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Aisha Baisalova

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Exploring Border Effects: Sensitivity of Cigarette Consumption to Excise Tax *†

Aisha Baisalova ‡

May 4, 2022

Abstract

Border effects can have a considerable influence on the effectiveness of excise tax policy measures. The opportunity to buy taxable goods in the nearest lower-tax state redistributes the tax burden among consumers and determines the treatment intensity of how an increase in the tax rate may affect consumption decision. Using Nielsen Consumer Panel data, we estimate the bias arising from border effects and investigate how sensitivity to cigarette excise tax and the size of bias vary for different demographic groups. We find that border effects create a bias in the estimate of consumption sensitivity to an increase in the excise tax rate, which is present for all demographic groups. Tax sensitivity increases with the average distance to the lower tax state border, implying that border residence decreases the impact of excise tax policy interventions on consumer choice.

Keywords: excise taxation, cigarettes, cross-state purchasing, tax avoidance, border effects
JEL Classification: D12, H26, H71, L66

1 Introduction

The majority of existing studies maintain that an increase in tax rates reduces the consumption of taxable products. Excise taxation is particularly important in the case of alcohol and cigarettes, as "sin" goods exhibit pronounced negative externalities that result in direct implications for public health.

Demographic composition is one of the various observable and unobservable factors that determines the consumer response to increases in excise taxes. According to statistics provided by the Centers for Disease Control and Prevention (hereinafter CDC) in the US, people with low levels of income and education have higher smoking rates than the average population. Heckley et al. (2017) show that people with a higher level of income and a college degree in total consume more alcohol compared to non-educated low-income adults, who are, however, are more exposed to binge drinking. All these facts indicate that heterogeneity in population significantly

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†Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business.The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

‡CERGE-EI, a joint workplace of Charles University and the Economics Institute of the Czech Academy of Sciences, 111 21 Politickych veznu 7, Prague, Czech Republic. Email: aisha.baisalova@cerge-ei.cz.

influences the social and welfare outcomes of measures taken by policymakers. Identifying what groups of population benefit or suffer from a specific tax policy can help policymakers to achieve their social goals. In general, a policy can be targeted not only to the aggregate population but also to a particular demographic group; for example, government policy to reduce alcohol consumption among youth. If the government's primary objective is the equal distribution of social benefits among the population, a significant increase in excise tax on cigarettes can lead to the opposite effect since poor consumers have higher propensity to smoke, resulting in a higher tax burden on this less fortunate stratum of the population. Regardless of what goals policymakers want to achieve, it is impossible to construct an appropriate public policy measure without knowing how welfare and public health implications will differ among various demographic groups.

Tax avoidance opportunities can serve as another important determinant of a consumer's purchase decision in response to an excise tax increase. Indeed, cross-state purchasing in the nearest lower-tax state decreases the impact of excise tax policy measures. Moreover, because of profit motives, shops close to borders may adjust prices to smooth the unfavorable tax difference to a certain extent. Ignoring these 'border effects' leads to a biased estimate of the tax elasticity of consumption. The bias is particularly large for border residents, since the cost of traveling to the nearest lower-tax state to purchase taxable goods at the lower price increases with the distance to the state border. In this study, we estimate the bias arising from border effects and investigate how sensitivity to cigarette excise tax and the size of bias vary for different demographic groups. We specifically concentrate on excise taxation of cigarettes in the US, where we can track the variability of state excise taxes across states.

We use Nielsen Consumer Panel data for the years from 2004 to 2019 to explore whether ignoring border effects will bias the estimate of tax elasticity. We estimate the bias arising from cross-state tax avoidance opportunities by constructing a regression of cigarette consumption on the excise tax rate and other explanatory variables, and comparing the estimation results to the same regression specification with additional variables related to cross-border purchasing. Furthermore, we analyze how the tax sensitivity of cigarette consumption and the size of bias vary among households with different demographic compositions.

Our results show that the consumer response to a cigarette tax increase varies substantially between households with different demographic characteristics. We observe higher tax elasticity for the low income group. Higher tax sensitivity estimated for unemployed consumers and consumers without college degree can be potentially explained by the fact that, on average, these demographic groups have lower income. Furthermore, we identify that estimated tax sensitivity increases with smoking intensity, in contrast to Lee (2008) and Cotti et al. (2018), who show that heavy smokers do not respond to excise tax policy measures. Finally, we find that border effects create a bias in the estimate of consumption sensitivity to an increase in the excise tax rate, which is present for all demographic groups. Tax sensitivity increases with the average distance to the lower tax state border, implying that border residence decreases the impact of excise tax policy interventions on the purchase decision of consumers.

2 Literature Review

The negative effect of excise tax increases on tobacco consumption has been discussed in numerous studies. Sensitivity of cigarette consumption to a tax increase is an important question for policy makers from the perspective of public health implications and tax revenue effects.

Using data from telephone survey conducted from April to July 2004 in 23 major cities and counties in Taiwan, Lee (2008) evaluates the effect on cigarette consumption of a large increase

in cigarette tax of NT$22 per pack, which is equivalent to a 44% price increase. The study analyzes how price elasticity varies among different socio-demographic groups and finds that price sensitivity decreases with income and is higher for female smokers, moderate smokers, and smokers who purchase mid- and low-price cigarettes.

Cotti et al. (2018) use Nielsen Consumer Panel data for the years 2011 through 2015 to investigate how tobacco control polices, such as excise taxes and smoke-free laws, affected purchases of cigarettes, electronic cigarettes and smoking cessation products. The authors analyze the impact of these policy measures on the probability that a household purchases tobacco products and on the quantity of cigarettes purchased. The results indicate that excise taxes decrease both these parameters, and smoke-free air laws decrease the quantity of tobacco products consumed. Cotti et al. (2018) investigate the heterogeneity of these effects for various demographic groups in order to understand what subgroups respond more strongly to tobacco control measures. According to the results, older households are more responsive to excise tax increases in cigarette consumption and, conversely, younger households respond more strongly in e-cigarette consumption. Furthermore, analysis of heterogeneity depending on the household's cigarette purchase level shows that light smokers decrease cigarette consumption in response to an excise tax increase, while for heavy smokers the effect of this tax policy measure is insignificant. Moreover, low income smokers are more sensitive to an excise tax increase compared to high income consumers, which is consistent with economic theory assumptions.

Pesko et al. (2020) find evidence that higher traditional cigarette tax rates reduce adult traditional cigarette use and increase adult e-cigarette use.The estimates are based on the data from the Behavioral Risk Factor Surveillance System and National Health Interview Survey over the period from 2011 to 2018. The effects were examined across demographic sub-groups. The study shows that younger consumers have higher own- and cross-tax responsiveness as younger adults are much more likely to use e-cigarettes than other groups of adults.

One limitation of these studies is that they do not take into consideration the fact that tax sensitivity can be affected by possible tax avoidance actions of consumers, such as stockpiling if the future increase of taxes is known in advance or cross-border purchasing in the nearest lower-tax state. Since the consumer decision is determined by the final purchase price, imperfect tax pass-through to prices may bias the estimate of tax sensitivity and decrease the applicability of the obtained results.

In their study, Harding et al. (2012) show that in the US cigarette taxes are less than fully passed through to prices mainly due to cross border purchasing. Using information on consumer location provided in Nielsen scanner data for the years 2006–2007, the authors show that tax avoidance opportunities create significant differences in the pass-through rate of taxes to prices. Kim & Lee (2020), employing a similar estimation strategy to that used by Harding et al. (2012), find that cigarette taxes are shifted significantly less to consumer prices in cities with large minority (black and Hispanic) populations. The estimates are obtained using Nielsen scanner data on cigarette sales for the years 2009–2011 from 1,687 stores across the US. Xu et al. (2014) investigate how tax pass-through rate differs between premium and generic brands of cigarettes and conclude that for premium brands consumers bear a full tax burden with an additional premium, i.e. pass-through rate is higher than 100%, whereas consumers of generic brands pay only 30-83 cents for every 1$ tax increase.

Imperfect tax pass-through stemming from potential tax avoidance opportunities creates a bias in the estimate of consumption sensitivity to an increase in the excise tax rate. A number of studies analyze the impact of cross-state purchasing on smoking behavior.

For example, Lovenheim (2008) examines the impact of border effects on price elasticity using data from Current Population Survey Tobacco Supplements spanning from September 1992 to

February 2002. The study finds that demand elasticities with respect to the home state price are indistinguishable from zero on average and vary significantly with the distance individuals live to a lower–price border. However, when tax avoidance opportunities are eradicated, the price elasticity is negative but still inelastic.

Using CPS Tobacco Use Supplement (TUS) data for February, June, and November 2003, Chiou & Muehlegger (2014) introduce a discrete choice model to examine tax avoidance and state border crossing in the market for cigarettes. The authors estimate a consumer's tradeoff between distance and price when choosing a location to maximize utility, which allows them to simulate tax avoidance under alternative cigarette excise tax levels.

