The Impact of Tobacco Taxes on Household Food Insecurity and Food Expenditure

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Abstract

Household food insecurity is defined as inadequate or insecure access to food resulting from financial constraints. Previous research has established that households with an adult smoker are more likely to experience food insecurity (McIntyre et al., 2000; Armour et al., 2008; Cutler-Triggs et al., 2008; Farrelly & Shafer, 2017; Kim & Tsoh, 2016; Kim-Mozeleski et al., 2019), however, the mechanism driving this observed association has not been determined. This paper examines if smoking is associated with food insecurity because cigarette expenditure competes with other expenses such as food when households face unexpected increases in expenditures and/or reductions in income. Using longitudinal data from the U.S. Panel Study of Income Dynamics (PSID) and variation in state level cigarette taxes, I find that increases in cigarette taxes threatens food security in smoking households. In particular, a $1 increase in taxes per pack of cigarettes reduces annual food expenditure approximately 4% and increases the probability of experiencing food insecurity 1.9 percentage points in smoking households. Considering both food insecurity and smoking are associated with numerous adverse health outcomes, caution should be used before increasing cigarette taxes further.

Keywords: food insecurity, food expenditure, smoking, cigarette taxes

1 Introduction

Household food insecurity is defined as inadequate or insecure access to food resulting from financial constraints. Food insecurity is associated with numerous adverse health outcomes such as increased risk of mortality (Tarasuk et al., 2019) and higher healthcare costs (Tarasuk et al., 2015). Previous research has established that households with an adult smoker are more likely to experience food insecurity (McIntyre et al., 2000; Armour et al., 2008; Cutler-Triggs et al., 2008; Farrelly & Shafer, 2017; Kim & Tsoh, 2016; Kim-Mozeleski et al., 2019), however, the mechanism driving this observed association has not been determined. This study uses longitudinal data from the U.S. Panel Study of Income Dynamics (PSID) for the years 1999, 2001, 2003, 2015, and 2017 and exploits variation in state level cigarette taxes to investigate if there is a household budget impact of cigarette taxation on food insecurity.

I find that increases in cigarette taxes are associated with reduced average food expenditure and increased risk of food insecurity in households with smokers. In particular, a $1 increase in taxes per pack of cigarettes reduces annual food expenditure approximately 4% and increases the probability of experiencing food insecurity 1.9 percentage points in smoking households. This finding suggests that caution should be used before increasing such taxes further. Perhaps alternative approaches, such as subsidizing cessation products and counselling, would be a way to address smoking prevalence without the same consequences for food security. If cigarette taxes are increased further some offsetting mechanism should be considered, as done with carbon tax rebates, to compensate low-income smoking households.

The paper proceeds as follows: Section 2 summarizes the existing literature investigating the relationship between smoking and food insecurity and motivates why cigarette taxes threaten food security. Section 3 introduces the data. Section 4 introduces the empirical strategy. The results are presented in Section 5, and Section 6 discusses the policy implications of this study.

2 Literature Review

2.1 Food Insecurity

Household food insecurity encompasses a range of experiences which vary in duration and severity. Food insecurity can involve concerns about running out of food before having enough money to buy more, the inability to afford a balanced diet, skipping meals, or not eating for a whole day due to a lack of money for food in extreme cases (Tarasuk et al., 2016). An extensive literature exists demonstrating how experiencing food insecurity contributes to a myriad of adverse health and social outcomes. For instance, food insecurity makes it more difficult to manage existing health conditions and increases an individual's risk of nutritional deficiency, numerous physical and mental health problems, and higher mortality rates (Tarasuk et al., 2019).

Healthcare costs are considerably higher for food insecure households and increase in a stepwise fashion with severity of insecurity (Tarasuk et al., 2015). Healthcare costs incurred by severely food insecure adults are nearly double that of a food secure adult after controlling for education level, income, and other well-known determinants of health. Hence, food insecurity poses immediate consequences for households and the healthcare system. The most direct way to ameliorate the consequences associated with food insecurity is to reduce food insecurity (Gundersen, 2011). Accordingly, understanding determinants of food insecurity is important for policy development aimed to reduce this burden.

The most potent determinant of food insecurity is household income. Although household income is tightly linked to food insecurity, the relationship is not one-to-one. Many low incomes can be managed such that food insecurity is avoided and some high-income earners are food insecure. Food insecurity more closely relates to a household's ability to buffer against budget shocks which involves the adequacy and security of income, availability and liquidity of assets, and other resources that can be drawn upon (Tarasuk, 2017).

2.2 Food Insecurity and Smoking

Having low income is one of the confounding factors which makes the effect of smoking on food insecurity difficult to isolate empirically. It is expected that low-income individuals are more likely to both smoke and experience food insecurity. For this reason, the current body of work on this topic has established an association between the two rather than characterizing the mechanism by which smoking increases the probability of experiencing food insecurity.

Armour, Pitts, & Lee (2008) attempt to address the described endogeneity problem by limiting their sample to low-income households within 200% of the federal poverty level. Using data from the 2001 Panel Study of Income Dynamics (PSID) they find households with at least one adult smoker have an increased risk of experiencing food insecurity by an estimated six percentage points. Moreover, the odds of being food insecure conditional on having a smoker in the household increase approximately one percentage point per additional pack of cigarettes consumed per week. They highlight that low-income families in their sample with an adult smoker purchased approximately ten packs of cigarettes per week, contributing to an average expense of $33.70 per week given average prices at the time. This additional expense in the consumption basket of smoking households is presented as a likely explanation for the observed association between smoking and food insecurity.

Smoking impacts food security of all household members. Cutler-Triggs, Fryer, Miyoshi, & Weitzman (2008) find food insecurity is more common and severe for children and adults living in households with smokers. Moreover, the authors present living with adult smokers as an independent risk factor for adult and child food insecurity due to the additional household expense. Between 1999 to 2002, children in smoking households experienced food insecurity at almost double the rate of children in non-smoking households (17% vs. 8.7%). Similarly, McIntyre et al. (2000) find primary caregivers of food insecure children are 1.7 times more likely to smoke daily than other caregivers. On the intensive margin, 72.2% of primary caregivers who reported frequent hunger smoke occasionally or daily compared to 50.7% among those who reported occasional hunger. Both Cutler-Triggs et al. (2008) and McIntyre

et al. (2000) suggest stress reduction and appetite suppression could also explain the higher prevalence of smoking in food insecure households.

Kim & Tsoh (2016) examine whether food insecurity is associated with higher smoking prevalence due to psychological distress or hunger control. Both explanations could explain why past-year food insecurity was associated with current smoking, however, it does not offer an adequate argument for explaining smoking as a risk factor for food insecurity. Food insecurity is strictly defined as arising due to financial constraints. Changes in appetite or dietary behaviour from stress or nicotine would not yield affirmative responses to food security related survey questions. Hence, the authors conclude that food insecurity is likely exacerbated through the budget channel–smoking reduces disposable income and tobacco expenditure does not sufficiently adjust in response to budget shocks–which in turn makes it more difficult to quit smoking.

Consistent with previous studies, Farrelly & Shafer (2017) find smoking is positively associated with food insecurity. The authors examine food insecurity prevalence over time and report that prevalence increased markedly after the 2008 recession and this increase was higher for adult smokers. They suggest low-income smokers spend a disproportionate share of their income on cigarettes, especially in states with high cigarette taxes. Following Kim & Tsoh (2016), Farrelly & Shafer (2017) examine the reciprocal relationship between smoking and food insecurity. Between 1998-2011, smoking prevalence declined slower in food insecure households compared to food secure households. This suggests experiencing food insecurity is somehow a barrier to successful smoking cessation.

Kim-Mozeleski et al. (2019) use individual-level longitudinal data from the 2003 and 2015 waves of the PSID to assess whether food insecurity is associated with lower smoking cessation. They find smokers who started food secure and became food insecure were less likely to stop smoking than smokers who stayed food secure. Further, nonsmokers who became food insecure were more likely to initiate smoking compared to their counterparts who stayed food secure throughout the study period. The authors conclude food insecurity

is a barrier to smoking cessation at the population level and may also be a risk factor for nonsmokers to initiate smoking.

Evidence from the literature suggests smoking and food insecurity have an intertwined relationship which is difficult to disentangle empirically. Some studies suggest smoking increases the likelihood of food insecurity and others show food insecurity increases the likelihood of smoking. Both associations remain significant after controlling for demographic characteristics. There is a lack of empirical evidence regarding the mechanism by which smoking and food insecurity are related.

