The Influence of Geography and Measurement in Estimating Cigarette Price Responsiveness

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Abstract:

We use data from the 2006-07 and 2010-11 waves of the Tobacco Use Supplement of the Current Population Survey to calculate cigarette price elasticities that compensate for within-state cigarette prices, which includes variation from the local tax environment. We use four state-level cigarette price measures and two sub-state-level cigarette price measures. For the two local price measures, we exploit month specific changes in these two prices in 446 sub-state areas of the United States. We document substantial variation in within-state prices, and we calculate that this variation approximately triples estimates of cigarette price responsiveness compared to using state-level prices. When using local prices, we calculate that a 10% rise in cigarette prices reduces cigarette consumption by a mean of 2.5%, which ranges from a 1.7% reduction at a price level $3 to a 5.6% reduction at a price level of $9. Our results suggest an important role for the local tax environment in studies of cigarette price responsiveness.

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I. Introduction

Several tax-related mechanisms may contribute to the presence of substantial variation in cigarette prices within states. As of September, 2015, there were more than 600 local jurisdictions nationwide with their own cigarette tax rates or fees, with most of these taxes being in three states with low state cigarette excise taxes such as Missouri (lowest state cigarette excise tax, 109 local taxes), Virginia (2nd lowest state cigarette excise tax, 93 local taxes), and Alabama (13th lowest state cigarette excise tax, 377 local taxes) (Campaign for Tobacco-Free Kids 2015a,b). Additionally, given the sovereign status of Native American tribes, tobacco products sold on Native American reservations often do not pay state or local taxes, potentially creating additional opportunities for tax evasion and avoidance, especially as state-level cigarette prices continue to rise (Chaloupka et al. 2015). For example, New York has the highest state tax, but one analysis suggests that 17.1% of New York residents purchased their cigarettes on reservations at last purchase and paid only 39% of the off-reservation price (Chaloupka et al. 2015). Meanwhile, the lowest state-level cigarette excise tax state, Missouri, is among the 17 states without a Native American reservation. These descriptive statistics motivate our paper by suggesting that local taxes and reservations may be important sources of tax variation to use in studies of cigarette price responsiveness. To the extent that local taxes are disproportionately clustered in states with low state excise taxes, and reservations are disproportionately clustered in states with high state excise taxes, this will bias estimates of cigarette tax responsiveness using state-level data towards the null of no effect.

An oft-cited cigarette price elasticity of demand estimate of -0.4 comes from several meta-analyses (IARC 2011; Gallet and List 2003; Chaloupka and Warner 2000), with a range of -0.2 to -0.6 (IARC 2011). Several recent price elasticity estimates provide support to the consensus estimate after correcting for cross-border purchasing (Harding, Leibtag, and Lovenheim 2012; Lovenheim 2008; Colman and Remler 2008). However, recent cigarette tax elasticity of demand studies have found that cigarette

tax responsiveness for adults ranges from -0.03 to -0.09 (Callison and Kaestner 2014; Maclean, Webber, and Marti 2014; Maclean, Kessler, and Kenkel 2015). These tax elasticity estimates are lower in part because state and federal taxes are only 1/3 of the retail price of cigarettes (Orzechowski and Walker 2015); nevertheless, even multiplying these tax elasticities by a factor of 3 to better approximate price elasticity estimates still places these estimates on the lower end of the consensus price elasticity estimate range. Taken together, this may suggest an important role of tax avoidance in reducing cigarette price responsiveness. As noted earlier, this tax avoidance is not limited to cross-state purchasing, as local taxes and Native American reservations may also have an important role in cigarette purchasing behaviors. A contribution of the current paper is to consider the role of within-state taxes on estimating cigarette price responsiveness.

In this study, we construct two cigarette prices with sub-state price variation, using Nielsen retail data and self-reported prices from the Tobacco Use Supplement of the Current Population Survey (TUS-CPS). We use these two measures, along with four more frequently used state-level cigarette prices, including from the Tax Burden on Tobacco (TBOT), to compare estimates of cigarette price responsiveness. Both the TUS-CPS and Nielsen local prices includes price variation from the local tax environment. The TUS-CPS price also includes tax avoidance-related travel opportunities that are available to individuals in a particular sub-state area. We also revisit how price elasticity estimates differ among adults of different incomes, ages, and education levels. Finally, we consider how price elasticities vary at low and high price levels.

We document significant within-state variation in cigarette prices. Using models controlling for state fixed effects, time fixed effects, and two unique anti-smoking sentiment variables that vary over time and within areas, we estimate that compensating for local price variation approximately triples estimates of cigarette price elasticities. If local taxes are driving differences between state and local estimates of price elasticities, then we hypothesize that states with Native American reservations should

have larger differences in estimated price elasticities when using state or local prices compared to states without reservations. We find evidence to support this. Collectively, our results suggest that local taxes are important determinants in estimating cigarette price elasticities.

