in illicit cigarette prices is very close to the minimum price (BRL 5.00), while there is a plateau in licit cigarette prices above the minimum price (between BRL 5.1 and BRL 11.0). At the same time, some legal brands are sold below the minimum price while some illegal brands are sold above it. Thus, the minimum price no longer provides a clear distinction between licit and illicit cigarettes.

Comparing PNS 2013 and 2019, there is a clear transition from a bimodal price distribution to a bell curve. The upward trend on the nominal price of illegal brands and downward trend on the nominal price of legal brands results in the overall Brazilian cigarette market selling cigarettes around the minimum legal price.

Price elasticities

Table 3 summarizes the estimated price elasticities, conditional, unconditional, and the combined total across the five Brazilian regions and by price category. According to our division of the market into three relatively equal parts, PC1 is the illegal market, PC2

represent medium brands and PC3 are higher price cigarettes.[7] The negative coefficients of the so-called prevalence elasticity according to equation (1) indicate the percentage change in the number of smokers due to a 1% cigarette price increase. So for example, the unconditional price elasticity in the North in PC1 indicates that is a 10% increase in cigarette price will decrease the share of illegal cigarette smokers by 3%. The unconditional elasticity in the same category suggests that 10% higher prices would lead smokers to decrease their consumption by 2%. Finally, the total elasticity combines these two effects. Tables A2 and A3 in the appendix contain the complete list of estimated coefficients, robust standard errors, and statistical significance levels for the unconditional and conditional demand equation.

Table 3 – Estimated price-elasticities by regions and price categories (PNS 2019)

	Conditional			Unconditional			Total (Price increasing)		
Region	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3
North	-0.30	-0.35	-0.42	-0.20	-0.35	-0.57	-0.45	-0.57	-0.75
Northeast	-0.35	-0.48	-0.70	-0.22	-0.37	-0.60	-0.49	-0.67	-0.88
Southeast	-0.49	-0.62	-0.90	-0.21	-0.35	-0.58	-0.59	-0.75	-0.96
South	-0.49	-0.66	-0.87	-0.20	-0.34	-0.56	-0.59	-0.78	-0.94
Midwest	-0.40	-0.63	-0.79	-0.20	-0.35	-0.57	-0.52	-0.76	-0.91
Brazil	**-0.37**	**-0.48**	**-0.65**	**-0.21**	**-0.36**	**-0.58**	**-0.50**	**-0.67**	**-0.86**

It is worth mentioning that the poorest states from the North region of the country appear to show higher unconditional price elasticity than other states, as well as those from the Northeast region with socio-economic conditions similar to the North. The differences, however, are small and not statistically significant. Overall, the price elasticities are in line with previous studies, such as Divino et al. (2020a, 2020b). The two richest regions (South and Southeast), where smoking prevalence is historically high, show higher price elasticity in absolute terms. Distinguishing the elasticity according to price classes of cigarettes shows that the lower the price, the lower the smoker's propensity to quit smoking as a response to price increases. What may seem counterintuitive at first might be justified by the fact that those individuals seeking to save money by consuming cheaper cigarettes tend to be heavier smokers, more addicted and clients of the illicit market. Moreover, recall that we are not comparing income groups; rather, because income is a control variable in the regressions, the comparison is among individuals with the same average income.

[7] See the Appendix B for an explanation on the computation of the total price elasticity.

Cross-price-elasticity estimation

Table 4 reports the own-price and cross-price elasticities for both the licit and illicit markets according to the specifications in equations (3a) and (3b), both for the pooled sample and each of the years 2013 and 2019 separately.

Table 4 – Conditional own- and cross-price elasticities

	PNS 2013		PNS 2013 and 2019		PNS 2019	
Variable	**Illicit mkt (1)**	**Licit mkt (2)**	**Illicit mkt (3)**	**Licit mkt (4)**	**Illicit mkt (5)**	**Licit mkt (6)**
Licit cigarette price (log)	-0.196	-0.320	-0.076	-0.412	-0.053	-0.417
	(0.14)	(0.136)	(0.057)	(0.058)	(0.061)	(0.066)
	[0.161]	[0.019]	[0.182]	[0.000]	[0.386]	[0.000]
Illicit cigarette price (log)	-0.142	0.146	-0.253	0.075	-0.366	0.021
	(0.07)	(0.065)	(0.045)	(0.043)	(0.061)	(0.058)
	[0.043]	[0.027]	[0.000]	[0.087]	[0.000]	[0.723]
R^2	0.129	0.149	0.097	0.130	0.118	0.141
# Obs.	1,233	1,233	2744	2744	1511	1511