2.3 Food Insecurity and Tobacco Taxes

The focus of this paper is to examine if smoking is associated with food insecurity because cigarette expenditure competes with other expenses such as food when households face unexpected increases in expenditures and/or reductions in income. This could have implications for tobacco taxation policies which increase the price of smoking. If cigarette tax increases threaten food security, then taxation beyond current levels may carry the consequence of impacting household health and well-being.

Contrary to the Permanent Income Hypothesis, there is evidence that many people fail to smooth consumption patterns by self-insuring against budget shocks. Chetty (2008) finds the median unemployment insurance recipient only has $128 (median) of liquid assets to draw upon before entering an unemployment spell. Additionally, low-income families devote a substantial portion of their budget to food expenditure, leaving a restricted budget for additional expenses (Kirkpatrick & Tarasuk, 2003). It follows that if households do not have the capacity to buffer shocks to their budget set, they may be forced to adjust food expenditure following income loss or higher cost of living. Examples of the trade-off between food and other expenses include households forced to decide whether to "heat or eat" or "treat or eat" [1]. In a similar vein, individuals addicted to tobacco may be forced to choose

[1] i.e. Weigh the cost of heating the household or purchasing out-of-pocket prescriptions against buying food.

between smoking and eating following a budget shock.

One such budget shock to smoking households is a tax increase that raises tobacco product prices. Cigarettes are a popular target for government revenue collection because the addictive nature of tobacco yields an inelastic demand for cigarettes relative to non-addictive goods. This means smoking behaviour is relatively unresponsive to price changes, especially for long-time smokers, so consumers are unable to avoid paying the tax. Tobacco taxes are also a powerful instrument for smoking cessation and preventing potential users from initiating tobacco use, especially amongst adolescents (Chaloupka et al., 2012).

The main criticism of tobacco taxes is the significant financial burden imposed on low-income smokers. Empirical evidence demonstrates low-income smokers are more responsive to cigarette price changes, but cigarette excise taxes are still considered regressive because of the disproportionate share of the tax paid by low-income smokers (Colman & Remler, 2008). For instance, Farrelly et al. (2012) analyze a sample of adults in New York from 2003–2004 to 2010–2011 and find that raising the state cigarette excise tax from $1.50 to $4.35 increased the percentage of income spent on cigarettes from 6.4% to 12.0% for smokers overall and more than doubled the proportion for the lowest income category (increasing from 11.6% to 23.6%).

As Farrelly et al. (2012) demonstrated, raising the cost of consuming tobacco means that, all else equal, households with a smoker have less discretionary income available to buffer against budget shocks. Food insecurity is a risk of illiquidity–a situation where an individual has insufficient cash on hand to adjust to unexpected expenses or losses. It follows that tobacco tax increases intended to deter smoking may have the unintended consequence of threatening food security in smoking households. Even if a current smoker eventually quits in response to higher taxes, there may be a time inconsistency problem which leaves them, and other members of their household, vulnerable to a bout of food insecurity in the short term.

3 Data

3.1 The Panel Study of Income Dynamics

I use publicly available data from the 1999, 2001, 2003, 2015, and 2017 waves of the U.S. Panel Study of Income Dynamics (PSID) for my analysis. The sample includes 10,245 households which were interviewed in all five years of the survey. Beginning in 1968, the PSID is the longest running longitudinal household survey in the world. Respondents enter the panel from three sources: As direct descendants of the original 1968 sample, the 1997 and 2017 immigrant refresher sample (which was added to make the survey sample more nationally representative), and marriages and births/adoptions into existing families. The survey was conducted annually until 1997 and biennially thereafter. A computer-assisted telephone interview (CATI) is used to collect detailed information about individuals designated as household heads/reference persons and basic information on other members of the family unit (PSID User Manual, 2019).

In addition to demographic and health-related information, the PSID contains detailed information on food security, food spending, participation in food assistance programs, and other food-related outcomes. Food security is measured by the Household Food Security Survey Module (HFSSM), which is a validated instrument consisting of 18 questions for households with children and a subset of 10 of these for households without children (Tiehen et al., 2019). The HFSSM has been included in surveys since 1996 and is used to derive official food insecurity measures for the United States and Canada. The PSID is the only nationally representative panel survey containing the full 18-question HFSSM, with the supplement included in the 1999, 2001, 2003, 2015, and 2017 waves of main survey. For this reason, my analysis only includes these five years of data.

Food insecurity is the outcome variable of interest. To quantify food insecurity, the HFSSM asks whether a condition or experience occurred at any time during the previous twelve-months due to lack of money or resources to obtain food. Accordingly, behaviour such

as voluntary fasting or dieting is excluded from the measure (Coleman-Jensen et al., 2018b). This is an important distinction to make in the context of this study because nicotine is an appetite suppressant. Respondents would not be identified as food insecure based on lower levels of hunger. Affirmative responses to the survey require insufficient food intake was due to financial constraints.

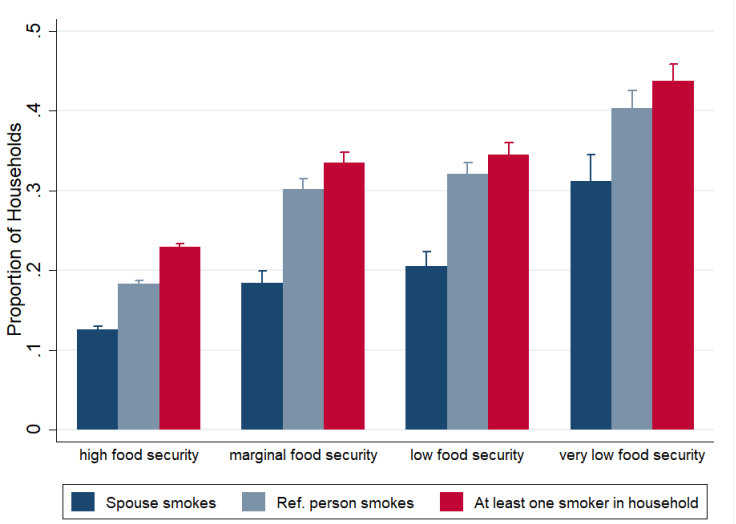
Respondents are asked questions such as "Did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?" (least severe) and "Did a child in the household ever not eat for a full day because you couldn't afford enough food?" (most severe). Respondents indicate whether the condition occurred almost every month, some months but not every month, or in only one or two months in the previous year. The subset of questions pertaining to frequency and duration allow the HFSSM to evaluate severity of food insecurity based on whether the occurrence is occasional/episodic or chronic. A household can be classified as having very low food security based on a single severe episode during the year (Coleman-Jensen et al., 2018b). This feature of the survey is important to keep in mind when interpreting food insecurity statistics.

Based on responses to these questions and whether there are children in the household, respondents fall in to four categories—high food security, marginal food security, low food security, and very low food security. As summarized by Gundersen (2019), high and marginally food secure households had two or fewer affirmative responses and are characterized by having access to enough food for an active and healthy life for all household members throughout the year. Low food secure households respond affirmatively to three to seven questions (or three to five for households without children) and are uncertain about having, or unable to acquire, enough food because they had insufficient money or resources for food. Very low food secure households respond affirmatively to eight or more questions (six or more for households without children) and contain one or more household members who were hungry at some time during the year because they could not afford enough food. The latter two

groups are often combined to form a "food insecure" group (Gundersen, 2019).

Household smoking status is self-reported by respondents answering yes/no to the question "(Do you/Does Reference Person) smoke cigarettes?" and "(Do you/Does [Spouse/Partner]) smoke cigarettes?" Respondents who answer "yes" to either question answer additional questions about their own, and their spouse's, smoking behavior such as average number of cigarettes smoked per day and age they began smoking. Persons who indicate they are not currently a smoker are asked if they have ever smoked. This information is used to identify previous smokers who have successfully quit smoking. Figure 1 shows the proportion of households with an adult smoker by the four described food security groups.

Figure 1: Proportion of Households with an Adult Smoker by Food Security Status



Notes: Each bar shows the mean and 95% confidence interval of a given smoking dummy variable. Spouse smokes=1 if the ref. person is married and responds affirmatively to the spouse smoking status question and 0 otherwise. Reference (ref.) person smokes=1 if the reference person currently smokes and 0 otherwise. At least one smoker in household=1 if either the reference person or spouse of a given family unit currently smokes and 0 otherwise.

