The Effects of Tobacco Control Policies on Tobacco Products, Tar, and Nicotine Consumption: Evidence from Household Panel Data

Chad Cotti[a] Erik Nesson[b] Nathan Tefft[c]

Abstract

This paper examines consumers' responses to a comprehensive set of tobacco control policies, including cigarette taxes, smokefree air laws, and smokeless tobacco taxes. Using the Nielsen Homescan Consumer Panel Dataset between the years of 2004 and 2012, we use within household variation to estimate the effects of tobacco control policy changes on household purchases of cigarettes and other tobacco-related products. We first confirm that cigarette taxes reduce cigarette purchases on both the extensive and intensive margins, but we do not find that smokefree air laws or smokeless tobacco taxes lead to statistically significant changes in tobacco product purchases. We find some evidence that cigarette taxes increase purchases of smoking-cessation products, but cigarette taxes do not lead to statistically significant changes in smokeless tobacco purchases. Importantly, we also provide new evidence on whether cigarette taxes affect smokers' tar and nicotine intake. Using UPC codes and product names, we are able to match 91% of cigarette product purchases in the NCPS to cigarette characteristics from the National Health and Nutrition Examination Surveys and the Federal Trade Commission. Although we find some evidence that smokers purchase cigarettes with higher tar, nicotine, and carbon monoxide contents, contrary to previous studies we also find that this effect is completely overwhelmed by the reduced number of cigarettes purchased.

Keywords: cigarette smoking, cigarette taxes, smokeless tobacco taxes, compensating behavior,
JEL Codes: D12, I12, I18

[a] Department of Economics, University of Wisconsin - Oshkosh, Oshkosh, WI
[b] Department of Economics, Ball State University, Muncie, IN
[c] (Corresponding author) Department of Economics, Bates College, Lewiston, ME

I. Introduction

Cigarette smoking causes many adverse health outcomes including cancers of the mouth, pharynx, larynx, esophagus, stomach, pancreas, bladder, kidney, cervix, and stomach; stroke; coronary heart disease; chronic obstructive pulmonary disease; asthma; and low birth weight (U.S. Department of Health and Human Services, 2004). Additionally, smokeless tobacco carries its own risks, including cancers of the mouth, tooth loss, and oral lesions (National Cancer Institute, 1992). In Chapter 29 of *The Handbook of Health Economics*, entitled "The Economics of Smoking," Chaloupka and Warner (2000), lay out a strong case for the importance of economic research into the impact of tobacco control policies on consumption outcomes. In particular they state:

> "Economic analysis of the markets for tobacco products, particularly cigarettes, has contributed considerable insight to debates about the importance of the industry and the appropriate roles of public policy in grappling with the health consequences of tobacco. Certainly the most significant example of this phenomenon has been the rapidly expanding and increasingly sophisticated body of research on the effects of price increases on cigarette consumption. Because excise tax comprises an important component of price, the resultant literature has played a prominent role in legislative debates about using taxation as a principal tool to discourage smoking. In addition to informing legislative debates, this literature has contributed both theory and empirical evidence to the growing interest in modeling the demand for addictive products."

Indeed, the body of economic research suggests that tobacco consumption responds to policy levers such as cigarette taxes, although some important aspects of consumers' responses to tobacco control policies remain relatively unexplored. For example, more detailed research examining whether cigarettes and other tobacco-related products are economic substitutes or complements is needed. A comprehensive understanding of this relationship is vital to predicting whether raising cigarette taxes will have the unintended consequence of raising smokeless tobacco use. Additionally, little research examines whether cigarette smokers respond to tobacco control policies by switching to cigarette brands with higher nicotine contents. Lastly, much of the economic research examining responses to tobacco control policies is based on repeated

cross-section data, raising concerns about endogeneity between tobacco control policies and unobservable drivers of smoking levels.

This paper aims to address these existing issues in the literature. Using the Nielsen Homescan Consumer Panel Dataset (NHCPD) between the years of 2004 and 2012, we examine a panel of households to estimate the effects of tobacco control policy changes on household purchases of cigarettes, smoking-cessation products, and chewing tobacco. Additionally, we use UPC codes and product names to match 91% of cigarette product purchases in the NHCPD to cigarette characteristics from the National Health and Nutrition Examination Surveys (NHANES) and the Federal Trade Commission. This allows us to examine whether households respond to changes in tobacco control policies by changing the tar, nicotine, and carbon monoxide contents of the cigarettes they purchase, and moreover, whether tobacco control policies lead to changes in households' estimated intakes of these substances.