3 Data Description

We obtain historical data on state cigarette excise taxes from the Centers for Disease Control and Prevention.

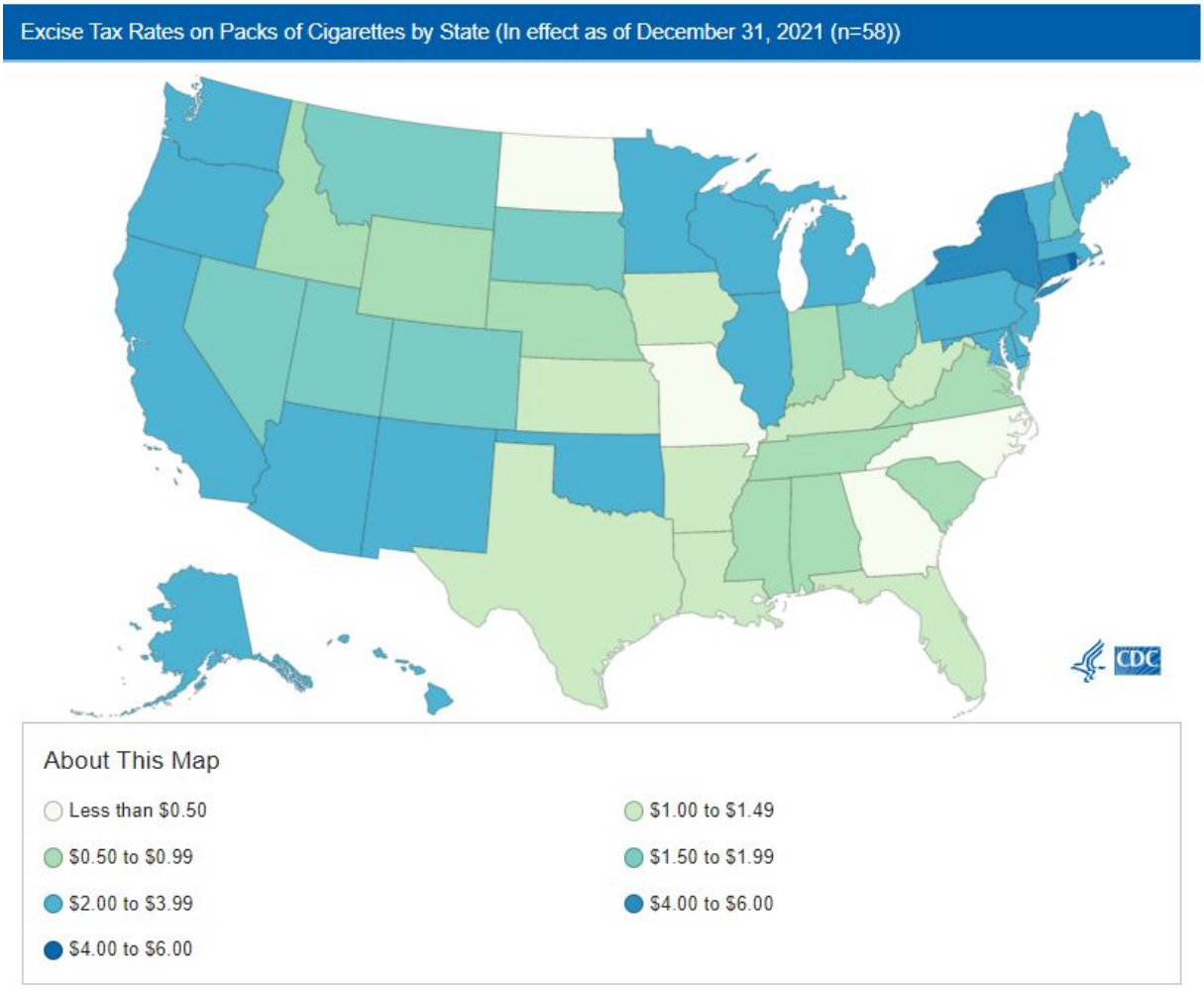

Figure 1: Excise Tax Rates on Packs of Cigarettes by State.

Source: Centers for Disease Control and Prevention (CDC)

Excise tax rate data is available on quarterly frequency. The main advantage of using US data is that in the US excise taxes are not uniform and exhibit significant variability across states. This allows us to to take into account not only changes in excise taxes over time, but also state-level heterogeneity. Figure 1 displays the variation in cigarette excise taxes across US states as of December 2021.

We use Nielsen Consumer Panel Data containing information about the purchase history of 40,000-60,000 households (varies by year) who continually provide information to Nielsen about their demographic characteristics, products they buy, as well as timing and location where they make purchases in a longitudinal study. Consumer panelists use in-home scanners to record all of their purchases intended for personal, in-home use. Panelists are geographically dispersed and demographically balanced (James M. Kilts Center for Marketing, Nielsen datasets, n.d.).

The scanner data covers 3,158,152 cigarette purchase transactions made by 52,726 households spanning from 2004 until 2019. Further, the transactional data set was transformed to panel data by aggregating the data to the household-quarter level. The frequency of the panel data set coincides with the frequency of historical cigarette tax data obtained from the CDC database.The resulting panel data set comprises 378,101 observations of quarterly cigarette purchases. The data set covers the demographic characteristics of the households, including income range, size, gender composition, presence and age of children, marital status, type of residence, race, and Hispanic origin. Additionally, it includes geographic characteristics, such as the panelist's zip code and product characteristics, which contain UPC code, description, brand, multi-pack, and size. The geographies of the data cover the entire United States (James M. Kilts Center for Marketing, Nielsen datasets, n.d.).

The major advantage of the Nielsen database is that it monitors the residence address of panelists. This allows us to incorporate geographic controls in our estimation strategy. Figure 2 shows the distribution of panelists in US states. We measure the distance to the nearest lower-tax state using Census TIGER/Line shape files provided by United States Census Bureau. We estimate the distance between consumers and lower-tax borders as the distance from the household's census tract of residence provided in the data to the border of the closest lower tax state. The lower tax state does not need to be a border state. We identify the coordinates of boundaries for each US state and calculate the distance from each consumer zip code to the state boundaries of every US state. We estimate the distance to the lower tax state for each time period and consumer zip code as the closest distance to the border of the state with the lower state cigarette tax. Further, we match the tax rate with the corresponding lower tax state. Since we measure the distance to the lower tax state for each time period, we are able to properly capture the state and time level heterogeneity in cigarette taxes and the cost of cross-border purchasing.

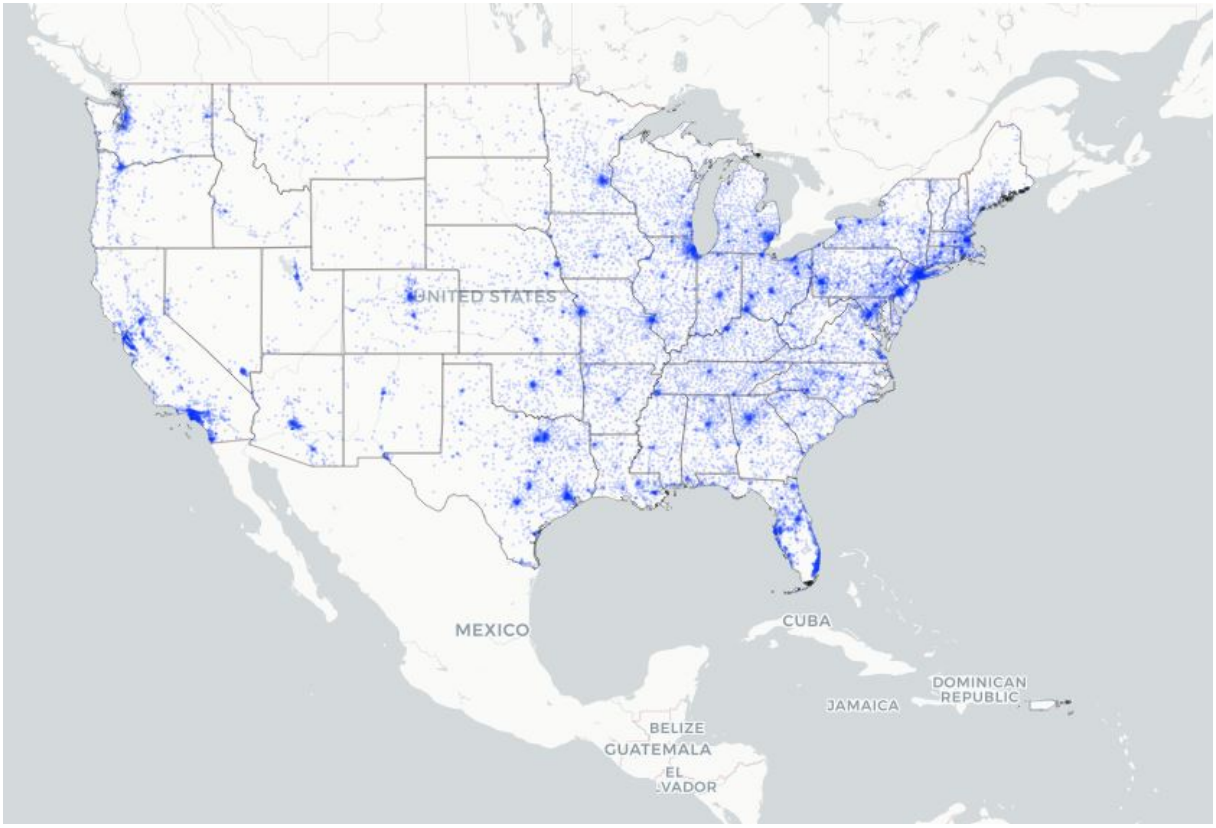

Figure 2: Distribution of Panelists in US States.