Additional variables used in the analysis include designated reference person/household head characteristics (age, sex, race, marital status, educational attainment, and drinking behavior), spouse characteristics (educational attainment and drinking behavior), and household characteristics (total family income, renter/owner, number of children, and number of household occupants). The second outcome variable considered in the analysis is the logarithm of total annual household food expenditure. Total household food expenditure is the

sum of reported expenditures on food at home, delivered, and eaten away from home.

Descriptive statistics for the sample across all years are reported in Table 1. Food insecure households are more likely to have a smoker in the household; drink less (reference person and spouse); rent their home; have household income below the Census poverty threshold for their given family structure; receive food stamps; and have a head of household who is female, below the age of 35, completed less than high school education (reference person and spouse), single, and African-American. The profile of household characteristics that relate to a greater risk of experiencing food insecurity is consistent with findings in other American studies (Coleman-Jensen et al., 2014). There are no notable differences in demographic characteristics of the sample across each year of the survey.

Table 1: PSID Descriptive Statistics, All Years

	Food Insecure					Food Secure				
	mean	sd	min	max	count	mean	sd	min	max	count
Household smoking/drinking behaviour										
Smoker in household	0.38	0.48	0	1	6110	0.24	0.43	0	1	44871
Total # cigarettes/day, if smoker in household	15.83	13.58	1	120	2256	16.21	13.16	1	174	10649
Drinker in household	0.57	0.49	0	1	6106	0.67	0.47	0	1	44942
Total # drinks/day, if drinker in household	2.42	2.21	1	25	3418	2.38	1.79	1	30	30080
Household characteristics										
male	0.55	0.50	0	1	6147	0.76	0.43	0	1	45078
# living in household	3.87	2.02	1	14	6147	3.36	1.61	1	14	45078
renter	0.59	0.49	0	1	6147	0.29	0.46	0	1	45078
lives in poverty	0.36	0.48	0	1	6147	0.09	0.29	0	1	45078
Received food stamps last year	0.39	0.49	0	1	6141	0.10	0.30	0	1	45043
Total Family Income	30227.13	26630.56	-3000	477987	6147	75710.05	89701.44	-99265	3660650	45078
# children	1.54	1.57	0	11	6147	1.10	1.30	0	9	45078
Age group										
age <35	0.32	0.47	0	1	6147	0.23	0.42	0	1	45078
age 35-44	0.31	0.46	0	1	6147	0.26	0.44	0	1	45078
age 45-54	0.20	0.40	0	1	6147	0.25	0.43	0	1	45078
age 55-64	0.11	0.31	0	1	6147	0.15	0.35	0	1	45078
age 65-74	0.04	0.20	0	1	6147	0.08	0.27	0	1	45078
age 75+	0.01	0.12	0	1	6147	0.04	0.18	0	1	45078
Highest educational attainment										
Less than HS (ref. person)	0.40	0.49	0	1	5893	0.16	0.37	0	1	43586
completed HS (ref. person)	0.31	0.46	0	1	6147	0.30	0.46	0	1	45078
Some post-secondary (ref. person)	0.31	0.46	0	1	6147	0.54	0.50	0	1	45078
Less than HS (spouse)	0.42	0.49	0	1	2431	0.12	0.32	0	1	29058
completed HS (spouse)	0.28	0.45	0	1	2590	0.30	0.46	0	1	30478
Some post-secondary (spouse)	0.14	0.35	0	1	6147	0.40	0.49	0	1	45078
Reference person's marital status										
Married	0.36	0.48	0	1	6147	0.64	0.48	0	1	45077
Never married	0.35	0.48	0	1	6147	0.17	0.38	0	1	45077
Divorced, separated, or widowed	0.29	0.45	0	1	6147	0.19	0.39	0	1	45077
Self-identified race of ref. person										
White	0.32	0.47	0	1	6036	0.60	0.49	0	1	44539
African-American	0.53	0.50	0	1	6036	0.33	0.47	0	1	44539
Indigenous	0.01	0.09	0	1	6036	0.00	0.07	0	1	44539
Asian	0.01	0.11	0	1	6036	0.01	0.12	0	1	44539
other	0.12	0.33	0	1	6036	0.05	0.22	0	1	44539
Household Expenditure (annual)										
Total food exp.	5446.86	4147.02	0	31200	6147	7455.69	4828.21	0	124800	45078
Total housing exp.	9791.02	6769.16	-1047	66800	6147	14506.20	12961.35	-1973	479200	45078
Total health care exp.	1490.02	3739.25	-414	104787	6147	2863.62	4405.72	-995	202400	45078

Notes: Data is from the 1999, 2001, 2003, 2015, and 2017 waves of the Panel Study of Income Dynamics.

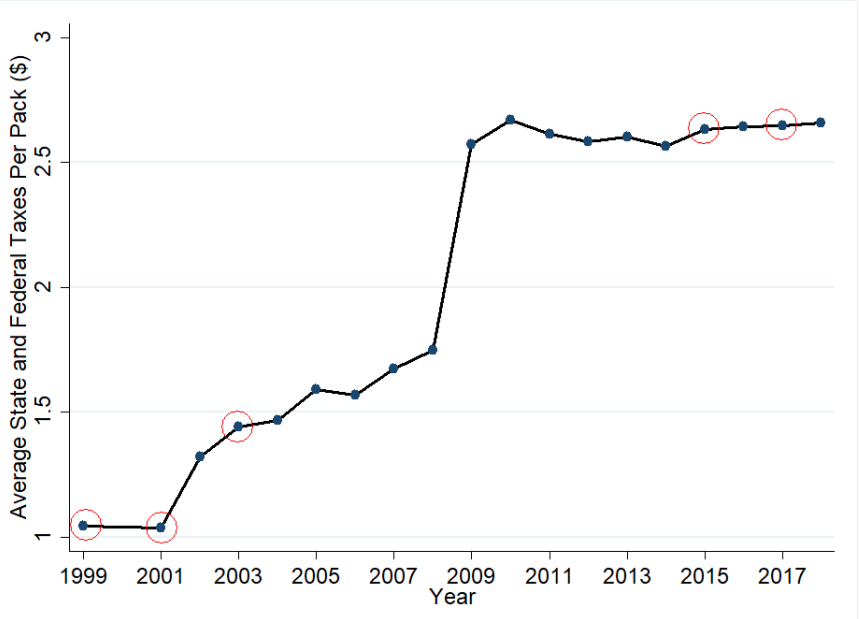
Reference:
Panel Study of Income Dynamics, public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI (2019).

3.2 Cigarette Tax Data

State-specific information on cigarette taxes are merged with the detailed individual-level data from PSID. The policy variable included in the analysis is total cigarette taxes at the state and federal level between 2000-2018. Tax information for 1999 is not included in the data set so I impute the tax data from 2000 for that year. Figure 2 plots the average total taxes per pack of cigarettes (2018 USD) for all states by year. The circled data points correspond with the years included in the analysis.

As discussed in Section 2.3, cigarettes taxes are popular for government revenue collection and as a tool for smoking cessation. Accordingly, cigarette taxes have increased markedly over time from a national average of $1.07 in 1999 to $2.65 in 2017. The steepest increase occurred in 2009 following a federal cigarette tax increase from $0.39 to $1.01 per pack. This increase achieved the Healthy People 2010 (HP2010) objective to increase the combined federal and average state cigarette tax to at least $2 per pack (Jamison et al., 2009).

Figure 2: Average Total Tax Per Pack of Cigarettes (2018 USD) by Year

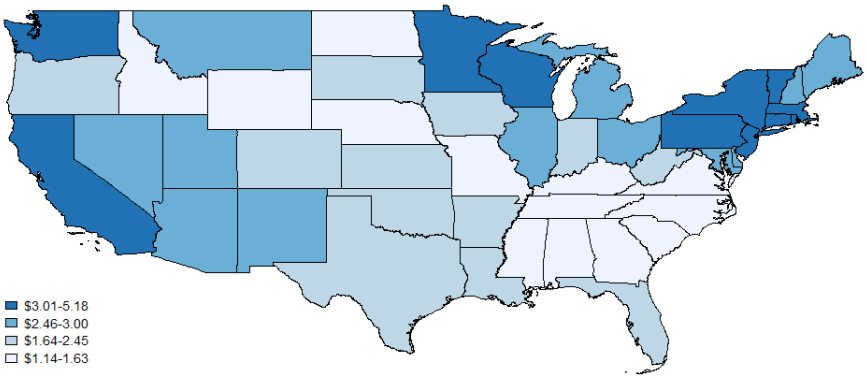


Notes: Each data point represents the national average of total taxes per pack of cigarettes for a given year. The red marker circling the data points for 1999, 2001, 2003, 2015, and 2017 indicate the years included in analysis.