In a preview of our results, we confirm that cigarette taxes meaningfully reduce cigarette consumption, even when examining within household variation. Results do not, however, provide strong evidence that smokefree air laws or smokeless tobacco taxes lead to statistically significant changes in tobacco product purchases. We find some evidence that cigarette taxes lead to substitution toward the purchases of smoking-cessation products, but cigarette taxes do not lead to statistically significant changes in smokeless tobacco consumption. Lastly, and importantly, we find that cigarette taxes reduce smokers' estimated tar, nicotine, and carbon monoxide consumption, and we do not find consistent evidence of the smoker compensatory behavior previously suggested by cross-sectional studies (Adda & Cornaglia, 2006; Evans & Farrelly, 1998; Farrelly, Nimsch, Hyland, & Cummings, 2004). These estimates are robust to the inclusion of controls for household-level demographic characteristics, geographic area controls expected to affect individual tobacco consumption, and time period, household, and geographic fixed effects. Furthermore, these estimates are also robust to several alternative approaches to modeling outcomes, such as including trends, and to the estimation method selected.

The findings presented here therefore contribute to the literature in several ways. We present a comprehensive investigation of the impact of several principal tobacco control policies on household consumption habits across range of tobacco related products. This includes investigating the impacts on the consumption of smoking cessation products (e.g. electronic cigarettes, nicotine patches/gum, etc.), which, due to their relatively new and expanding presence

in the marketplace, have not been studied in conjunction with tobacco control polies in a comprehensive way. This analysis also leverages highly detailed household panel data to provide confidence in the accuracy of estimates. Lastly, by matching detailed cigarette characteristics information on tar, nicotine, and carbon monoxide content, as well as cigarette length and type, from the NHANES back to the NHCPD, we are able to more definitively understand the degree to which smokers alter their smoking behavior to compensate for changes in tobacco control policies.

Ultimately, we view the findings in this paper as further demonstrating the effectiveness of cigarette excise taxes as a policy lever to reduce smoking levels for a number of reasons. First, we find that cigarette taxes lead to statistically and economically significant reductions in cigarette smoking, even when including household level fixed effects. Moreover, although previous literature utilizing cross sectional data has suggested that substitution to other tobacco products or cigarettes with higher tar and nicotine contents may blunt the impact of cigarette taxes, our results suggest that substitution is overwhelmed by the reduction in total cigarette purchases. Lastly, we confirm previous studies suggesting that other tobacco control policies, such as smokefree air laws, do not lead to statistically significant changes in smoking outcomes.

The rest of this paper is organized as follows. Section **Error! Reference source not found.** summarizes the previous economic literature estimating the effects of tobacco control policies, Section III describes the NHCPD, Section IV overviews our empirical strategy, Section V describes our results, and Section VI concludes.

II. Literature Review and Background

a) *Research on Tobacco Control Policies*

The literature on impacts of tobacco control policies is vast and covers decades of research. Beginning in the 1970s, economists began to examine the link between cigarette prices and consumption. While elasticity estimates varied depending on time frame, dataset, age group, etc., a general consensus about the effectiveness of cigarette taxes on reducing cigarette consumption has formed, with own-price elasticity estimates of between -0.2 and -0.6 for adults and -1.0 to -1.3 for youth (see Chaloupka and Warner (2000) for an extensive summary of the literature) . The evidence of the impact of taxes on cigarette demand is so well established that

the Surgeon General's Report (2000) concluded "*raising tobacco excise taxes is widely regarded as one of the most effective tobacco prevention and control strategies."* Nevertheless, these conclusions spurred even more research into the effects of other tobacco control policies, such as smoking bans and smokeless tobacco taxes, and investigation into potential substitution across tobacco related products.