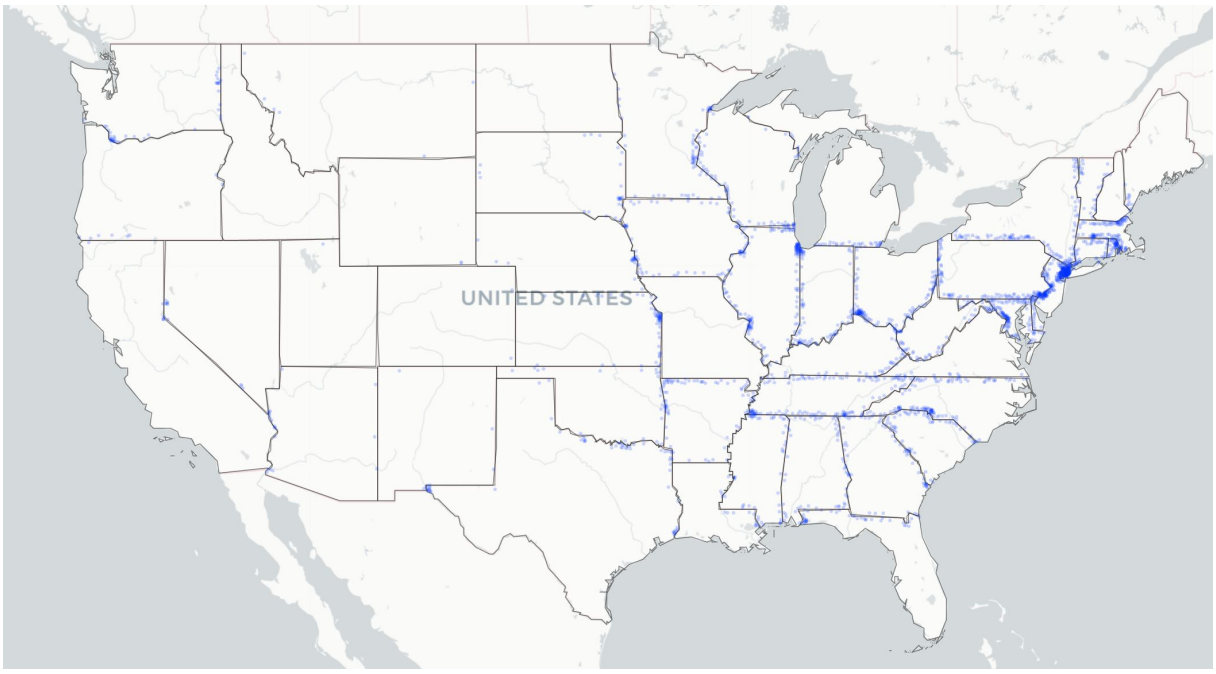

Figure 3: Distribution of Panelists Residing Near the Border of a Lower Tax State.

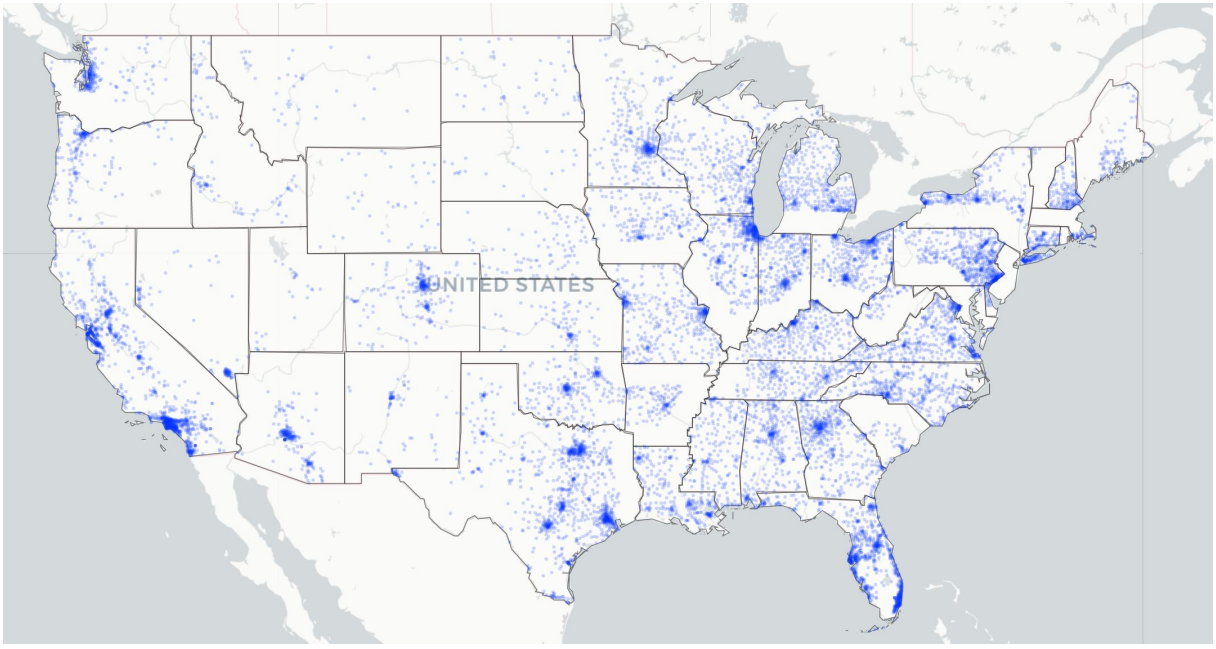

Figure 4: Distribution of Panelists Residing Far from the Border.

Table 1 summarizes the descriptive statistics of analysis variables in the created panel data set.

Table 1: Descriptive Statistics of Analysis Variables

Statistic	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Total packs purchased	46.144	63.484	0	5	64	2,234
Price per pack	4.575	3.598	0	3.2	5.5	600
Lower tax state value	0.704	0.608	0.025	0.300	0.995	4.250
Lower tax state distance	189.487	207.521	0.000	52.342	249.092	1,218.755
Tax value	1.210	0.852	0.025	0.550	1.600	4.350
Tax difference	0.506	0.469	0.000	0.130	0.810	2.810
Tax distance interaction	76.484	100.273	0.000	13.214	102.538	1,050.534
Smoking rate [1]	46.144	52.101	0	9	65.4	669

We create the following rules for the construction of categorical analysis variables. The majority of these variables are demographic characteristics. The distribution of variables by categories is presented in Table 2.

[1]Smoking rate is calculated as the average number of cigarette packs consumed during a quarter

Table 2: Rules for Construction of Categorical Variables

Category	N
Household Income	
High: Annual income≥70,000$	83,242
Middle: Annual income 30.000$ - 69.999$	174,766
Low: Annual income < 30.000$	120,093
Household size	
1: 1 member	89,722
2: 2 members	159,819
3: 3 members	61,672
4: 4 members	39,480
5: 5 members	16,640
6 plus: ≥ 6 members	10,768
Head Employment [2]	
≤35 hours	38,886
35+ hours	198,079
Not employed	141,136
Head Education [2]	
BA plus	94,314
Some college	130,103
High school graduate or lower	153,684
Head Age [2]	
< 35 years	18,481
35-49	104,087
≥ 50	255,533
Presence of children	
0: No children	298,333
1: Children present	79,768
Gender composition	
Female and male head	231,856
Female head only	104,700
Male head only	41,545
Border residence	
Residence ≤ 25 km. from the lower tax state border	53,824
Residence ≻ 25 km. from the lower tax state border	324,277
Smoking rate	
Heavy smoker: ≥ 80th percentile	156,655
Average smoker: 30th percentile - 80th percentile	186,861
Light smoker: ≤ 30th percentile	34,585

[2]Note: The sample includes only those households in the Nielsen Homescan data sample that make at least

4 Estimation Strategy

This section considers the econometric model that measures the household's tax sensitivity with regard to cigarette consumption. Tax avoidance opportunities, such as cross-border purchasing in the closest lower-tax state, may have a considerable impact on the estimate of tax elasticity. Households buy taxable goods in the shops belonging to the nearest lower-tax state if the transportation costs are lower than the benefits from buying taxable goods at a lower price. Moreover, because of profit motives, shops close to the borders may adjust prices to smooth the unfavorable tax difference to a certain extent. The combination of these factors constitutes 'border effects'. Omitting the border effects from estimation creates a bias in the estimate of consumption sensitivity to an increase in the excise tax rate. The bias arising from the border effects is estimated by constructing a regression of cigarette consumption on the excise tax rate and household demographic characteristics and comparing estimation results to the same regression specification with additional variables related to border effects.