This study estimates models of the effect of cigarette taxes on food-related outcomes.

The identification strategy exploits changes in cigarette taxes imposed at different times and by different amounts across states. Figure 3 shows total taxes per pack of cigarettes by state in 2017 to highlight the geographic dimension of policy variation.

Figure 3: Total Taxes Per Pack of Cigarettes by State, 2017



Notes: This figure shows the variation in total taxes per pack of cigarettes across states for the year 2017.

4 Empirical Strategy

The first part of the analysis estimates the relationship between smoking and food insecurity and food expenditure. I estimate the following model:

$$Y_{ijt} = \theta S_{ijt} \ + \ X_{ijt}\beta \ + \ \lambda_j \ + \ \gamma_t \ + \ \epsilon_{ijt} \tag{1}$$

Where Y_{ijt} is a food-related outcome for individual i residing in state j at time t. The two food related outcomes include a binary food insecurity variable which equals 1 if the respondent is classified as having low or very low food security that year and 0 otherwise and log total annual food expenditure. S_{ijt} is a smoking household dummy variable which equals 1 if either the reference person or their spouse currently smokes cigarettes in period t and 0 otherwise. X_{ijt} is a vector of individual and household characteristics, λ_j and γ_t are state and time effects, and ϵ_{ijt} is a disturbance term. The included control variables in X_{ijt} are drinking behaviour (reference person and spouse), total family income, sex of household

head, number of people living in household, number of children, whether the individual rents their dwelling, age, educational attainment (reference person and spouse), marital status, and self-reported race.

The reported standard errors are robust to clustering at the state level and an arbitrary form of heteroskedasticity. Cluster-corrected standard errors account for an unknown form of serial correlation in the error term within state groupings. Without clustering, intra-group correlation is ignored and reported standard errors are understated.

The association between smoking and the food-related outcome is captured by the estimated value of θ. The observed association found in this study has two main advantages over the estimates presented in previous studies. First, the data is a panel design so I observe the same individuals over an eighteen year time horizon. Second, the longitudinal nature of the data allows me to employ two-way fixed effects to transform the data to only use within state and time variation. The complete set of dummy variables for year of observation allows me to nonparametrically detrend the variables used in the analysis. The complete set of dummy variables for state of observation allows the intercept in the model to adjust based on where the respondents resides. This method controls for unobserved characteristics that influence food insecurity and food expenditure for a given person across state and time that are not captured by the included controls (X_{ijt}).

The second part of the analysis examines whether increasing cigarette tax rates has unintended consequences for food-related outcomes. If cigarette consumption is price inelastic, the percentage change in cigarette consumption falls by less than the percentage increase in the price of smoking. This implies individuals addicted to tobacco do not sufficiently adjust their consumption following increased tax rates. Holding income constant, households with an addicted smoker then have a lower amount of discretionary income remaining after paying for cigarettes. In these households, increased cigarette taxes can crowd out other goods in their consumption basket such as food.

I employ a difference-in-differences strategy using cigarette tax rates as a treatment vari-

able assigned to smoking households. This strategy allows me to estimate the impact of cigarette taxes on food related outcomes in smoking households compared to nonsmoking households. The estimated equation is as follows:

$$Y_{ijt} = \gamma_1 S_{ijt} \; + \; \gamma_2 (T - \bar{T}) \; + \; \gamma_3 S_{ijt} \times (T - \bar{T}) \; + \; X_{ijt}\beta \; + \; \phi_i \; + \; \lambda_j \; + \; \gamma_t \; + \; \varepsilon_{ijt} \quad (2)$$

Where $(T - \bar{T})$ is the demeaned tax rate imposed on person i residing in state j at time t. $\bar{T}$ refers to the overall mean cigarette tax rate across all states and year. The vector of demographic characteristics is the same as specified in (1) and ϕ_i, λ_j, and γ_t are individual, state, and time effects respectively. The high-dimensional three-way fixed effects are important for capturing the effect of cigarette price changes on the food related outcomes. State–level tobacco taxes may be endogenous to smoking behaviour beyond price regulation because states with high taxes are also likely to have greater anti-smoking sentiment (Auld, 2005). Transforming the data to only use within-state, time, and individual variation holds such factors constant when estimating the effect of the tax.

Standard errors associated with estimates from equation (2) are adjusted using a covariance matrix estimator proposed by Cameron et al. (2011) which allows for multi-way clustering. The estimator offers an extension of the standard cluster robust estimator to control for the panel survey design of the data. To ensure the precision of the estimates are not overstated, I account for state, time, and individual level clusters. This specification is important because cigarette taxes are a state-year policy variable impacting individuals.

The parameter of interest is the coefficient on the interaction term. The estimated value of γ_3 captures the change in the food-related outcome following a tax increase for smoking households compared to nonsmoking households. The estimated value of γ_2 serves as a pseudo-exogeneity test for the treatment variable because cigarette taxes should not affect food related outcomes in households without a smoker. Ideally the parameter estimate is

close to zero and statistically insignificant.

5 Results

5.1 Descriptive Analysis

In 2018, 11.1% of Americans experienced food insecurity at some point throughout the year which translates to 14.3 million households (Coleman-Jensen et al., 2018a). The reported official national food insecurity statistics are in line with the proportion of households that experienced food insecurity in the representative sample interviewed in the PSID. Table 2 reports the frequency and proportion of households that experienced food insecurity by year. On average, 12% of households in the sample experienced food insecurity per year between 1999 and 2017. Food insecurity prevalence was lowest in 2003 (9.62%) and highest in 2015 (15.33%).

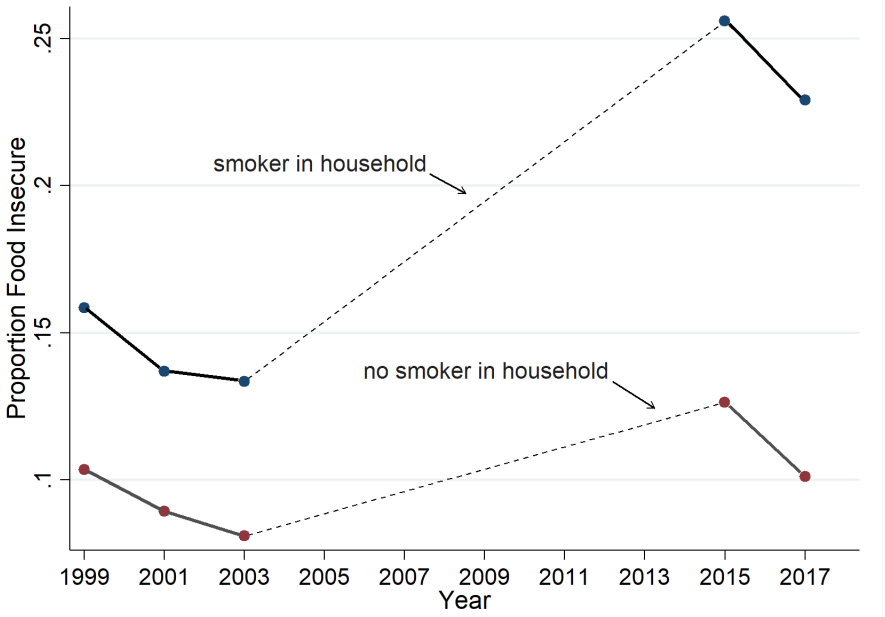
Table 2: Frequency of Households Food Insecure by Year

	Food Secure	**Food insecure**	**Total**
1999	9,012	1,233	10,245
	87.96	12.04	100.00
2001	9,182	1,063	10,245
	89.62	10.38	100.00
2003	9,259	986	10,245
	90.38	9.62	100.00
2015	8,674	1,571	10,245
	84.67	15.33	100.00
2017	8,951	1,294	10,245
	87.37	12.63	100.00
Total	45,078	6,147	51,225
	88.00	12.00	100.00

Figure 4 presents the proportion of households that experienced food insecurity by year and household smoking status. Smoking households consistently experience food insecurity at a much higher rate than nonsmoking households across all years. The difference in prevalence between smoking and nonsmoking households was largest in 2015 with smoking

households experiencing food insecurity at double the rate (26% vs. 13%). This timing is consistent with the findings of Farrelly & Shafer (2017) which report food insecurity rates increased markedly post 2008 recession and this increase was much higher for adult smokers. I do not have observations for the years immediately following 2008, but the data suggests the exaggerated difference between smoking and nonsmoking households persisted as of 2015.