For example, Ohsfeldt and Boyle (1994) conducted the first such study on smokeless tobacco (SLT) taxes and cigarette taxes used Current Population Survey data from 1985, finding a large own-price elasticity of approximately -0.5, as well as a strong positive cross-price elasticity with cigarettes of just under 0.5, suggesting (at least for adults) that substitution between cigarettes and SLT is present. Similarly, Ohsfeldt et al. (1997) followed up this study with a look at individual-level data (1997) from the 1995 Current Population Survey data, and concluded that the negative own-price elasticity they found was much smaller (about -0.15) and the cross-price elasticity was smaller as well (only about 0.10). Chaloupka et al. (1997) revisited the question of SLT use after the Comprehensive Smokeless Tobacco Act of 1986 and other anti-smoking developments in the early 1990s. They found an own-price elasticity for SLT use that was high. Among users, however, the price elasticity of the intensity of use was low. Tauras et al. (2007) revisited the SLT demand question, using the 1995, 1997, 1999, and 2001 National School-Based Youth Risk Behavior Survey, and found price elasticity estimates in the range of -0.1 to -0.2. Moreover, the contemporary and related literature of the impacts of smoking restrictions (smoking bans) has also been prominent, as a number of recent studies have shown a substantial reduction in cigarette sales and smoking prevalence following the implementation of smoking bans (Gallus et al., 2006; Levy, Chaloupka, & Gitchell, 2004). In an attempt to relate these findings, Adams at al. (2013) utilized several waves of Behavioral Risk Factor Surveillance System data to test for compensatory behavior across tobacco products. They find a meaningful increase in smokeless tobacco use among smokers, particularly those who drink and are of typical bar-going age.

While very impactful, these studies do suffer from important shortcomings. They typically do not study tobacco control policies concurrently, nor are they able to leverage panel data, which presents an empirical challenges surrounding identification. In particular, much of the economic research examining responses to tobacco control policies is based on repeated cross-section data, raising concerns about endogeneity between tobacco control policies and

unobservable drivers of smoking levels. By utilizing panel data in purchase habits from the NHCPD for several years, on thousands of households, across several tobacco related products (including cessation/anti-tobacco products), we hope to add meaningfully to this literature by addressing previous shortcoming and expanding the comprehensiveness of the policies and products studied.

b) Within Product Substitution and Compensation

In addition to reductions in consumption and substitution to other related products in responses to tobacco control policies, there is also great interest in understanding the compensating behaviors among tobacco users in terms of within-product substitution. Economic theory suggests that if cigarette taxes are levied on each cigarette regardless of nicotine content, smokers may switch to brands with higher nicotine contents or change the way which they smoke each cigarette (Adda & Cornaglia, 2006; Harris, 1980). From a public policy perspective, if smokers reduce the number of cigarettes they smoke but do not change their intake of carcinogens in response to tobacco control policies, then the policies may not reduce smoking-related diseases. Importantly, in the economics literature, Evans and Farrelly (1998) and Farrelly et al. (2004) find that smokers facing higher cigarette taxes decrease the self-reported number of cigarettes smoked but that these taxes are associated with increased tar and nicotine contents of the cigarettes smoked. This increase in tar and nicotine content offsets the reduced number of cigarettes smoked, leaving daily estimated nicotine intake unchanged. Some more recent studies measure smoking behavior through biomarkers of recent nicotine intake, although these papers arrive at differing conclusions. Adda and Cornaglia (2006) find that while increased cigarette taxes decrease the number of cigarettes smoked, cigarette taxes do not change the average levels of serum cotinine, a biomarker of recent nicotine exposure, found in smokers. However, Abrevaya and Puzzello (2012), a comment, find that Adda and Cornaglia's results are unstable when the sample is increased to all respondents in the NHANES III data. In a reply Adda and Cornaglia (2013) extend the NHANES III data set through 2006 and find that their initial results largely hold. Most recently, Nesson (2015) extends the NHANES dataset further to include data through 2012 and finds that cigarette taxes lead to statistically significant reductions in serum cotinine levels.