In the first regression specification (1), we regress cigarette consumption on excise tax rate, distance to the nearest border of lower-tax state, difference in the tax rate between state of residence and lower-tax state, interaction between distance and tax difference, and household's demographic characteristics. In addition, the econometric model should consider the fact that different states are heterogeneous by their nature and vary by economic factors, such as GDP per capita, poverty rate, cultural factors, smoke-free laws and many others, as well as the fact that individuals can have different search costs, attitudes towards stockpiling behavior, etc. This fact should be incorporated in our model through state level and household fixed effects. Household fixed effects control for unobservable individual-level heterogeneity and, therefore, reduce heterogeneity bias. State-level fixed effects represent geographic controls. The analytical formulation of the panel data regression is the following:

$$cig_{ijt} = \alpha_0 + \alpha_1 \tau_{jt}^h + \alpha_2 \left(\tau_{jt}^h - \tau_{jt}^b\right) + \alpha_3 D_{ijt} + \alpha_4 D_{ijt} \times \left(\tau_{jt}^h - \tau_{jt}^b\right) + \beta X_i + \sigma_i + \omega_j + \epsilon_{ijt}, \quad (1)$$

where cig_{ijt} is the number of cigarette packs consumed by a household i in state j and time t;
τ_{jt}^h is the home state tax;
τ_{jt}^b is the closest lower-tax state's tax;
D_{ijt} is the distance to the closest lower-tax state;
X_i is a vector of household demographic characteristics;
σ_i and ω_j are individual and state level fixed-effects.

In the second regression specification (2), we use the same model but without variables related to border effects, which are distance to the nearest border of lower-tax state, difference in the tax rate between state of residence and lower-tax state, interaction between distance and tax difference.

$$cig_{ijt} = \alpha_0 + \alpha_1 \tau_{jt}^h + \beta X_i + \sigma_i + \omega_j + \epsilon_{ijt}, \quad (2)$$

where cig_{ijt} is the number of cigarette packs consumed by a household i in state j and time t;
τ_{jt}^h is the home state tax;

one cigarette purchase. "Head age" and "Head education" refer to male household head if a male household head is present. In the cases in which no male household head is present, these variables refer to the female household head. This is in line with the study by the National Institute of Drug Abuse (April 2021) that finds men tend to use tobacco products at higher rates than women, and therefore men are more likely to be the primary buyers of cigarettes in grocery stores in a two-headed household.

X_i is a vector of household demographic characteristics;
σ_i and ω_j are individual and state level fixed-effects.

Estimated sensitivity of cigarette consumption to an increase in the tax rate is compared in these two model specifications. The difference between two estimates of the coefficient on the excise tax rate constitutes a bias arising from omitting variables related to border effects. The regression specification was separately estimated for each demographic group in order to test for the presence of bias related to cross-state purchasing. This allows us to analyze how the size of bias and estimated tax sensitivity vary among households with different demographic compositions. The set of robustness checks for the proposed model specification is summarized in Section 6.

It is worth noting that we employed a 'within' fixed effects model that measures the within-individuals and within-states variability in the variables, since we are using household level and state level fixed effects as their own controls. Therefore, coefficients on demographic characteristics represent the marginal change in cigarette consumption associated with changes in socioeconomic characteristics for a particular household, for example, an increase in the household's size, change in head employment status, household has a child, etc. Coefficient on home state tax measures the consumer response to a change in the home state tax as state-level fixed effects absorb state level heterogeneity. A similar interpretation applies to coefficient on difference in the tax rate between state of residence and lower-tax state and distance to the closest lower-tax state. Distance to the lower-tax state border can change due to a change in the panelist's residence or tax change in the neighboring states. Note that distance to the lower tax state was estimated for each time period and panelist's zip code, which allows us to properly capture time level heterogeneity in the cost of cross-state purchasing. Table 3 shows the distribution of households that experienced a change in the distance to the closest lower-tax state.

Table 3: Distance to the Closest Lower-tax State

Distance changed	Number of households
Distance to the closest lower-tax state not changed	40,054
Distance to the closest lower-tax state changed	12,672

The choice of the 'within' fixed effects model was determined by the large heterogeneity bias in the regression specification without household-level fixed effects, which resulted in the coefficient estimates on demographic characteristics being inconsistent with economic theory assumptions. Nevertheless, estimated tax sensitivity and variables related to border effects are within a similar range. Estimation results of an alternative regression specification without household-level fixed effects are presented in the Appendix.

5 Estimation Results

Table 4 summarizes the fixed effects regression model results of quarterly cigarette consumption for the following two specifications. In column (1), we estimate the model specification with variables related to border effects, which are distance to the nearest border of lower-tax state, difference in the tax rate between states of residence and lower-tax state, interaction between distance and tax difference. In column (2), we removed variables related to border effects in order to assess the presence of omitted variable bias. In addition to demographic characteristics, we

added household and state-level fixed effects for both model specifications (1) and (2) to control for individual-level and geographic heterogeneity.

We observe that tax sensitivity in the model specification with variables related to border effects is larger than in the similar specification excluding these variables. Moreover, variables related to border effects are statistically significant in the model specification (1). Therefore, estimate of tax elasticity is biased when variables related to 'border effects' are omitted from the model. As a result, sensitivity of cigarette consumption to a change in cigarette tax in model specification (2) is underestimated.

The estimation results show how demographic groups vary by intensity of cigarette consumption. For example, smoking intensity is lower for older consumers and those with higher income, implying that young low-income consumers contain the largest share of heavy smokers. Households with children have lower cigarette consumption, which is consistent with the existing studies. Lin H. (2020) evaluates the existence of the upward inter-generational effect of the presence of children on parents' smoking behavior in China. The estimation results show that the number of children is significantly inversely associated with smoking behavior. Households with a single female head have a lower amount of quarterly cigarette purchases than households with a single male head. This is in line with the study by the National Institute of Drug Abuse (April 2021) that men tend to use tobacco products at higher rates than women.

Further, we estimate the same regression specification for different demographic groups. This allows us to analyze how tax elasticity and the size of bias vary among households with different demographic compositions. The results with estimated tax sensitivity among heterogeneous consumer groups for two regression specifications with and without variables related to border effects are presented in Table 5.

We find that border effects create a bias in the estimate of consumption sensitivity to an increase in excise tax rate, which is present for all demographic groups. Border effects affect all demographic groups, which is confirmed by the presence of bias when omitting variables related to border effects. The bias is particularly large for border residents, since the cost of traveling to the nearest lower-tax state to purchase taxable goods at a lower price increases with the distance to the state border. Therefore, border residence may decrease the impact of excise tax policy interventions on the consumer's purchase decision.

Table 5 demonstrates that estimated elasticities are larger for the low income group. Higher tax sensitivity estimated for unemployed consumers and consumers without college degree can be potentially explained by the fact that, on average, these demographic groups have lower income. Moreover, from the estimation results of the panel regression presented in Table 4, we observe a decreasing pattern of cigarette consumption with age. Lower sensitivity of young consumers to a cigarette tax increase can be partially attributed to a lower reaction of this demographic group to policy measures and smoking bans as opposed to adult consumers. This result is in line with Lee (2008), who shows that adolescent smokers under 18 years of age have lower cigarette price elasticity. Nevertheless, a possible reason for the 'irregular' coefficient on the tax rate can stem from the small population sample of young consumers, which comprises only $18,481$ observations. Furthermore, we identify that estimated tax elasticity increases with smoking intensity in contrast to Lee (2008) and Cotti et al. (2018), who show that heavy smokers do not respond to excise tax policy measures.

Table 4: Estimation of Baseline Model on the Whole Population Sample.