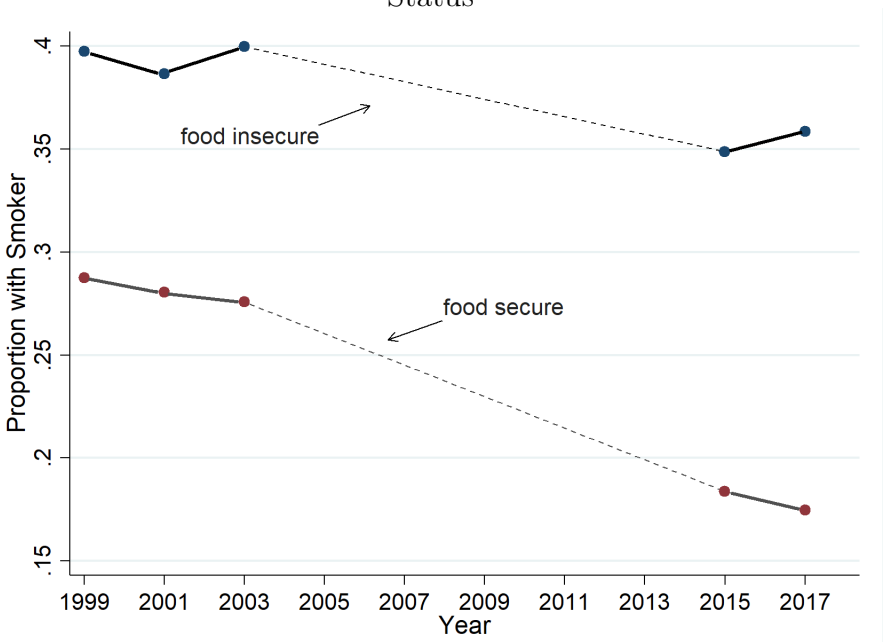
Figure 4: Proportion of Households Food Insecure by Year and Smoking Status



Notes: Each data point represents the mean of the food insecurity dummy variable for each year stratified by smoking status. The solid lines represent trends observed in the data. The dashed lines between 2003 and 2015 indicates there is no data for these years.

Figure 5 presents the proportion of households with at least one adult smoker by year and food security status. The proportion of households with an adult smoker has trended downward over time across both groups. The decline was lower for food insecure households, and between 2001-2003 and 2015-2017 the proportion of households with a smoker increased for this group.

Figure 5: Proportion of Households With an Adult Smoker by Year and Food Security Status



Notes: Each data point represents the mean of the smoking household dummy variable for each year stratified by food security status. The solid lines represent trends observed in the data. The dashed lines between 2003 and 2015 indicates there is no data for these years.

The focus of this study is to examine how smoking behaviour influences food insecurity rather than the reciprocal relationship. However, as discussed in Section 2.2 of the literature review, some studies hypothesize that food insecurity may promote smoking for stress relief and/or suppression of hunger (Kim-Mozeleski et al., 2019). What is relevant to this study is the potentially mutually reinforcing relationship between smoking and food insecurity. In particular, experiencing food insecurity appears to reduce an individual's capacity to adjust smoking behaviour in times of scarcity, which thereby exacerbates food insecurity because cigarette expenditure competes with discretionary household expenses such as food.

5.2 Smoking and Food-Related Outcomes

Table 3 and Figure 6 present the OLS estimated effect of having a smoker in the household on the probability of experiencing food insecurity. I examine variants of equation (1) to compare the estimated value of θ across models with varying levels of control variables.

Table 3 column 1 reports that the raw correlation between having a smoker in the household and the probability of experiencing food insecurity is a 7.4 percentage point increase over nonsmoking households. As reported in column 2, roughly half the difference in food insecurity between smoking and nonsmoking households is explained by the included control variables. The estimate in column 2 is still potentially biased due to unobserved factors which jointly influence the probability a household contains a smoker and is food insecure.

I include two-way fixed effects to further remove confounding factors from influencing the estimated association. I include the complete set of dummy variables for year of observation to nonparametrically detrends the variables used in the analysis. The complete set of dummy variables for state (column 3) and individuals (column 4) allows the intercept in the model to adjust based on where the respondents resides or individually for each respondent. This method controls for unobserved factors which influence food insecurity and food expenditure for a given person across state and time that are not captured by the included demographic controls. For example, state-specific social assistance policies influence food-related outcomes but are not variables available in my data set.

The state-year fixed effects model shows that having at least one adult smoker in the household increases the probability of experiencing food insecurity 4.4 percentage points. The estimate is statistically significant at all conventional test sizes and is in line with, but slightly smaller than, estimates from previous studies. In contrast, the coefficient estimate from the individual-year fixed effects model is statistically significant but nearly half the magnitude at 2.6 percentage points. It could be the case that individuals who quit smoking throughout the study period dampen the estimated effect.

To test this hypothesis, I remove observations from the estimation sample that have an adult in the household who previously smoked but no longer does. I refer to the restricted sample as the "current and never smokers" because quitters are excluded. After doing so, the individual-year fixed effects estimate (reported in the second row of column 4) increases in magnitude to 6.2 percentage points and remains statistically significant, albeit with a

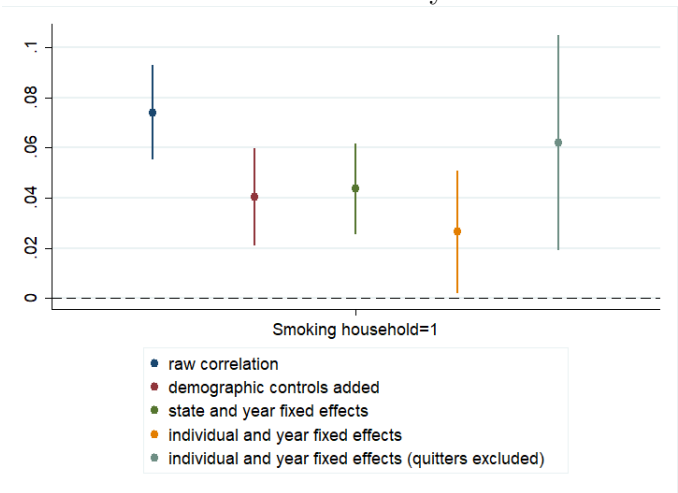
much larger 95% confidence interval.

Table 3: OLS Estimated Effect of Having a Smoker in Household on Probability of Food Insecurity

Sample	Independent variable	(1) uncontrolled	(2) controlled	(3) state & year fixed effects	(4) individual & year fixed effects
All	Smoker in household=1	0.074	0.040	0.044	0.026
		(0.0094)	(0.0096)	(0.0089)	(0.0122)
Current & never smokers	Smoker in household=1	0.082	0.049	0.053	0.062
		(0.0116)	(0.0129)	(0.0124)	(0.0214)
	Control Variables	no	yes	yes	yes
	State fixed effects	no	no	yes	no
	Individual fixed effects	no	no	no	yes
	Year fixed effects	no	no	yes	yes
All	N	50758	32355	32355	31751
Current & never smokers	N	34279	19680	19680	18464

Notes: Dependent variable is a binary variable for food insecurity. Control variables include household head characteristics (age, sex, race, marital status, educational attainment, and drinking behavior), spouse characteristics (educational attainment and drinking behavior), and household characteristics (total family income, renter/owner, number of children, and number of household occupants). Standard errors are reported in parentheses and are clustered at the state level.

Figure 6: OLS Estimated Effect of Having a Smoker in the Household on Probability of Food Insecurity



Notes: Figure plots the estimated coefficient on the smoker in household dummy variable. Each point includes 95% confidence interval around the estimate. Standard errors are clustered at the state level. Quitters excluded refers to the sample restricted to current and never smokers.