However, in addition to sharing problems associated with utilizing cross-sectional data discussed above, these studies leave other issues unresolved as well. First, measuring changes in smokers' behavior using the self-reported number of cigarettes smoked and information from cigarette packs may introduce measurement error. The self-reported number of cigarettes smoked per day shows evidence of misreporting, as most responses are for round numbers of cigarettes smoked per day such as five, 10, or 20 cigarettes smoked per day. However, the actual number of purchases per month in the NHCPD display no such discontinuities. Relatedly, previous studies which examine changes in smokers' cigarette brand purchases such as Evans and Farrelly (1998) and Farrelly et al. (2004), determine cigarette characteristics by asking survey respondents to provide a pack of cigarettes that they usually smoke.[1] This may omit information if smokers purchase more than one brand of cigarette, and if multi-product purchases are correlated with tobacco control policies, this may lead to biased estimates of smokers' responses to tobacco control policies. Using biomarkers of smoking intake to measure smokers' behavior offers an advantage over using the self-reported number of cigarettes smoked in that there is less measurement error introduced by misreports. However, the use of biomarkers introduces its own concerns. First, the collection of biomarkers is a time and money-intensive process, so surveys containing biomarkers such as NHANES contain much smaller sample sizes than other health surveys such as the Behavioral Risk Factor Surveillance System or National Health Interview Survey. Second, as biomarkers of nicotine are metabolized and removed from the body, smokers consuming the same amount of nicotine may have very different levels of these biomarkers, depending on the time of day or day of the week they were interviewed.

III. Data

To study the comprehensive impact of state-level policies on household purchases of tobacco and anti-tobacco products, we use data from the NHCPD between 2004 and 2012. The Nielsen Corporation recruits a sample of American households that continually provide information on their purchasing behavior, including when and where they shop, what food and non-food items they purchase, and how much they pay for each item. Specifically, Nielsen

[1] For example, in NHANES survey respondents are asked, "May I please see the pack for the brand of cigarettes you usually smoke?" See the NHANES documentation for the smoking module for the 2011/2012 waves, available at http://wwwn.cdc.gov/nchs/nhanes/2011-2012/SMQ_G.htm (accessed February 2015).

provides each NHCPD household with a device to scan the UPC code of each item they purchase on a shopping trip and report where they bought the item. If the store participates in Nielsen's point-of-sale (POS) data collection program, the item is assigned the average weekly price of that good at that store. If the store is not a POS participant, the Homescan panelist is asked to provide the price. Each unique UPC code is treated as a separate item.

The sample includes respondents from all states and major metropolitan areas, and allows for calculations of national, regional, and market area projections. The dataset contains approximately 40,000 households between 2004 and 2006, and 60,000 households between 2007 and 2011. Respondents are provided incentives to encourage continued participation, but these are designed to not influence purchasing habits. Approximately 80% of households each year continue participation in the following year.

The NHCPD does not include purchases made outside of retail stores, which may underestimate total household purchases and, importantly for this project, bias estimates of price responses. A primary concern is Internet purchases. Although online purchases cannot directly be measured, the potential for bias in elasticity estimates will be addressed by including a measure of household Internet use from the NHCPD.

While the NHCPD is a rich data source of all retail purchases, it does not provide details about the specific characteristics of cigarettes purchased. To complement the data on household purchases, we merge in cigarette characteristics collected from the National Health and Nutrition Examination Surveys (NHANES). NHANES is a cross-sectional survey of health and nutritional information conducted by the CDC which combines surveys, physical examinations, and laboratory measurements. NHANES releases waves every two years, and each wave is nationally representative and contains about 10,000 individuals. Since the 2001-2002 wave, NHANES has collected cigarette UPC codes and characteristics including tar, nicotine, and carbon monoxide content, length, and whether the cigarette is menthol. We created a database of all the unique UPC codes with cigarette characteristics and NHANES survey wave combinations. We then merged the cigarette characteristics using the survey wave and UPC code, achieving a match rate of 91%.[2]

[2] When merging based on complete survey year and UPC matches, approximately 35% of cigarette purchases were for a brand that was successfully assigned NHANES characteristics. In order to increase the match rate we successively stepped backward through NHANES years until a purchase matched a UPC (or until the NHANES years were exhausted). This additional step increased the cigarette purchase match rate to approximately 43% of