	Dependent variable:	
	Total packs purchased	
	(1)	(2)
Tax difference	4.858***	
	(0.484)	
Lower tax state distance	−0.004***	
	(0.001)	
Tax distance interaction	−0.024***	
	(0.002)	
Tax value	−13.902***	−12.294***
	(0.300)	(0.221)
Factor: Low income	1.560***	1.705***
	(0.472)	(0.472)
Factor: Middle Income	1.401***	1.487***
	(0.355)	(0.355)
Factor: Household size 2	2.399***	2.521***
	(0.453)	(0.453)
Factor: Household size 3	5.336***	5.512***
	(0.547)	(0.547)
Factor: Household size 4	4.294***	4.532***
	(0.657)	(0.657)
Factor: Household size 5	8.387***	8.670***
	(0.831)	(0.832)
Factor: Household size 6 plus	5.164***	5.410***
	(0.985)	(0.985)
Factor: Head employment 35+ hours	3.246***	3.317***
	(0.387)	(0.387)
Factor: Head employment Not employed	−1.123***	−1.284***
	(0.397)	(0.397)
Factor: Head education HS graduate or lower	−2.402***	−2.390***
	(0.528)	(0.528)
Factor: Head education Some college	−1.350***	−1.295***
	(0.428)	(0.428)
Factor: Head age ≥50	−9.561***	−10.073***
	(0.896)	(0.896)
Factor: Head age 35-49	−2.767***	−2.957***
	(0.844)	(0.844)
Factor: Presence of children = yes	−2.032***	−1.979***
	(0.440)	(0.440)
Factor: Gender composition Female head only	−8.270***	−8.319***
	(0.551)	(0.551)
Factor: Gender composition Male head only	−4.720***	−4.725***
	(0.859)	(0.859)
Consumer fixed effects:	*yes*	*yes*
State fixed effects:	*yes*	*yes*
Observations	378,101	378,101
R^2	0.018	0.017
F Statistic	87.288*** (df = 67; 325308)	86.855*** (df = 64; 325311)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 5: Estimated Tax Sensitivity among Heterogeneous Consumer Groups

Demographic Group	Coefficient Estimate on τ^h (1)	(2)	Omitted Variable Bias	Omitted Variable Bias as % of $\tau^h_{(2)}$	D	$\tau^h - \tau^b$	$D \times \left(\tau^h - \tau^b\right)$
Border resident	-19.929***	-9.639***	10.290	107%	-0.394**	15.247***	1.920
Not border resident	-14.225***	-12.798***	1.427	11%	-0.011***	2.725***	-0.380***
Heavy smoker	-24.079***	-20.863***	3.216	15%	-0.007***	9.203***	-1.107***
Average smoker	-6.451***	-5.402***	1.049	19%	-0.001**	3.022***	-0.272***
Light smoker	-0.271***	-0.176***	0.095	54%	-0.0001	0.151**	0.005
High income	-13.294***	-11.832***	1.462	12%	-0.004**	5.014***	-0.667***
Middle income	-13.600***	-11.689***	1.911	16%	-0.004***	5.563***	-0.026***
Low income	-15.243***	-13.606***	1.637	12%	-0.004***	4.108***	-0.472***
Head employment: 35+ hours	-12.106***	-10.509***	1.597	15%	-0.003**	5.158***	-0.680***
Head employment: $\leq$35 hours	-11.741***	-9.158***	2.583	28%	0.0005	7.790***	-0.537***
Head employment: Not employed	-16.019***	-14.069***	1.950	14%	-0.009***	4.150***	-0.458***
Head education: HS graduate or lower	-15.975***	-13.493***	2.482	18%	-0.009***	4.978***	-0.488***
Head education: Some college	-12.556***	-11.541***	1.015	9%	0.002	5.370***	-0.730***
Head education: BA +	-11.426***	-10.100***	1.325	13%	-0.003**	4.895***	-0.703***
Head age: $\geq$50	-14.310***	-13.011***	1.299	10%	-0.003***	4.852***	-0.705***
Head age: 35-49	-13.756***	-11.183***	2.573	23%	-0.004**	5.787***	-0.445***
Head age: $<$ 35 years	-6.843***	-5.418***	1.425	26%	0.003	6.794***	-1.475***
Presence of children: yes	-12.079***	-9.181***	2.898	32%	-0.005***	6.052***	-0.418***
Presence of children: no	-14.298***	-12.913***	1.385	11%	-0.004***	4.380***	-0.600***
Gender composition: Female head only	-12.354***	-10.523***	1.831	17%	-0.001	5.541***	-0.485***
Gender composition: Female and male head	-14.764***	-13.266***	1.498	11%	-0.004***	4.761***	-0.705***
Gender composition: Male head only	-12.536***	-10.615***	1.920	18%	-0.006***	4.627***	-0.532***

Note: *p<0.1; **p<0.05; ***p<0.01; $\tau^h_{(2)}$ refers to τ^h estimate in spec (2); Omitted Variable Bias is estimated as $\tau^h_{(2)} - \tau^h_{(1)}$; D, $\tau^h - \tau^b$, $D \times \left(\tau^h - \tau^b\right)$ refer to distance to the nearest border of lower-tax state, difference in the tax rate between states of residence and lower-tax state, interaction between distance and tax difference respectively

6 Robustness analysis

As a robustness check, we want to ensure that tax sensitivity τ^h in model specification (2) on average exhibits a decreasing pattern when we subsequently remove households residing near a lower-tax state border from the estimation. We start with the whole population sample and estimate the tax elasticity of cigarette demand for each demographic group. Further, we subsequently exclude border residents residing less than 5, 10, 15, ..., 50 kilometers away from the border and re-estimate the tax sensitivity for each population group. We performed the same exercise for the aggregate sample. The decreasing pattern of the negative coefficient on the home state tax τ^h implies that the cost of cross-border purchasing increases with the distance to the lower-tax state border. Therefore, the tax sensitivity estimate gradually converges to the unbiased estimate when border effects are eliminated.

Figure 5 demonstrates the expected decreasing pattern of tax sensitivity for the aggregate sample when we increase the cost of cross-border purchasing.

We performed the same robustness check for each demographic group. We observe a similar pattern in the evolution of tax sensitivity for unemployed and low-income consumers. Tax elasticity reaches its minimum at the 15^{th} and 25^{th} kilometer from the lower-tax state border and then demonstrates an increasing pattern. One potential explanation can be that the impact from the gradual decrease of the population sample size outperforms the influence of border effects on the tax sensitivity estimate for these demographic groups. For the remaining demographic groups by head education, head age, gender composition, we observe a decreasing pattern when average distance to the lower tax state border is gradually increasing. It is worth noting that tax sensitivity for households with a female head reaches its minimum at the 15^{th} kilometer, compared to the male head households at the 25^{th} kilometer, which may indicate that the border effect for female consumers reaches its maximum at the lower distance. Tax sensitivity by smoking intensity demonstrates an expected decreasing pattern with a more pronounced effect for heavy and average smokers. Tax elasticity of light smokers still preserves a bias related to border effects; nevertheless, it is comparatively smaller as a measure of predicted decrease in quarterly cigarette consumption in response to a 1$ tax increase.

The performed robustness check confirmed the validity of border effects and the direction of bias. Tax sensitivity, on average, gradually increases in absolute value when we subsequently remove border residents and increase the average distance to the lower tax state border.