Table 4 and Figure 7 present the estimated effect of having a smoker in the household on the logarithm of total annual food expenditure. The raw correlation between having a smoker in the household and food expenditure is a 13.4% decrease compared to nonsmoking households. Again, roughly half the difference in food expenditure between smoking and nonsmoking households is explained by the included control variables. The state-year fixed

effects model estimates total annual food expenditure is approximately 3.8% lower in smoking households. The estimate is statistically significant at all conventional test sizes.

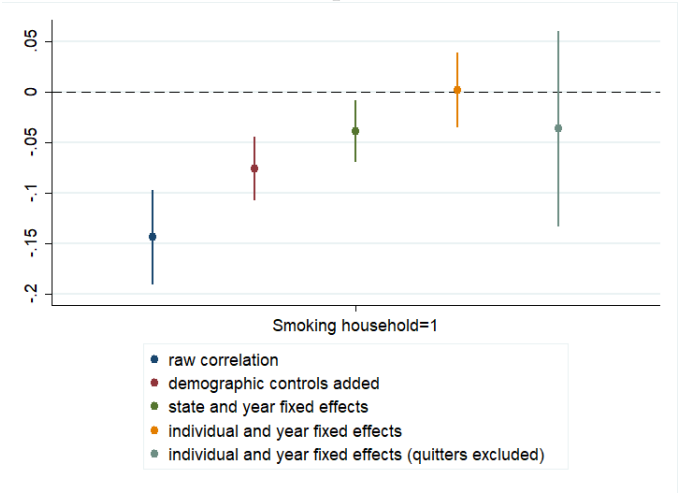
Restricting the sample to always and never smokers becomes important for the individual-year fixed effects model in this context. When all respondents are included in the estimation sample, the coefficient estimate is close to zero, slightly positive, and statistically insignificant. In other words, this estimate suggests having a smoker in the household has virtually no impact on food expenditure. This result contradicts my *a priori* expectation and the estimates presented in columns 1-3. Excluding people who quit smoking throughout the study period returns the point-estimate to negative and very similar magnitude to the state-year model (-0.036 vs. -0.039). However, the estimate is likely statistically insignificant due to decreased estimation precision resulting from the smaller sample size.

Table 4: OLS Estimated Effect of Having a Smoker in Household on Log Annual Food Expenditure

Sample	Independent variable	(1) uncontrolled	(2) controlled	(3) state & year fixed effects	(4) individual & year fixed effects
All	Smoker in household=1	-0.144	-0.076	-0.039	0.002
		(0.0231)	(0.0158)	(0.0150)	(0.0184)
Current & never smokers	Smoker in household=1	-0.158	-0.094	-0.053	-0.036
		(0.0256)	(0.0215)	(0.0202)	(0.0480)
	Control Variables	no	yes	yes	yes
	State fixed effects	no	no	yes	no
	Individual fixed effects	no	no	no	yes
	Year fixed effects	no	no	yes	yes
All	N	50165	32216	32216	31599
Current & never smokers	N	33797	19581	19581	18363

Notes: Dependent variable is log total annual food expenditure. Control variables include household head characteristics (age, sex, race, marital status, educational attainment, and drinking behavior), spouse characteristics (educational attainment and drinking behavior), and household characteristics (total family income, renter/owner, number of children, and number of household occupants). Standard errors are reported in parentheses and are clustered at the state level.

Figure 7: OLS Estimated Effect of Having a Smoker in the Household on Log Total Annual Food Expenditure



Notes: Figure plots the estimated coefficient on the smoker in household dummy variable for the model specified in the legend. Each point includes 95% confidence band around the estimate. Standard errors are clustered at the state level. Quitters excluded refers to the sample restricted to current and never smokers.

The first part of the analysis provides evidence that smoking is a predictor of food insecurity and relates to a reduction in annual food expenditure. I hypothesize the mechanism by which smoking influences these outcomes is through the budget channel, but I cannot rule out alternative explanations at this point. For instance, in the case of food expenditure, smoking households may purchase less food because nicotine is an appetite suppressant. The next section of the analysis demonstrates the budget impact of increasing cigarette taxes on food-related outcomes.

5.3 The Impact of Cigarette Taxes on Food Related Outcomes

This section of the analysis employs a difference-in-differences strategy using the tax rates as a treatment variable assigned to smoking households. This model builds on the previous section and estimates whether cigarette taxes imposed by the government have an unintended consequence of increasing the prevalence of food insecurity. My preferred model is reported in column 3 of Tables 5 and 6. This model includes the vector of demographic controls and individual, state, and year effects. I present the results graphically in Figures 8 and 9.

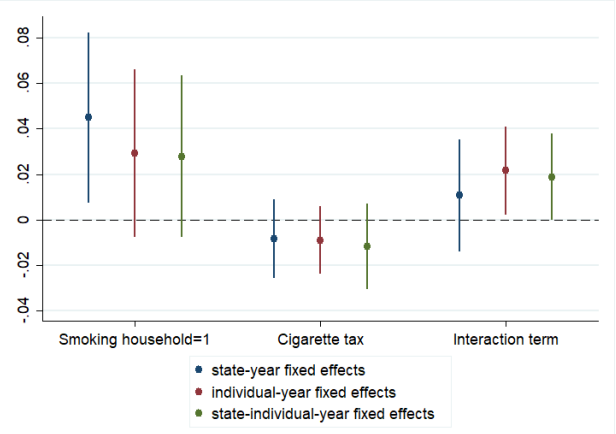
A $1.00 increase in taxes per pack of cigarettes raises the probability a smoking household experiences food insecurity by an additional 1.9 percentage points over nonsmoking households. This difference is statistically significant at the 5% significance level. A $1.00 increase in taxes per pack of cigarettes reduces total annual food expenditure by an additional 4% over nonsmoking households. This difference is statistically significant at all conventional test sizes. This means a $1.00 increase in total taxes over the average tax rate leaves smoking households 3.5 percentage points more likely to experience food insecurity and purchasing approximately 5% less food annually compared to nonsmoking households overall.

Table 5: Estimated Effect of Tobacco Taxes on Probability of Food Insecurity

	(1) state-year fixed effects	(2) individual-year fixed effects	(3) state-individual-year fixed effects
Smoker in household=1	0.045	0.029	0.028
	(0.0135)	(0.0133)	(0.0128)
$(T - \bar{T})$	-0.008	-0.009	-0.012
	(0.0062)	(0.0053)	(0.0067)
Smoker in household=1 $\times$ $(T - \bar{T})$	0.011	0.022	0.019
	(0.0089)	(0.0070)	(0.0069)
Control Variables	yes	yes	yes
State fixed effects	yes	no	yes
Individual fixed effects	no	yes	yes
Year fixed effects	yes	yes	yes
N	32355	31751	31751

Notes: Dependent variable is a binary variable for food insecurity. Control variables include household head characteristics (age, sex, race, marital status, educational attainment, and drinking behavior), spouse characteristics (educational attainment and drinking behavior), and household characteristics (total family income, renter/owner, number of children, and number of household occupants). Standard errors are reported in parentheses and are clustered at the state, individual, and year level.

Figure 8: Estimated Effect of Tobacco Taxes on Probability of Food Insecurity



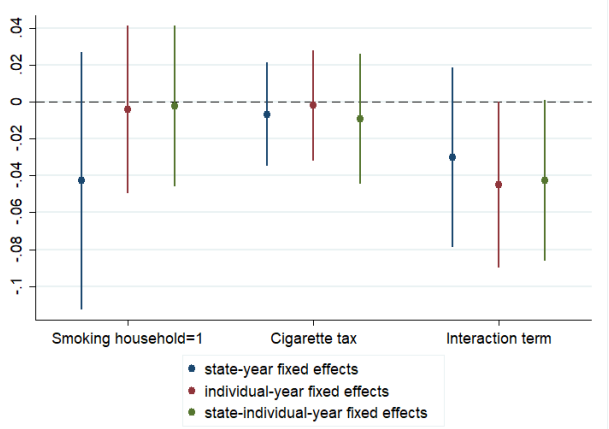
Notes: Figure plots the estimated coefficient on the smoker in household dummy variable for the model specified in the legend. Each point includes 95% confidence band around the estimate. Standard errors are clustered at the state, individual, and year level.