Data on cigarette tax rates are available in the Tax Burden on Tobacco (TBOT) historical compilation, produced by Orzechowski and Walker (2012). The TBOT is an annual compendium on tobacco revenues and industry statistics that provides information on cigarette taxes for all 50 states and the District of Columbia, as well as information on the month and year in which tax changes occurred. We use this information to assign real (denominated in Q4 2012 dollars) cigarette tax rates for every household in the NHCPD. A few cities, such as Chicago and New York, levy municipal-level cigarette taxes. In these rare cases, and when the household-level data allow for the identification of municipality, we use historical information on local cigarette tax rates drawn from municipal tax administrators. We also include an indicator variable for whether a state levies a smokeless tobacco tax using data from the Centers for Disease Control and Prevention and the Office on Smoking and Health. Lastly, we include a measure of the percent of each household's county that lives under a smoking ban in bars derived from Americans for Nonsmokers' Rights Foundation (ANR) Tobacco Control Laws Database. The ANR Tobacco Control Laws Database is a repository of nearly 8,500 state, county, and municipal level laws, with detailed information about the day, month, and year of implementation by legislative type (e.g. clean indoor air laws/smoking bans, youth access, advertising, conditional use permits). Using the ANR database, we calculate the percent of each county living under a smoking ban in bars in each quarter.

IV. Methods

We utilize a quasi-natural experiment design, connecting policy changes within counties and states, over time, to within-household changes in tobacco-related purchases. We first estimate the effects of tobacco control policies on the purchase of a comprehensive set of tobacco products, including cigarettes, smokeless tobacco, and smoking-cessation products. Thus, we are able to study the potential substitution responses when the scope of a policy is limited to only specific tobacco products. We utilize household fixed effects regression models to estimate the total effect of tobacco control policies on each tobacco product. We first estimate a linear

recorded cigarette purchases. Finally, since unique UPC codes are generated for each packaging variation of a cigarette brand (i.e. single packs vs. 3-packs vs. cartons), we standardized cigarette product names in the NHCPD to match cigarette products for which a package variety was matched to NHANES. This additional step increased our match rate to 91%. This additional step assumes that cigarette brand characteristics are identical across packaging, i.e. 84mm Marlboro Light Non-Menthol cigarettes have identical nicotine, tar, and carbon monoxide characteristics whether sold in single packs or cartons.

probability model to estimate the probability that a household purchases a specific tobacco product as follows:

$$(1) \qquad \mathrm{P}(T_{hst} > 0) = \beta_0 + Z_{st}\beta_Z + X_{hst}\beta_X + \tau_t + \delta_h + \varepsilon_{hst},$$

where $\mathrm{P}(T_{hst} > 0)$ is the probability that household *h* at time *t* purchases the tobacco product of interest, Z_{st} includes tobacco control policies such as cigarette taxes expressed in dollars or an indicator variable for whether a smoking ban is in effect, and X_{hst} contains household-level demographic characteristics . We also include time period and household fixed effects, given by τ_t and δ_h, respectively. As we include household fixed effects, we only include households in these models which contain variation in whether they purchase cigarettes. In these instances, a dichotomous measure at the household level can be a reasonable proxy for cessation, although in multi-person households it is only an indirect measure. We will also vary our model specification to include geographic fixed effects and time trends to demonstrate the robust of the results to these alternative approaches.

Next we estimate the effects of tobacco control policies on the amount of tobacco products purchased using a similar fixed effects model:

$$(2) \qquad T_{hst} = \alpha_0 + Z_{st}\alpha_Z + X_{hst}\alpha_X + D_{st}\alpha_D + \tau_t + \delta_h + \varepsilon_{hst},$$

where T_{hst} represents the amount of the tobacco product purchased each month and all other variables are defined as above. By estimating the effects of each policy on each tobacco product category within this framework we will identify the comprehensive, causal policy effects across all tobacco product sub-categories. We also use the merged cigarette characteristics from the NHANES to explore whether tobacco control policies induce smokers to substitute to cigarettes that are either longer or have higher tar and nicotine contents. To estimate these effects, we examine all purchases which can be matched to cigarette characteristics and examine household-month observations where at least one purchase is matched to cigarette characteristics. We also ran models where we restrict our sample to households where all purchases can be matched to cigarette purchases, and the results from these regressions are very similar. We modify Equation (2) to run two additional models. First, we replace the dependent variable with cigarette characteristics. Specifically, we look at an indicator variable for whether or not the cigarette is filtered, the length of the cigarette measured as an ordinal variable, and the tar, nicotine, and

carbon monoxide contents of each cigarette, measured in milligrams.[3] If a household purchases more than one cigarette brand per month, we weight the different product characteristics by the amount of each specific cigarette brand purchased. Second, we multiply the tar, nicotine, and carbon monoxide contents of each cigarette by the number of cigarettes purchased to arrive at an estimated monthly consumption level for these different compounds. We cluster our standard errors at the household level in all regressions (Bertrand, Duflo, & Mullainathan, 2004).