Notes: The first row indicates whether the dependent variable is the log of legal or illegal cigarette consumption according to equations (3a) and (3b). Regressions include controls for gender, age group, education group, years of smoking, family size, log income and state dummies. For the pooled sample, the estimation also includes a year dummy. Table A4 in the appendix contains the complete list of estimated coefficients. Robust standard errors are in parenthesis and p-values are in brackets.

The own-price elasticities are negative and significant in all six estimations. An increase in illicit cigarettes prices will decrease consumption of illicit cigarettes and the same applies to the relation between legal cigarette prices and legal cigarette consumption. Specifically, a tax increase that leads to a 10 percent price rise would reduce consumption of legal cigarettes by 4.1 percent (according to the pooled sample estimation in column 4). The magnitude of these coefficients varies slightly but is within the range of previous comparable studies (Divino et al, 2020a). More importantly, for the PNS 2019, the own-price elasticities are close to the price elasticities we obtained with the state-level mean prices in Table 3. This similarity indicates that the endogeneity bias, arguably well addressed by the mean prices, is equally tackled by the PSM approach that proceeds with the exchanged PSM matched individual prices.

A 10% price increase in illegal cigarettes would reduce consumption of illegal cigarettes by 2.5% (according to the pooled sample estimation in column 3). As already documented in the previous section and by Divino et al (2020b), smokers from the illicit market are less price sensitive than consumers of legal cigarettes, as indicated by the own-price

elasticity of -0.25 in the illicit market against the value of -0.412 in the licit market. The same qualitative results for the own-price elasticities hold when the coefficients are estimated from the PNS 2013 or the PNS 2019 sample separately.

The effect of an increase on legal cigarette prices on illicit cigarette consumption is not statistically different from zero (according to the pooled sample estimation in column 3). That means we observe no-transition of consumers from the legal to the illegal market due to legal price increases.

The effect of an increase on illicit cigarette prices on licit cigarette consumption is positive. Columns (2) and (4) indicate that the consumption of legal cigarettes is positively related to the price of illegal cigarettes when either the 2013 or the pooled PNS data are used. Thus, a 10 percent increase on illegal cigarettes would increase the consumption of legal products by between 1.4% and 0.7%. Both estimates are statistically significant at the 5% and 10% confidence level, respectively. In other words, there is a statistically significant demand-switching effect of consumers from the illicit to the licit market whenever the smuggled cigarettes become more expensive.

As the overall elasticity is bigger than -1.0 (inelastic), a higher tax increase means higher revenue collection because the decrease in consumption is more than compensated by the increase in prices. Thus, contrary to the industry argument, cigarette tax increases would lead simultaneously to price increase, consumption reduction, and no effect on the size of the illicit cigarette market.

In sum, the results of the cross- and own price elasticities are robust to the estimation of the preferred specification without state level fixed effects or without any control variables. The results are still similar, however, at lower significance levels in line with the decline in the precision of the estimates. Simultaneous estimation of both equations (3a) and (3b) with interaction terms for the type of market also yield highly similar results.

Conclusions

This research uses individual-level survey data to estimate own- and cross-price elasticities of cigarette consumption and to analyze the effectiveness of the minimum legal price in increasing prices and distinguishing between legal and illegal cigarettes in Brazil. The findings provide new evidence to inform the current debate about Brazilian tax reform and the broader discussion about the effectiveness of taxes as a tobacco control measure.

In contrast to previous analyses, this paper explicitly accounts for interrelations between legal and illegal cigarette prices and their demand. We found convincing empirical evidence that contradicts the tobacco industry's arguments against tax increases in the context of illicit trade. First, despite growing cigarette taxes in recent years, we observe

that the (relative) size of the illicit cigarette market did not increase in Brazil. Second, prices of illegal cigarettes tend to go up when higher taxes raise the price of legal cigarettes. Third, in the combined sample the estimated cross-price elasticities show that smokers are willing to move from the illicit to the licit market but not the other way around.