Table 6: Estimated Effect of Tobacco Taxes on Log Total Annual Food Expenditure

	(1) state-year fixed effects	(2) individual-year fixed effects	(3) state-individual-year fixed effects
Smoker in household=1	-0.043	-0.004	-0.002
	(0.0252)	(0.0163)	(0.0157)
$(T - \bar{T})$	-0.007	-0.002	-0.009
	(0.0101)	(0.0108)	(0.0127)
Smoker in household=1 $\times$ $(T - \bar{T})$	-0.030	-0.045	-0.042
	(0.0175)	(0.0162)	(0.0157)
Control Variables	yes	yes	yes
State fixed effects	yes	no	yes
Individual fixed effects	no	yes	yes
Year fixed effects	yes	yes	yes
N	32216	31599	31599

Notes: Dependent variable is log total annual food expenditure. Control variables include household head characteristics (age, sex, race, marital status, educational attainment, and drinking behavior), spouse characteristics (educational attainment and drinking behavior), and household characteristics (total family income, renter/owner, number of children, and number of household occupants). Standard errors are reported in parentheses and are clustered at the state, individual, and year level.

Figure 9: Estimated Effect of Tobacco Taxes on Log Total Annual Food Expenditure



Notes: Figure plots the estimated coefficient on the smoker in household dummy variable for the model specified in the legend. Each point includes 95% confidence band around the estimate. Standard errors are clustered at the state, individual, and year level.

The cigarette taxes perform as expected with the pseudo-exogeneity test for both food-related outcomes as the estimated coefficient on the treatment variable is statistically insignificant and close to zero. In the case of the food insecurity model, the estimated effect of the treatment variable alone is slightly negative. This may be picking up the effect of some people quitting smoking in response to higher taxes which may reduce food insecurity. Alternatively, the tax rates could be endogenous because higher income states may have both lower prevalence of food insecurity and less reliance on sales taxes and more on income taxes to generate revenue. Regardless, on average, increases in cigarette taxes should not

impact food-related outcomes in households without a smoker. This appears to be the case for both food-related outcomes.

The discussed coefficient estimates for the interaction terms can be interpreted as causal assuming all unobserved characteristics that influence food-related outcomes for a given state, time, and person are controlled for by the three-way fixed effects. The identifying assumption is that, in absence of changes to cigarette taxes, food-related outcomes would have trended in the same way across states and individuals over time. Statistical inference is done using very conservative standard errors to ensure precision of the estimates are not overstated.

Accordingly, the estimates presented in this section provide evidence that raising cigarette taxes has adverse effects on food-related outcomes in smoking households.

5.4 Sensitivity Analysis

I perform several sensitivity checks to see if any specific group in the sample is driving the estimated effect of tobacco taxes on food-related outcomes. I also assess the robustness of my results by testing the assumptions invoked when interpreting the estimates from equation (2).

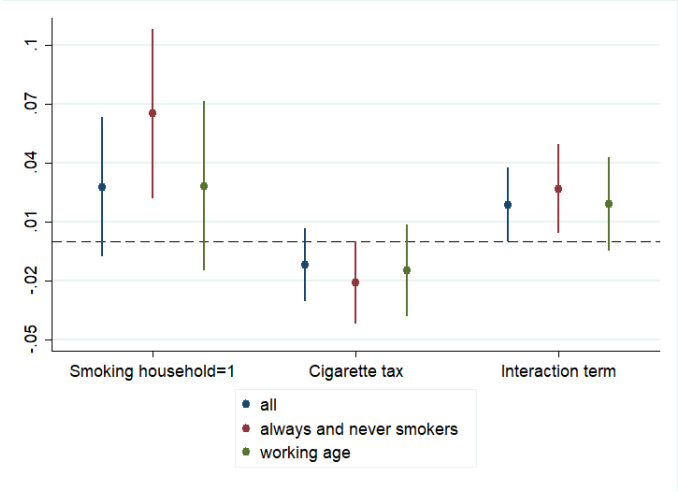
One problematic group could be respondents who have someone in the household who quit smoking. I re-estimate equation (2) excluding households in which the reference person or their spouse previously smoked but no longer do. The estimated effect on the food-related outcomes are presented with the red plots in Figures 10 and 11. In the case of food insecurity (Figure 10), the estimated coefficient associated with the interaction term increases in magnitude. Previous smokers dampen the estimate of the effect of increasing cigarette taxes on food insecurity in smoking households. In the case of food expenditure (Figure 11), the effect of the taxes is dampened and statistically insignificant after excluding previous smokers.

I also check whether the estimates are sensitive to the age of respondents. Specifically, I

re-estimate equation (2) and restrict the sample to the working age population between the ages of 18-65. In the Unites States, people begin receiving Medicare at the age of 65 which provides additional income-support to buffer against budget shocks. The estimated effect of tobacco taxes on the food-related outcomes in smoking households excluding this group are presented with the green plots in Figures 10 and 11. The estimated effect on food insecurity is estimated with less precision and become statistically insignificant. The estimated effect on food expenditure increases in magnitude and remains statistically significant.

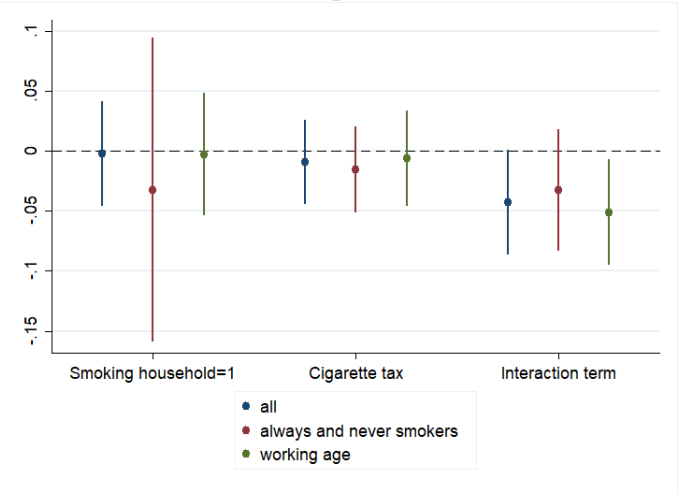
The results from the sensitivity analysis show that whether I include certain groups or not, the overall result remains the same–food-related outcomes in smoking households are adversely effected by increased cigarette taxes.

Figure 10: Sensitivity Checks–Estimated Effect of Tobacco Taxes on Probability of Food Insecurity



Notes: Dependent variable is a binary variable for insecurity. Estimates are from equation (2) which includes individual, state, and year effects. Standard errors are robust to an arbitrary form of heteroskedasticity and state, year, and individual clusters.

Figure 11: Sensitivity Checks–Estimated Effect of Tobacco Taxes on Log Total Annual Food Expenditure

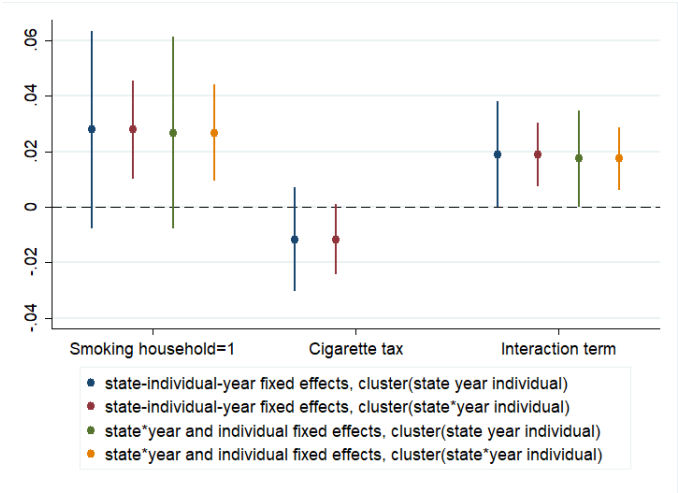


Notes: Dependent variable is log total annual food expenditure. Estimates are from equation (2) which includes individual, state, and year effects. Standard errors are robust to an arbitrary form of heteroskedasticity and state, year, and individual clusters.