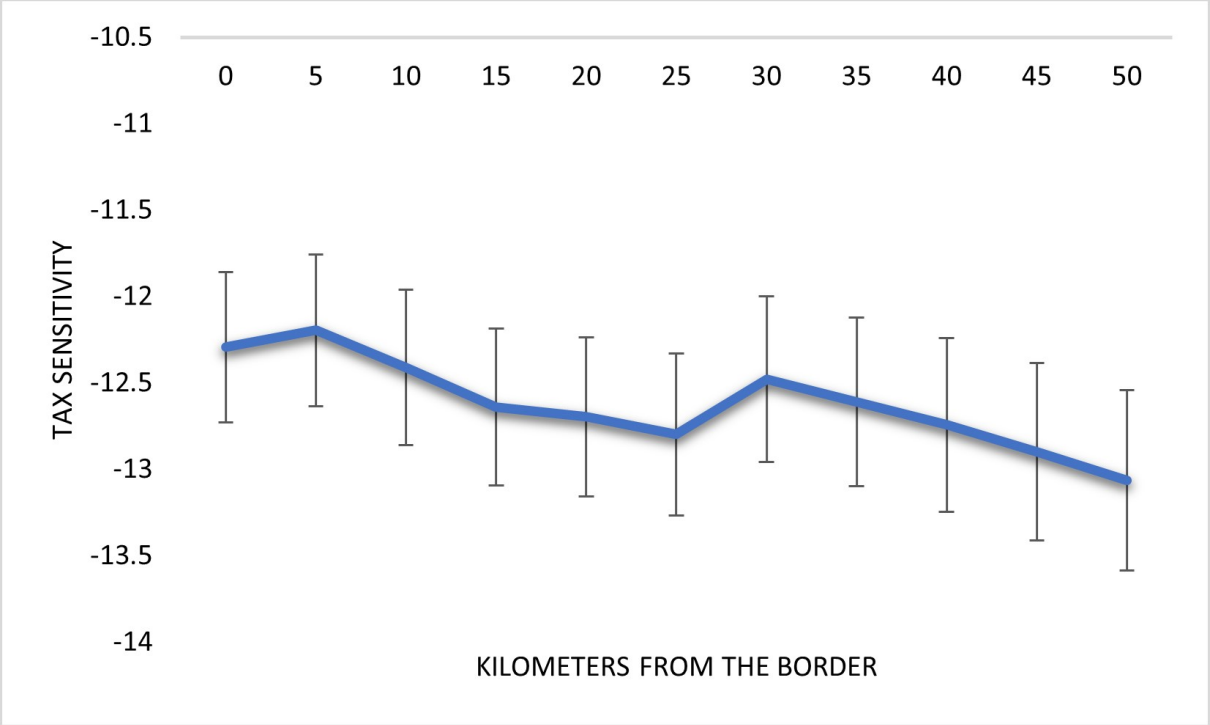

Figure 5: Excluding households residing near the border: Aggregate Sample

Note: The error bands show the bounds of the 95 percent confidence interval

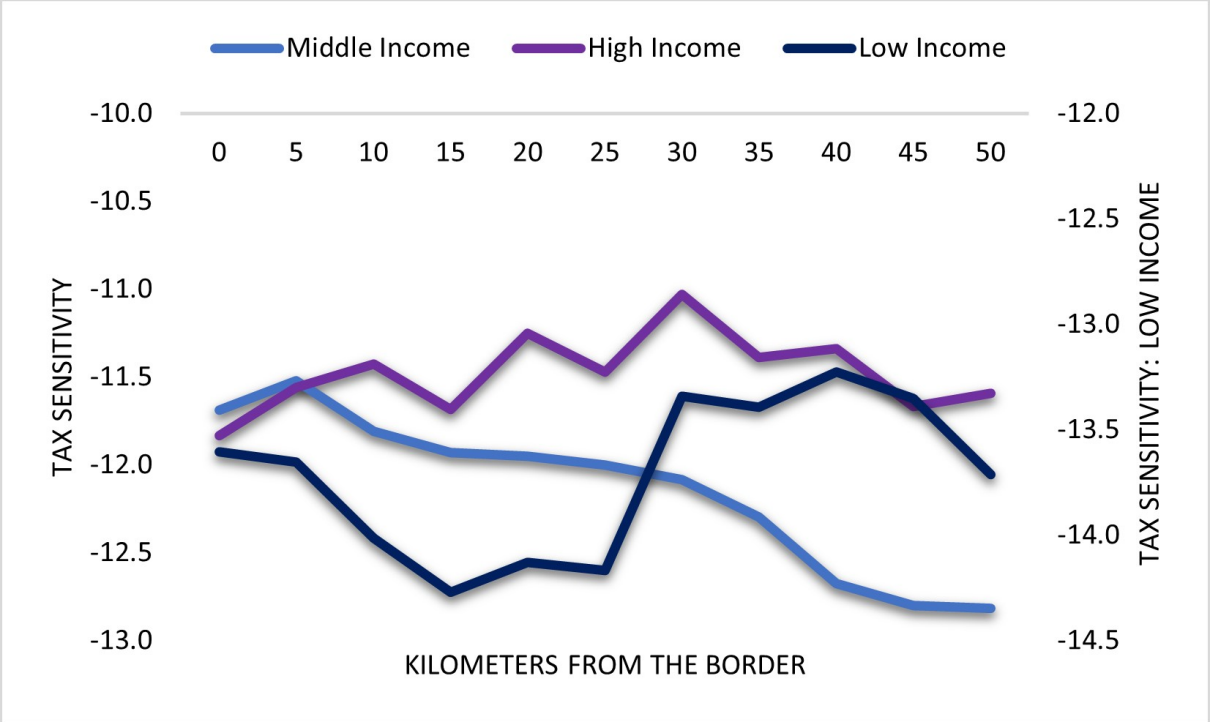

Figure 6: Excluding households residing near the border: Household Income

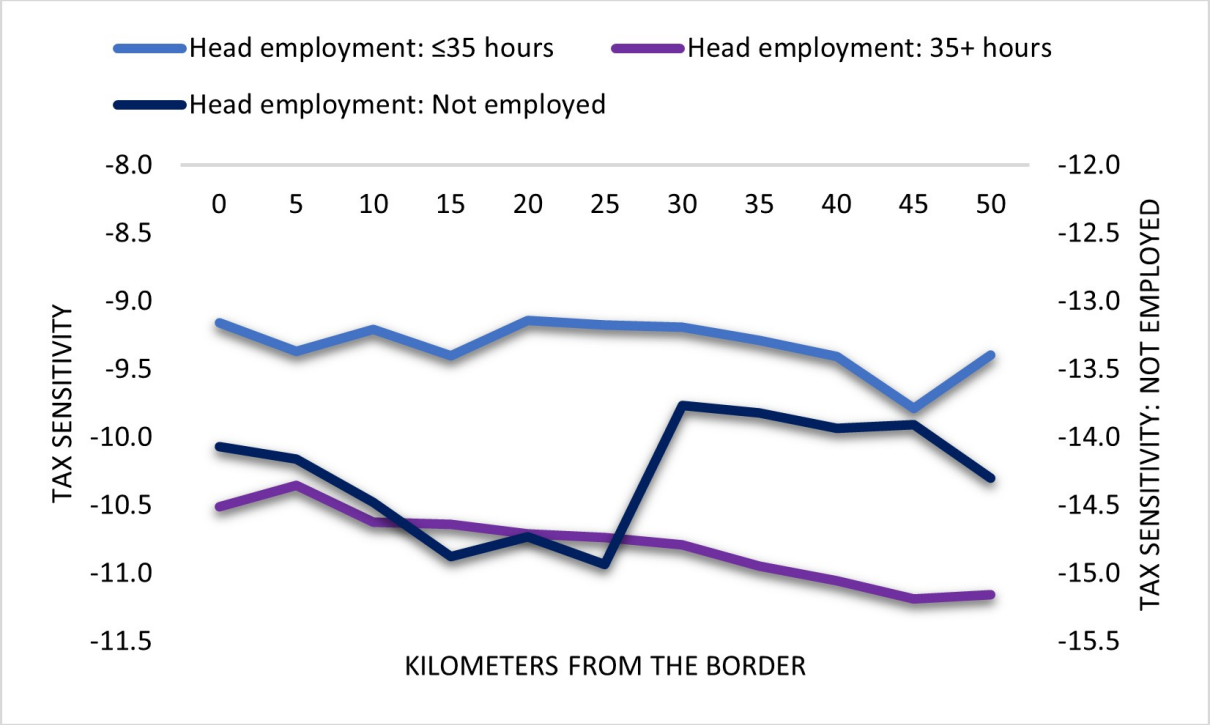

Figure 7: Excluding households residing near the border: Head Employment

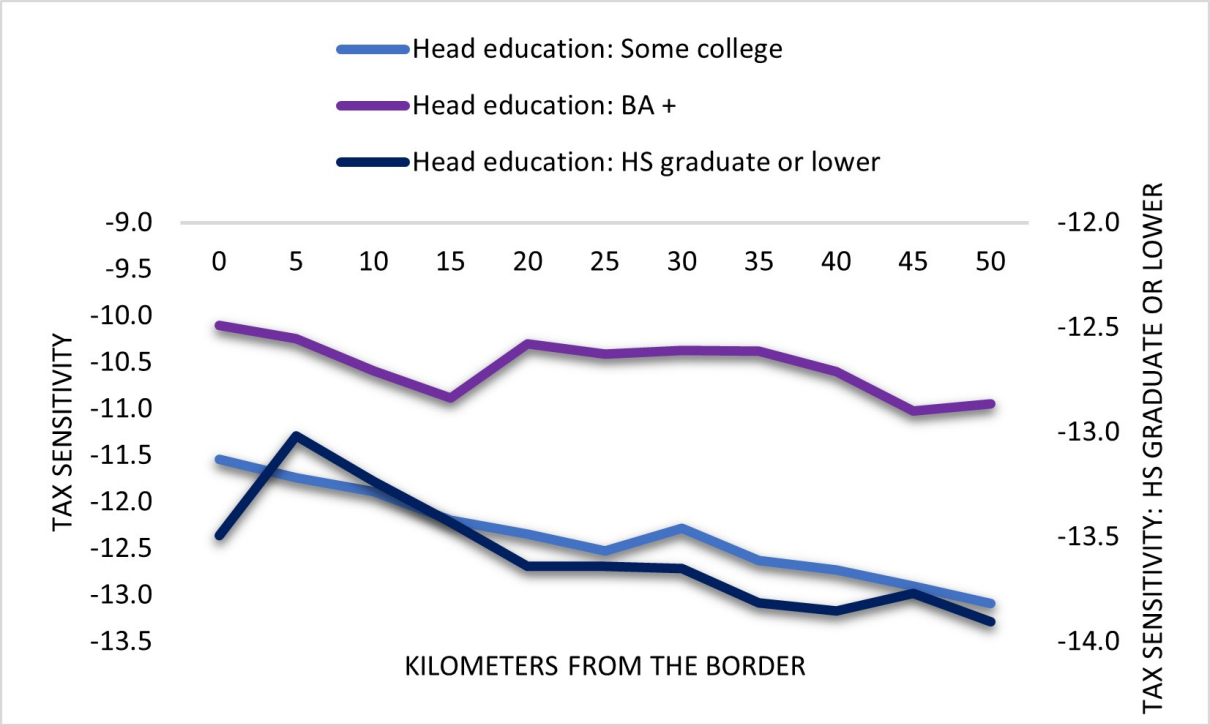