Contrary to the frequent claims of the cigarette industry, this study's results indicate that a cigarette tax increase would not cause a demand-switching effect towards the illicit market. Instead, it would simultaneously reduce smoking and increase tax revenues. In fact, there is a significant one-sided demand-switching effect from the illicit to the licit market whenever there is a price increase of illicit cigarettes. Specifically, if illicit prices increase by 10 percent, then consumption of licit cigarettes would rise by 0.7 percent, according to the pooled sample of the 2013 and 2019 PNS data.

Alternatively, the effect of increasing legal cigarette prices on illicit cigarette consumption is not statistically significant. Thus, there is no significant evidence that a price increase of licit cigarettes due to tax reform would expand the illicit market. In addition, if the illicit dealers increase the price of illicit cigarettes after the tax reform is in place—which seems likely as licit and illicit prices are highly positively correlated—this would lead to an additional reduction in the consumption of illicit cigarettes. The combined effect would be a substantial decrease of the illicit market. We also observe that the lack of adjustment of the minimum price over time resulted in an overlap between prices in the illicit and licit market, which ultimately led to a decrease in the cross-price elasticities.

The positive and statistically significant cross-price elasticity estimate from the illicit to the licit market represents a second-order effect of public policies that fight cigarette smuggling, which not only will reduce the illicit trade of cigarettes by itself but also will make these cigarettes more expensive and cause a demand-switching effect towards the licit cigarette market. For the year 2019, recall that we observe an overlap between cigarette prices in the illicit and licit market due to increased production costs of imported illegal cigarettes and a stagnant minimum legal price. Given that the two markets are indistinct and apparently little can be gained from switching, the cross-price elasticity in column (6) of Table 2 turns statistically insignificant and numerically close to zero. That is, even in the face of price increases consumers seem to prefer to maintain their habitual brand and type of product, be it legal or illegal.

Public policies that make illicit cigarettes more expensive—like border controls or controls along the supply chain—will result in increases in illicit cigarette prices, reducing illicit consumption even further. The trend in the exchange rate also seems to be increasing the price of illicit cigarettes. However, the lack of updates to the minimum price appears to have the undesired consequence of limiting additional increases in illicit cigarette prices, reducing the positive second-order effect of demand-switching.

The current minimum price is no longer an effective tax policy instrument to sustain and support cigarette price increases. It is important to regularly raise the minimum price to

make the tobacco control policy more effective in regard to both licit and illicit cigarettes. Regularly raising the minimum price will not only reduce the illicit trade of cigarettes but also will make them more expensive and cause a demand-switching effect towards the licit market. This observation is qualitatively and quantitatively in line with previous studies based on different methodologies (West et al., 2008; Joossens et al., 2009; Goodchild et al., 2020). Moreover, the northern states, which are the poorest in the country in terms of per capita income, would benefit the most from the higher illicit prices since they are more sensitive to price variations than the other states.

A limitation of the methodology in this study is that the estimation of price and cross-price elasticities using PSM proceeds only with matched pairs of smokers. Therefore, there may be a bias related to behaviors—for example, heavy smokers or those with a lower budget may be more likely to choose the cheaper illegal products—even though the results are robust. Also, because of the combination of PSM and conditional price estimation, the comparable sample of smokers is relatively small and includes relatively few smokers of high-price cigarettes. Therefore, the matched sample does not allow us to derive specific elasticities by price categories and by regions of the country, as we did in the case of the conditional specification mentioned in the previous section.

The tobacco tax reform bills under consideration in the Brazilian National Congress provide the opportunity to raise cigarette prices, tax burden, and tax revenues while decreasing cigarette consumption and yielding no demand-switching effect to the illicit market. Fighting cigarette smuggling will not only reduce illicit trade but also will make these cigarettes more expensive and cause a demand-switching effect towards the licit market, decreasing consumption and increasing tax revenues simultaneously. These combined effects suggest that anti-smuggling efforts are a very effective public policy to reduce cigarette consumption in the country.