Next, I estimate a model which provides compelling estimates in that it invokes the weakest assumptions. Figures 12 and 13 present estimates with a complete set of interactions between the time and state effects. Since taxes vary at this level, I cannot include the tax variable as a regressor, but I can include the smoker-tax interaction term. This strategy in effect uses nonsmoking households within each state-year pair as a control group. As seen from comparing the blue and green plots in Figures 12 and 13, the model which requires the fewest assumptions for interpretation produces the same result as the three-way fixed effects model.

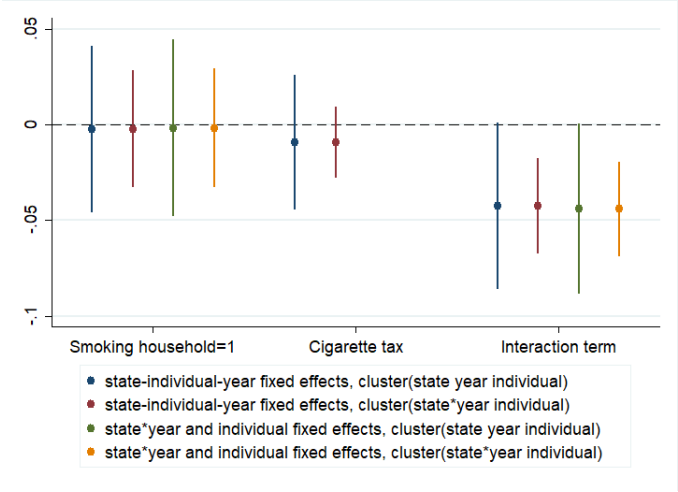
I also use Figures 12 and 13 to depict the conservative nature of the standard errors used throughout the analysis. Recall, the standard errors used thus far are adjusted using a covariance matrix estimator proposed by Cameron et al. (2011) which allows for multi-way clustering at the state, year, and individual level. As a point of comparison, the red and yellow plots show the coefficient estimates with standard errors which, following Acemoglu & Pischke (2003), account for state*time and individual level clusters. The authors use this specification for analysis of a state-year policy variable which impacts individuals.

Figure 12: State*Year Fixed Effects–Estimated Effect of Tobacco Taxes on Probability of Food Insecurity



Notes: Dependent variable is a binary variable for insecurity. Estimates plotted in blue and red are from equation (2) which includes individual, state, and year effects. Estimates plotted in green and yellow are from an alternative model which includes state*year and individual effects. Standard errors associated with the blue and green estimates follow the rest of the analysis and are clustered at the state, year, and individual level. Standard errors associated with the red and yellow estimates are clustered by state*year and individuals.

Figure 13: State*Year Fixed Effects–Estimated Effect of Tobacco Taxes on Probability of Food Insecurity

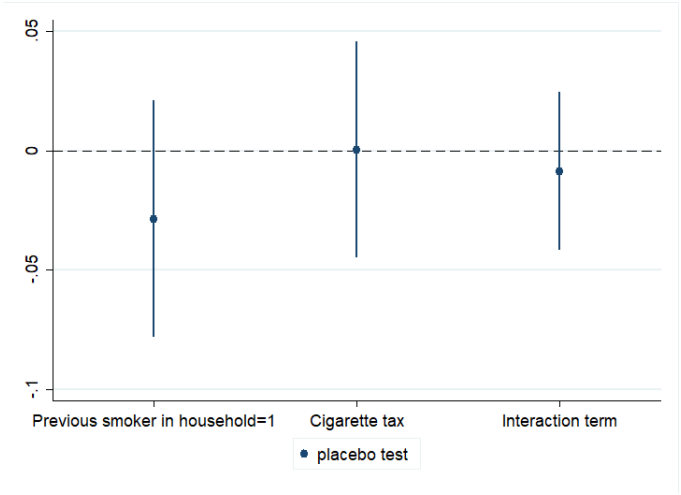


Notes: Dependent variable is log total annual food expenditure. Estimates plotted in blue and red are from equation (2) which includes individual, state, and year effects. Estimates plotted in green and yellow are from an alternative model which includes state*year and individual effects. Standard errors associated with the blue and green estimates follow the rest of the analysis and are clustered at the state, year, and individual level. Standard errors associated with the red and yellow estimates are clustered by state*year and individuals.

Finally, I perform a placebo test to further ensure nothing is biasing the tax model results. I replace the smoking household dummy with a dummy variable which equals 1

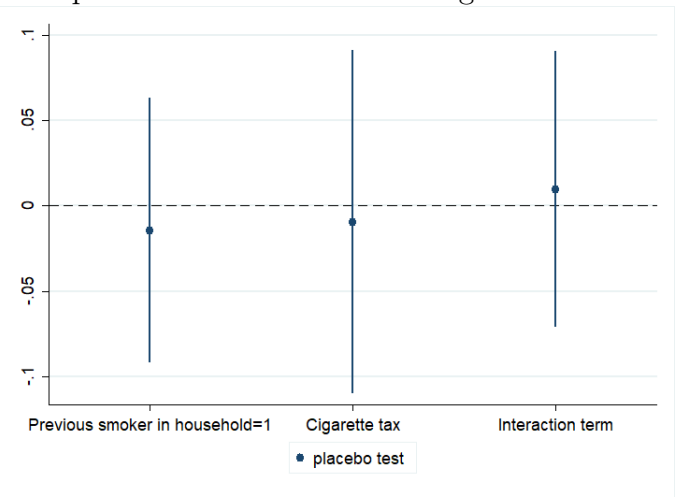
if the reference person or their spouse quit smoking, and 0 otherwise. I anticipate the interaction term between the cigarette tax variable and previous smoker dummy will be statistically insignificant and close to zero. Current tax increases should not impact food-related outcomes of former smokers. Figures 14 and 15 present the estimation results from the placebo test for each outcome variable. As anticipated, former smoking households are not responsive to a policy treatment variable which should only impact current smoking households.

Figure 14: Placebo Test–Estimated Effect of Tobacco Taxes on Probability of Food Insecurity in Former Smoking Households



Notes: Dependent variable is a binary variable for insecurity. Estimates are from a variant of equation (2) where the smoking household dummy variable is replaced with a previous smoker in household dummy variable. Previous smoker in household=1 if either the reference person or their house previous smoked but do not currently smoke. The model includes individual, state, and year effects. Standard errors are robust to an arbitrary form of heteroskedasticity and state, year, and individual clusters.

Figure 15: Placebo Test–Estimated Effect of Tobacco Taxes on Log Total Annual Food Expenditure in Former Smoking Households



Notes: Dependent variable is log total annual food expenditure. Estimates are from a variant of equation (2) where the smoking household dummy variable is replaced with a previous smoker in household dummy variable. Previous smoker in household=1 if either the reference person or their house previous smoked but do not currently smoke. The model includes individual, state, and year effects. Standard errors are robust to an arbitrary form of heteroskedasticity and state, year, and individual clusters.

6 Policy Discussion

Cigarette taxes have consistently increased over time as price regulation has proven successful in reducing smoking prevalence and the associated consequences. The findings of this study highlight a distributional issue associated with cigarette taxation. I find evidence that cigarette tax increases intended to deter smoking have an unintended adverse effect on food-related outcomes. In particular, the policy heightens the risk that smokers, and their nonsmoking family members, experience food insecurity. This is problematic as both food insecurity and smoking are associated with numerous adverse health outcomes and pose a burden to the healthcare system.

If reducing smoking and improving health is the goal of tobacco taxation, state and federal governments should consider the consequence of inducing food insecurity before increasing cigarette taxes further. Cigarette prices may be at the point where diminishing returns to further taxation binds. That is, fewer people quit smoking in response to each increase because the policy has already reached the people more capable of quitting.

Given the current levels of price regulation, social stigma, and health research, individuals who continue to smoke today are more likely to be long-time smokers with more severe addiction which implies their behavior is more price inelastic. This suggests further increases in the tax may not be the best means for discouraging smoking or the health of households with a smoker present. Perhaps alternative approaches, such as subsidizing cessation products and counselling, would be a way to address smoking prevalence without the same consequences for food security.

If cigarette taxes are increased further, there should be a mechanism in place to offset the negative consequences of the policy for smokers and other members of their household. For instance, higher taxes could be introduced with food subsidies for low-income smoking households. This type of initiative would have to be carried out in way that ensures smoking is not incentivized. This is possible as Chaloupka et al. (2012) find cigarette taxes have a greater positive health impact when the generated revenues are used to support other smoking cessation initiatives and health promotion.

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