V. Results

Table 1 shows summary statistics. Our total sample includes just over 5.6 million observations, although we only include households which use the relevant tobacco product at least once during our sample. Thus our analysis sample is 1,750,752 observations from 36,988 households for cigarettes, 335,649 observations from 6,081 households for smoking-cessation products, and 396,589 observations from 7,048 households for chewing tobacco products. In a month, the probability that a household purchases cigarettes is just about 9%.

Table 2 shows results estimating the effects of tobacco control policies on tobacco-related purchases using the models outlined in Equations (1) and (2). We find that a $1.00 increase in cigarette taxes reduces the probability that a household will purchase cigarettes in a quarter by 2.2 percentage points, statistically significant at the one percent level. This coefficient suggests a reduction of roughly 8 percent off the mean of 0.29, and translates to a participation tax elasticity of around 9 percent, slightly smaller than many participation elasticities in the literature (Evans & Farrelly, 1998; Nesson, 2015; J. A. Tauras, 2004, 2006). We find some evidence that cigarette tax increases also increase the probability that households will purchase smoking-cessation products, although this coefficient is only significant at the 10 percent level, an increase of roughly 7 percent off the mean. We do not find statistically significant changes in consumers' tobacco-related purchases in response to smokeless tobacco taxes of bar smokefree air laws. Turning to examining the total quantities of tobacco products purchased, we find that a $1.00 increase in cigarette taxes reduces the quantity of cigarettes ever-purchase households purchase by about 16 cigarettes a month, corresponding to a 12 percent decrease of the mean of 139 cigarettes a month and a tax elasticity of about -0.13. These results are comparable to those in

[3] Specifically, the values for cigarette length are 1 (68-72mm), 2 (79-88mm), 3 (94-101mm), and 4 (110-121mm).

the previous literature (Adda & Cornaglia, 2013; Evans & Farrelly, 1998; Farrelly et al., 2004; Harding et al., 2012; Nesson, 2015; J. A. Tauras, 2006).[4]

In Table 3, we investigate whether heavier smokers respond differently to tobacco control policies than lighter smokers. Specifically, we estimate separate models for households who purchase at least a pack of cigarettes per day and occasional smokers. Comparing the results from pack-a-day smokers vs. occasional smokers in Panel A, we see that heavier smokers respond more strongly, in terms of quantity, to cigarette taxes in terms of the number of cigarettes smoked. However, in terms of tax elasticities, lighter smoking households are much more responsive with an estimated conditional tax elasticity of around -0.22 compared to -0.11. In our main specification, we no longer find evidence taxes cigarette taxes impact the likelihood of purchasing smoking cession products among either type of smoker. Although (as show in the Appendix Tables), these results are a bit more sensitive to model specification.

Next, we use the sample of NHCPD tobacco purchases matched to cigarette characteristics to estimate whether tobacco control policies induce smokers to switch to cigarettes with different characteristics and whether tobacco control policies lead to reductions in estimated tar, nicotine, and carbon monoxide intake. Table 4 shows summary statistics from the matched sample of cigarette purchases. Nearly all cigarettes purchased in this sample are filtered. The mean cigarette length of 2.6 indicates that the average cigarette length is about 90mm long, and the average tar, nicotine, and carbon monoxide contents are just under 12mg, 1mg, and 12mg, respectively. As a basis for comparison, Winston Filtered 100mm cigarettes have 16mg of tar, 1.3mg of nicotine, and 15mg of carbon monoxide. On the lower end of tar, nicotine, and carbon monoxide contents, Marlboro Ultra-Light 83mm cigarettes have 6mg of tar, 0.5mg of nicotine, and 8mg of carbon monoxide.