Figure 8: Excluding households residing near the border: Head Education

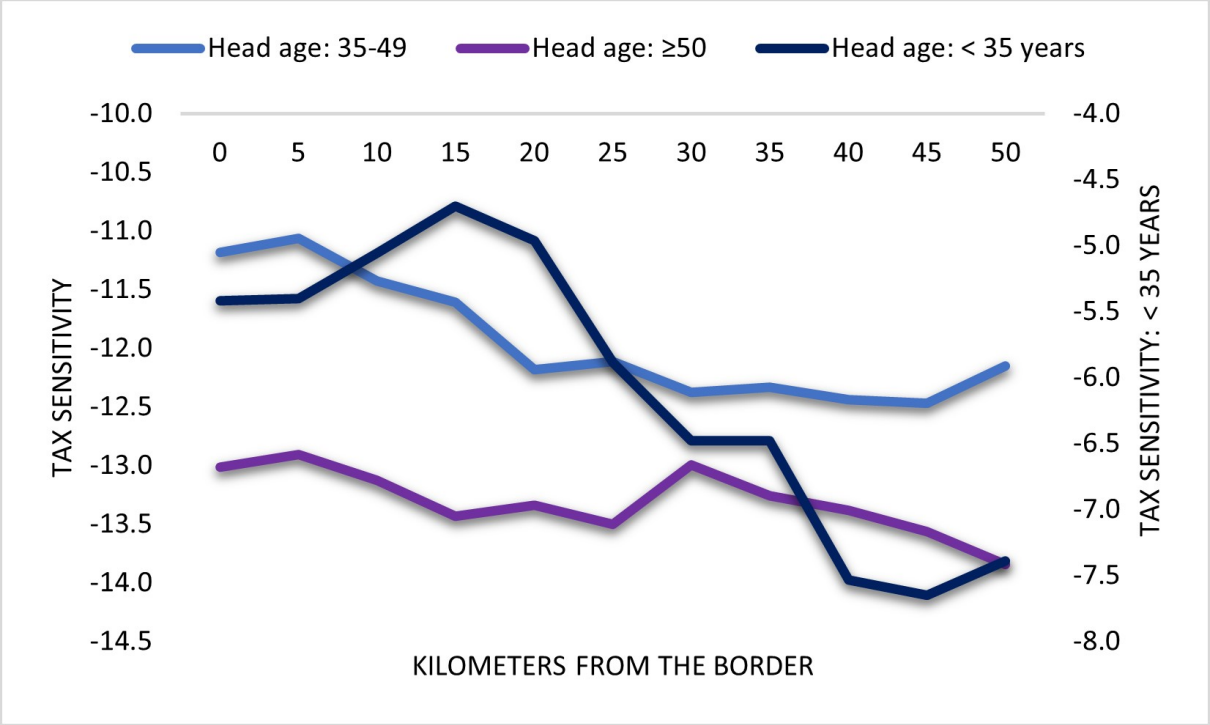

Figure 9: Excluding households residing near the border: Head Age

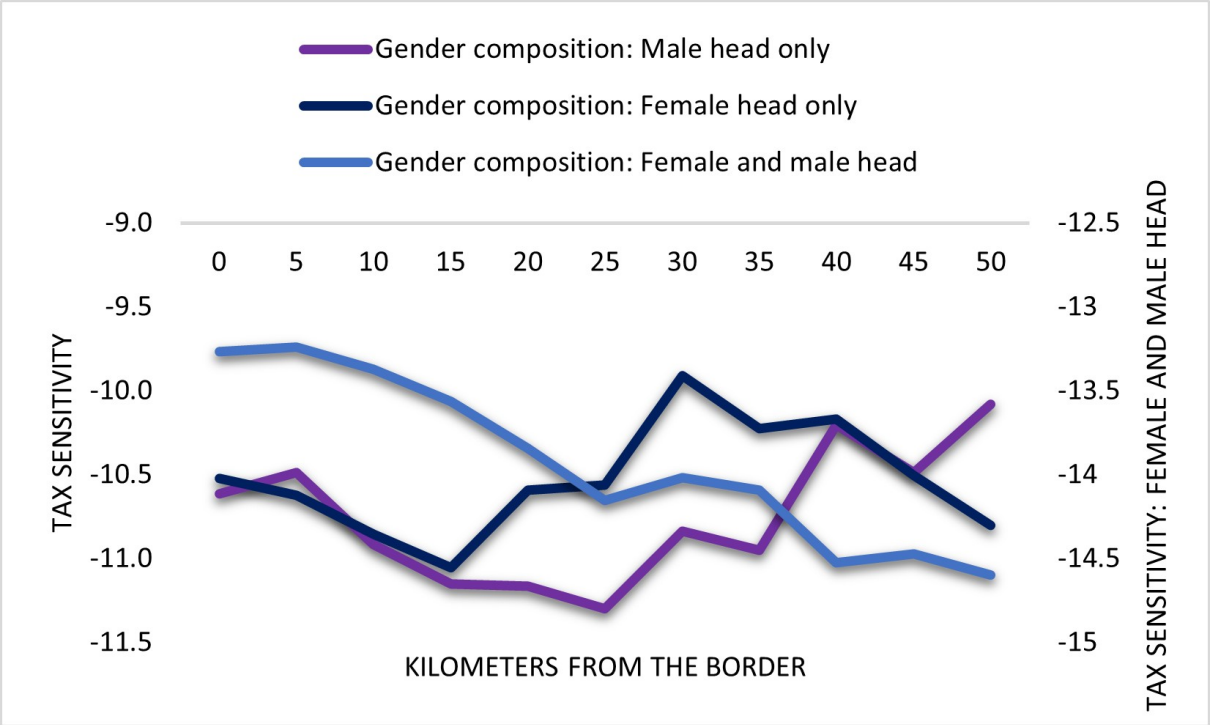

Figure 10: Excluding households residing near the border: Gender Composition

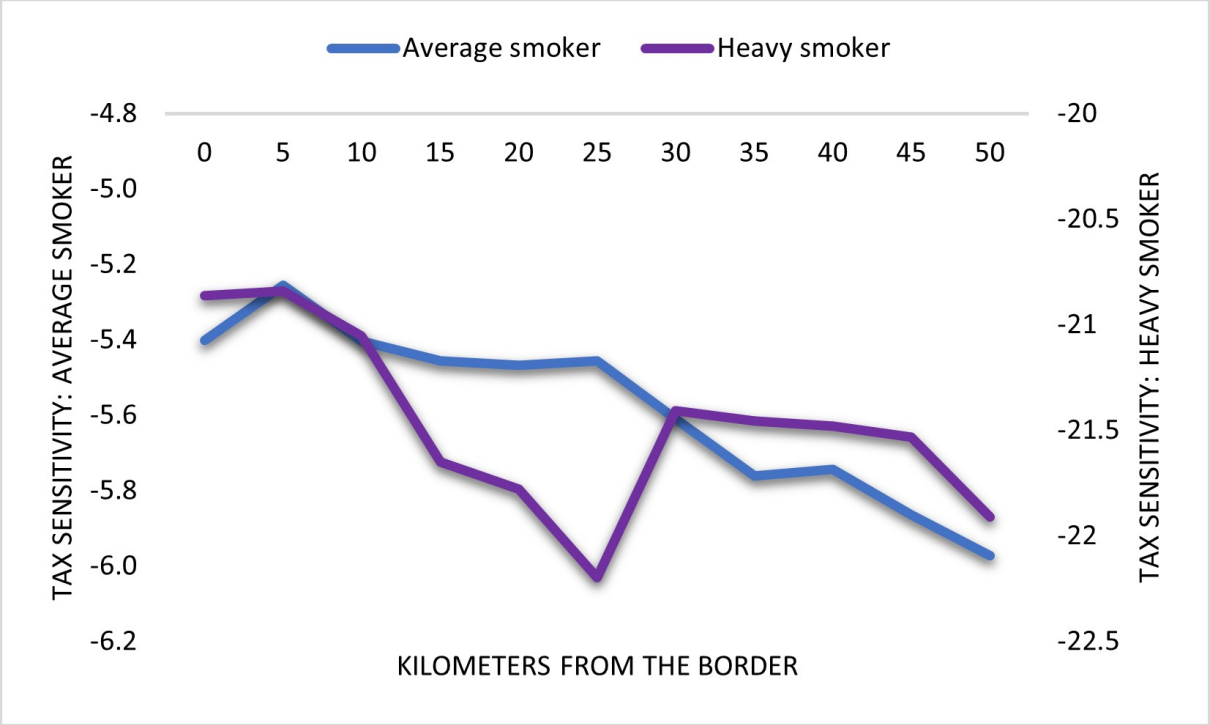

Figure 11: Excluding households residing near the border: Smoking Intensity by Heavy and Average Smokers