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Appendix

Appendix A. Distribution of socioeconomic characteristics for smokers of illicit and licit cigarettes

Table A1. Distribution of socioeconomic characteristics for smokers of illicit and licit cigarettes before and after the PSM (pooled sample 2013–2019)

Variable	Status	Mean of licit cigarette smokers	Mean of illicit cigarette smokers	Difference in means t-test
Age	unmatched	45.8	45.0	2.64***
	matched	45.9	46.7	-2.07**
Years of schooling	unmatched	6.4	8.7	-20.8***
	matched	7.1	6.9	0.8
Years of smoking	unmatched	27.5	24.0	7.9***
	matched	27.5	28.0	-0.9
Share of males	unmatched	0.6	0.6	1.1
	matched	0.6	0.6	-0.4
Log(income)	unmatched	6.6	7.1	-18.1***
	matched	6.7	6.7	-0.5
Family size	unmatched	3.1	3.0	3.0***
	matched	3.1	3.0	0.2
Year	unmatched	2016.4	2016.1	9.3
	matched	2016.3	2016.3	0.0

Table A.1 contains the mean values of the socioeconomic characteristics that are used in the present estimations for smokers in the legal and illegal markets. While the average of all variables except gender are statistically different between both groups of smokers, they become insignificant after the PSM.

Appendix B Own-price-elasticity estimation

The total price elasticity reflects adjustments along two dimensions: (i) smoking intensity, or the intensive margin, and (ii) the smoking prevalence, or the extensive margin [Divino et al. (2020)]. Since both dimensions change simultaneously, the total effect of a price change is not simply the sum of the conditional and the unconditional elasticity. It depends on whether there is either an increase or a decrease in the cigarette price as follows:

$$\varepsilon_q = \varepsilon_d + \varepsilon_u + \text{sgn}\left(\frac{\Delta P}{P}\right) \times \varepsilon_d \times \varepsilon_u, \quad \text{sgn}\left(\frac{\Delta P}{P}\right) = \begin{cases} -1, \text{if } \dfrac{\Delta P}{P} < 0 \\ 0, \text{if } \dfrac{\Delta P}{P} = 0, \\ +1, \text{if } \dfrac{\Delta P}{P} > 0 \end{cases}$$

where $\varepsilon_q, \varepsilon_d$ and ε_u are the total, conditional and unconditional price-elasticities, respectively, and $sgn(.)$ is a function that takes the sign of the price change.

Table B1. Unconditional detailed estimation results for demand equation (1)

Variable	Coefficient
P_all	-0.026***
	(0.006)
P_all	
Region	
Northeast	-0.152***
	(0.016)
Southeast	0.062***
	(0.017)
South	0.117***
	(0.020)
Midwest	0.043**
	(0.021)
Age	
30 – 39	-0.137***
	(0.015)
40 – 49	-0.377***
	(0.017)
50 – 59	-0.805***
	(0.023)
60+	-1.921***
	(0.036)

Schooling years	
5 – 9	-0.072***
	(0.017)
10 – 11	-0.290***
	(0.021)
11+	-0.257***
	(0.020)
Smoking years	0.047***
	(0.001)
Male	0.222***
	(0.011)
Income	-0.061***
	(0.007)
# family members	
2	-0.199***
	(0.017)
3	-0.240***
	(0.017)
4	-0.273***
	(0.018)
5+	-0.151***
	(0.019)
PNS2019	-0.205***
	(0.012)
Constant	-0.337***
	(0.067)
# Observations	122,947

Notes: Robust standard errors in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table B2. Conditional detailed estimation results for demand equation (2)

Variable	Coefficient
PC1 (P_illicit)	-0.305***
	(0.043)
PC2	-0.345***
	(0.060)
PC3	-0.416***
	(0.114)
PC1 (P_illicit)	
Region	

Northeast	-0.049
	(0.031)
Southeast	-0.182***
	(0.031)
South	-0.181***
	(0.031)
Midwest	-0.095***
	(0.031)
PC2	0
Region	0
Northeast	-0.137***
	(0.043)
Southeast	-0.272***
	(0.041)
South	-0.319***
	(0.044)
Midwest	-0.282***
	(0.048)
PC3	
Region	
Northeast	-0.279***
	(0.093)
Southeast	-0.482***
	(0.083)
South	-0.452***
	(0.087)
Midwest	-0.370***
	(0.092)
Age	
30 – 39	-0.027
	(0.028)
40 - 49	-0.138***
	(0.034)
50 – 59	-0.246***
	(0.042)
60+	-0.497***
	(0.054)
Schooling years	
5 – 9	0.145***
	(0.026)
10 – 11	0.153***
	(0.032)
11+	0.123***