Table 5 shows estimates from the models estimating the effects of tobacco control policies on cigarette characteristics and estimated tar, nicotine, and carbon monoxide consumption. The left panel displays results estimating whether tobacco control policies affect the characteristics of cigarettes consumers purchase. We examine five characteristics: the percent of filtered cigarettes purchased each period, the average cigarette length, average cigarette tar content (measured in milligrams), average cigarette nicotine content (measured in milligrams),

[4] Appendix Tables A1 – A9 demonstrate the robustness of our results to alternative specification of our model, including adding state-specific time trends.

and average cigarette carbon monoxide content (measured in milligrams). We find little evidence of smoker substitution with respect to filtered cigarettes or cigarette length, as these coefficients are very small and not statistically significant. However, we do find some evidence that cigarette excise taxes lead to statistically significant changes in tar, nicotine, and carbon monoxide content. For example, in our preferred specifications, a $1.00 increase in cigarette taxes leads to a statistically significant 0.08mg increase in the average tar content of cigarettes smoked. However, this point estimate translates to an elasticity of 0.008 and these results for tar, nicotine, and carbon monoxide are not robust to changing the sample to examine households where all purchases are matched to cigarette characteristics. In this model, the coefficients are not statistically significant at conventional levels and are roughly half the size.

The right panel displays results estimating whether tobacco control policies affect household tar, nicotine, and carbon monoxide consumption. For comparison, we also include results for monthly cigarette purchases among this subsample. Here, our coefficients are all negative and statistically significant at the 5 percent level. We find that cigarette excise taxes lead to a reduction in cigarette purchases of about 31 cigarettes a month, a tax elasticity of about -0.07. We find very similar and negative elasticities with respect to tar, nicotine, and carbon monoxide consumption, all around -0.07 and statistically significant at the one percent level. These outcomes indicate that, while some compensatory behavior exists with regard to tax increases, these effects are trivial as they are overwhelmed by the effects of smoking less cigarettes.

VI. Conclusion

This paper utilizes household panel data to estimate the effects of tobacco control policies on a range of tobacco-related outcomes, including purchases of cigarettes, smokeless tobacco, and smoking-cessation products. Using panel data on the monthly purchases of a large number of households, we are able to control for household-level fixed effects, which provides much clearer evidence of detailed changes in purchasing habits in response to different tobacco control policies. Moreover, we are able to circumvent the many potential issues arising from the use of self-reported smoking data. Lastly, we are able to look at within-household changes in cigarette characteristics, including the tar, nicotine, and carbon monoxide contents of the cigarettes smoked, and estimate the total household intake of these substances.

Our results provide convincing evidence that cigarette taxes are an effective policy level with which to reduce cigarette smoking. We find that, even when examining cigarette purchases within households over time, cigarette taxes both induce households to stop purchasing cigarettes and reduce the number of cigarettes that they purchase. Moreover, these tax effects are evident for both light and heavy-smoking households. Additionally, we find the interrelatedness between cigarettes and other tobacco products may actually increase the effectiveness of cigarette taxes in reducing tobacco product use. We find that cigarette tax changes increase the probability that lighter smoking households will purchase smoking-cessation products and reduce the probability these households purchase smokeless tobacco. Lastly, we find some, albeit weak, evidence of substitution to cigarettes with higher tar, nicotine, and carbon monoxide contents. However, we find that cigarette excise taxes reduce households' total estimated tar, nicotine, and carbon monoxide consumption. Moreover, the estimated tax elasticities of total tar, nicotine, and carbon monoxide consumption are very close to the tax elasticity of cigarettes purchased.

Our methodology lends itself to a number of extensions. The literature on consumers responses to prices has also recently examined the effect of salience on purchasing behavior, and our data is well positioned to add to the literature examining whether smokers respond differently to more salient taxes, included in the price of the cigarettes, or less-visible sales taxes, incorporated only at the register.

References

Abrevaya, J., & Puzzello, L. (2012). Taxes, Cigarette Consumption, and Smoking Intensity: Comment. *American Economic Review*, *102*(4), 1751–1763. Retrieved from http://www.aeaweb.org/articles.php?doi=10.1257/aer.102.4.1751

Adams, S., Cotti, C., & Fuhrmann, D. M. (2013). Smokeless Tobacco Use Following Smoking Bans in Bars. *Southern Economic Journal*, *80*(1), 147–161. Retrieved from http://econpapers.repec.org/RePEc:sej:ancoec:v:80:1:y:2013:p:147-161

Adda, J., & Cornaglia, F. (2006). Taxes, Cigarette Consumption, and Smoking Intensity. *The American Economic Review*, *96*(4), 1013–1028. doi:doi:10.1257/000282806779468553

Adda, J., & Cornaglia, F. (2013). Taxes, Cigarette Consumption, and Smoking Intensity: Reply. *American Economic Review*, *103*(7), 3102–3114. Retrieved from http://www.aeaweb.org/articles.php?doi=10.1257/aer.103.7.3102