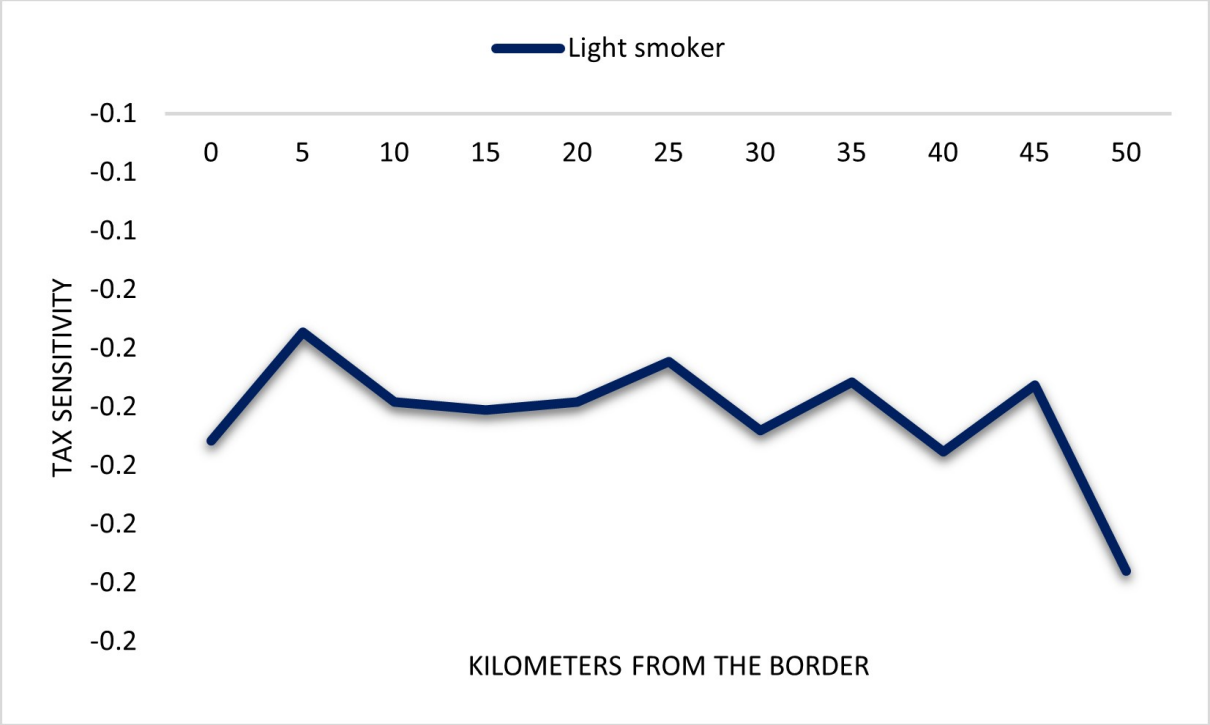

Figure 12: Excluding households residing near the border: Smoking Intensity by Light Smokers

7 Conclusion

Using Nielsen Consumer Panel data for the years from 2004 to 2019, this study explores whether ignoring tax avoidance opportunities will bias the estimate of tax elasticity. We find that border effects create a bias in the estimate of tax elasticity, which is present for all demographic groups. The bias is particularly large for border residents, since the cost of traveling to the nearest lower-tax state to purchase taxable goods at a lower price increases with the distance to the state border. This implies that ignoring possible tax avoidance actions of consumers, in particular cross border purchasing, results in a biased estimate of tax sensitivity and decreases the applicability of the obtained results. The fact that residing near a lower tax state border decreases the impact of excise tax policy interventions should be considered by policy makers.

Moreover, we analyze how the consumer response to a cigarette tax increase varies between households with different demographic compositions. We observe higher tax elasticity for the low income group. Higher tax sensitivity estimated for unemployed consumers and consumers without college degree can be potentially explained by the fact that, on average, these demographic groups have lower income. Furthermore, we identify that estimated tax sensitivity is statistically significant for heavy smokers and increases with smoking intensity, which can be beneficial from the perspective of potential public health implications, unlike Lee (2008) and Cotti et al. (2018), who show that heavy smokers do not respond to excise tax policy measures.

8 Appendix

Table 6: Estimation of Baseline Model Excluding Household-Level Fixed Effects.

	Dependent variable:	
	Total packs purchased	
	(1)	(2)
Tax difference	7.331***	
	(0.436)	
Lower tax state distance	−0.004***	
	(0.001)	
Tax distance interaction	−0.027***	
	(0.002)	
Tax value	−14.527***	−12.063***
	(0.277)	(0.215)
Factor: Low income	3.009***	3.335***
	(0.332)	(0.332)
Factor: Middle Income	3.420***	3.618***
	(0.272)	(0.272)
Factor: Household size 2	4.279***	4.260***
	(0.354)	(0.354)
Factor: Household size 3	−0.445	−0.459
	(0.433)	(0.433)
Factor: Household size 4	−2.726***	−2.805***
	(0.531)	(0.531)
Factor: Household size 5	−2.364***	−2.461***
	(0.669)	(0.670)
Factor: Household size 6 plus	−3.270***	−3.448***
	(0.774)	(0.774)
Factor: Head employment 35+ hours	1.048***	1.165***
	(0.357)	(0.357)
Factor: Head employment Not employed	3.941***	4.023***
	(0.359)	(0.359)
Factor: Head education HS graduate or lower	3.267***	3.323***
	(0.271)	(0.272)
Factor: Head education Some college	1.670***	1.717***
	(0.269)	(0.270)
Factor: Head age ≥50	22.883***	22.861***
	(0.494)	(0.494)
Factor: Head age 35-49	13.403***	13.465***
	(0.498)	(0.499)
Factor: Presence of children = yes	−9.191***	−9.155***
	(0.369)	(0.369)
Factor: Gender composition Female head only	−8.325***	−8.466***
	(0.317)	(0.318)
Factor: Gender composition Male head only	0.670*	0.560
	(0.405)	(0.405)
Constant	38.601***	37.344***
	(1.015)	(1.009)
Consumer fixed effects:	*no*	*no*
State fixed effects:	*yes*	*yes*
Observations	378,101	378,101
R^2	0.044	0.042
F Statistic	255.316*** (df = 68; 378032)	257.801*** (df = 65; 378035)
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 6 presents the estimation results of an alternative regression specification without household-level fixed effects and shows that the coefficient estimates predict that cigarette consumption on average decreases with household size, which is inconsistent with economic theory assumptions. The presence of heterogeneity bias determines the choice of the 'within' fixed effects model. Nevertheless, estimated tax sensitivity and variables related to border effects are within a similar range.

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Abstrakt

Hraniční efekty mohou mít významný vliv na účinnost daňové politiky. Příležitost koupit zboží v blízkém státě s nižším zdaněním redistribuuje daňovou zátěž mezi spotřebiteli a ovlivňuje dopad zvýšení daní na rozhodování o spotřebě. S využitím panelových dat o spotřebitelích od společnosti Nielsen odhaduji zkreslení způsobené vlivem hraničních efektů a zkoumám způsob a rozsah, jakým se citlivost na zdanění cigaret mění v závislosti na různých demografických skupinách. Zjišťuji, že vliv hraničních efektů vytváří zkreslení odhadu citlivosti spotřeby na míru zdanění napříč všemi demografickými skupinami. Vliv změny zdanění se zvyšuje s průměrnou vzdáleností od hranic státu s nižším zdaněním, což naznačuje, že v příhraničních oblastech je nižší dopad daňových politik na rozhodování o spotřebě.

Klíčová slova: spotřební daně, cigarety, přeshraniční nákupy, vyhýbání se daňovým povinnostem, hraniční efekty

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