	(0.031)
Smoking years	0.017***
	(0.001)
Male	0.191***
	(0.017)
Income	0.035***
	(0.011)
# family members	
2	-0.001
	(0.023)
3	0.009
	(0.024)
4	0.02
	(0.027)
5+	-0.023
	(0.029)
PNS2019	-0.038**
	(0.019)
Constant	0.903***
	(0.095)
# Observations	10,464
R-squared	0.094

Notes: Robust standard errors in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Appendix C Cross-price-elasticity estimation

Table C1. PSM detailed estimation results for demand equations (3a) and (3b)

PNS year	2013–2019		2013		2019	
Variable/Market	illegal	legal	illegal	legal	illegal	legal
P_licit	-0.076	-0.412***	-0.196	-0.320**	-0.053	-0.417***
	(0.057)	(0.058)	(0.140)	(0.136)	(0.061)	(0.066)
P_illicit	-0.253***	0.075*	-0.142**	0.146**	-0.366***	0.021
	(0.045)	(0.043)	(0.070)	(0.065)	(0.061)	(0.058)
Age						
30 – 39	0.032	0.092	0.027	-0.016	0.053	0.190**
	(0.054)	(0.057)	(0.076)	(0.079)	(0.074)	(0.082)
40 - 49	-0.073	-0.013	-0.293***	-0.197**	0.159*	0.14
	(0.069)	(0.069)	(0.101)	(0.100)	(0.093)	(0.095)
50 – 59	-0.163*	-0.068	-0.340***	-0.260**	0.041	0.109
	(0.085)	(0.080)	(0.122)	(0.118)	(0.114)	(0.110)
60+	-0.389***	-0.190*	-0.638***	-0.442***	-0.1	0.051
	(0.114)	(0.105)	(0.169)	(0.156)	(0.150)	(0.142)
Schooling years						
5 – 9	0.125***	0.159***	0.192***	0.157***	0.016	0.168**
	(0.046)	(0.044)	(0.064)	(0.058)	(0.071)	(0.073)
10 – 11	0.114*	0.138**	0.164**	0.147*	-0.101	0.183
	(0.064)	(0.064)	(0.078)	(0.076)	(0.141)	(0.144)
11+	0.057	0.133**	0.028	0.046	-0.037	0.149*
	(0.058)	(0.059)	(0.101)	(0.108)	(0.079)	(0.082)
Smoking years	0.012***	0.012***	0.018***	0.018***	0.005	0.007**
	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
Male	0.203***	0.212***	0.208***	0.230***	0.221***	0.199***
	(0.033)	(0.032)	(0.050)	(0.049)	(0.043)	(0.043)
Income	0.029	0.028	0.026	0.016	0.042	0.048
	(0.024)	(0.022)	(0.032)	(0.033)	(0.035)	(0.032)
# family members						
2	-0.045	0.05	0.042	0.039	-0.092	0.057
	(0.047)	(0.042)	(0.074)	(0.069)	(0.061)	(0.054)
3	-0.009	0.042	0.052	0.001	-0.062	0.065
	(0.048)	(0.045)	(0.074)	(0.068)	(0.062)	(0.062)
4	0.014	0.05	0.021	0.001	0.024	0.094
	(0.052)	(0.051)	(0.080)	(0.078)	(0.067)	(0.069)
5+	0.001	0.032	-0.026	0.016	0.06	0.043
	(0.055)	(0.056)	(0.081)	(0.080)	(0.075)	(0.081)
PNS2019	-0.008	-0.175***				
	(0.037)	(0.037)				
Constant	2.209***	2.233***	2.230***	2.043***	2.371***	2.002***

	(0.211)	(0.200)	(0.344)	(0.353)	(0.298)	(0.266)
# Observations	2744	2744	1233	1233	1511	1511
R-squared	0.097	0.13	0.129	0.149	0.118	0.141

Notes: The PSM estimates are also controlled for fixed effects for federal states because cigarette prices are specific for each smoker. Robust standard errors in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.