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How Much Should We Trust Differences-In-Differences Estimates? . *The Quarterly Journal of Economics* , *119* (1), 249–275. doi:10.1162/003355304772839588

Chaloupka, F. J., Tauras, J. A., & Grossman, M. (1997). Public Policy and Youth Smokeless Tobacco Use. *Southern Economic Journal*, *64*(2), 503–516. doi:10.2307/1060863

Chaloupka, F. J., & Warner, K. E. (2000). Chapter 29 The economics of smoking. *Handbook of Health Economics*, *1*, 1539–1627. doi:10.1016/S1574-0064(00)80042-6

Evans, W. N., & Farrelly, M. C. (1998). The Compensating Behavior of Smokers: Taxes, Tar, and Nicotine. *The RAND Journal of Economics*, *29*(3), 578–595. doi:10.2307/2556105

Farrelly, M. C., Nimsch, C. T., Hyland, A., & Cummings, M. (2004). The effects of higher cigarette prices on tar and nicotine consumption in a cohort of adult smokers. *Health Economics*, *13*(1), 49–58. doi:10.1002/hec.820

Gallus, S., Zuccaro, P., Colombo, P., Apolone, G., Pacifici, R., Garattini, S., & La Vecchia, C. (2006). Effects of new smoking regulations in Italy. *Annals of Oncology* , *17* (2), 346–347. doi:10.1093/annonc/mdj070

Harding, M., Leibtag, E., & Lovenheim, M. F. (2012). The Heterogeneous Geographic and Socioeconomic Incidence of Cigarette Taxes: Evidence from Nielsen Homescan Data. *American Economic Journal: Economic Policy*. Retrieved from http://www.aeaweb.org/articles_detail.php?doi=10.1257/pol.4.4.169

Harris, J. E. (1980). Taxing tar and nicotine. *The American Economic Review*, 300–311.

Levy, D., Chaloupka, F. J., & Gitchell, J. (2004). The Effects of Tobacco Control Policies on Smoking Rates: A Tobacco Control Scorecard. *Journal of Public Health Management and Practice*, *10*(4), 338–353.

National Cancer Institute. (1992). *Smokeless Tobacco or Health: An International Perspective. Tobacco Control Monograph No. 2*. Bethesda, MD.

Nesson, E. (2015). *Heterogeneity in Smokers' Responses to Tobacco Control Policies*. Retrieved from http://ssrn.com/abstract=2558140

Ohsfeldt, R. L., & Boyle, R. G. (1994). Tobacco Excise Taxes and Rates of Smokeless Tobacco Use in the US: An Exploratory Ecological Analysis. *Tobacco Control*, *3*(4), 316–323. doi:10.2307/20207099

Ohsfeldt, R. L., Boyle, R. G., & Capilouto, E. (1997). Letter: Effects of tobacco excise taxes on the use of smokeless tobacco products in the USA. *Health Economics*, *6*(5), 525–531. doi:10.1002/(SICI)1099-1050(199709)6:5<525::AID-HEC300>3.0.CO;2-Y

Orzechowski, W., & Walker, R. C. (2010). *The Tax Burden on Tobacco, Historical Compilation, Vol. 45*. Arlington, VA: Orzechowski and Walker.

Tauras, J. A. (2004). PUBLIC POLICY AND SOME-DAY SMOKING AMONG ADULTS. *Journal of Applied Economics*, *7*(1).

Tauras, J. A. (2006). SMOKE-FREE AIR LAWS, CIGARETTE PRICES, AND ADULT CIGARETTE DEMAND. *Economic Inquiry*, *44*(2), 333–342. doi:10.1093/ei/cbj028

Tauras, J., Powell, L., Chaloupka, F., & Ross, H. (2007). The demand for smokeless tobacco among male high school students in the United States: the impact of taxes, prices and policies. *Applied Economics*, *39*(1), 31–41. doi:10.1080/00036840500427940

U.S. Department of Health and Human Services. (2000). *Reducing Tobacco Use: A Report of the Surgeon General*. Atlanta, Georgia.

U.S. Department of Health and Human Services. (2004). *The Health Consequences of Smoking, A Report of the Surgeon General.* Rockville, MD.