II. Data

A. Tobacco Use Supplement of the Current Population Survey

We use data from the Current Population Survey (CPS), which is collected by the Bureau of Labor Statistics through telephone and face-to-face interviews. Every month the CPS surveys a sample of approximately 60,000 households to collect a wide range of demographic, labor force, and household characteristics. Data on special topics are also gathered from these same respondents in periodic supplemental surveys, including the Tobacco Use Supplement (TUS). Seven waves of the TUS have been sponsored by the National Cancer Institute (NCI) starting in 1992.[1] We use the most recent two waves 2006-07 and 2010-11 for this analysis given the availability of consistently collected geocode information during these waves and because of our ability to link Nielsen retail data that first became available starting in 2006.

We use a sample consisting of 346,979 self-responding individuals ages 18 and older that reside in the continental United States.[2] Proxy respondents are allowed, but we exclude these respondents because they are not asked the full range of smoking questions. We first determine if an individual is a current smoker or not using information on if an individual has smoked 100 cigarettes in their lifetime and if an individual currently smokes every day or some days. Individuals that are current smokers are asked on how many of the past 30 days they smoked cigarettes, and on average the number of cigarettes that they smoked on these days. We use this information to calculate a strictly positive

[1] A wave was also collected in 2000, but with only partial questions.
[2] Alaska and Hawaii are excluded because Nielsen data is not collected in these states.

monthly cigarette consumption variable for current smokers. As indicated by Table 1, the overall smoking rate and the number of cigarettes consumed by smokers per month has declined across the seven waves of the data. The adult smoking rate was 24.5% in 1992-93 and smokers consumed 520 cigarettes monthly. By 2010-11, the smoking rate had fallen to 16.1% and smokers consumed 382 cigarettes monthly. These declines in cigarette use are associated with increases in real cigarette excise taxes (federal and state) from $0.79 in 1992-1993 to $2.46 in 2010-2011.

We use the rich demographic data provided in the CPS in our analysis (gender, age, race, Hispanic ethnicity, education, real family income, employment/labor force participation, and marital status). Family income is recorded from all sources over the past 12 months. We linearly impute missing household income using socio-demographic characteristics, month fixed effects, and state-level unemployment rates. All monetary values (e.g. household income, cigarette prices) were adjusted for inflation and are presented in constant January, 2011 dollars. We use self-response weights in all analyses.

Descriptive statistics for the TUS-CPS are provided in Table 2.

B. Cigarette Prices

We construct six measures of cigarette prices. For the first price measure, we match cigarette excise taxes from the TBOT. These excise taxes include federal and state taxes. We do not have data on changes in local cigarette excise taxes over time. However, as we noted earlier, the current status of local excise taxes in 2015 suggests that low state-level cigarette excise tax states of Alabama, Virginia, and Missouri have many local taxes that our state-level tax measure does not account for. Additionally, we do not have good information on tax savings from Native American reservation purchases. For this reason, we use a variety of cigarette price measures that accounts for the local taxes.

For the second price measure, we use the TBOT's cigarette prices, which are also inclusive of federal, state, and some local taxes (Chaloupka et al. 2013). The TBOT prices are collected through an annual mail survey of retail establishments that sell cigarettes in all 50 states and Washington, DC. In recent years, approximately 15,000 to 16,000 retailers have been surveyed, with response rates in the mid-teens and retailer numbers vary from a few dozen to nearly 100 in a given state. We adjusted the annual cigarette taxes and prices to quarterly using exact dates of cigarette excise tax changes, assuming a unitary pass-through rate from taxes to prices. We matched the cigarette prices onto the TUS-CPS data using state of residence. Limitations of the TBOT data are that 1) it does not account for opportunities to price minimize by purchasing cigarettes in out-of-state locations or Native American reservations, and 2) it does not capture individual's propensity to consume more heavily from reduced price sources.

We address these limitations by using two other data sources: self-reported cigarette prices provided by the TUS-CPS and Nielsen retail prices. In the TUS-CPS, individuals report prices for the last pack or carton purchased (depending on their usual purchase) after using discounts or coupons. We adjust carton prices to a per pack price. We create cigarette prices for area *a* by multiplying individual *i*'s last price paid for a pack of cigarettes by the ratio of *i*'s monthly cigarette consumption over the average number of cigarettes consumed in the area.[3]

$$(1)\quad price\ paid_a = \sum_{i=1}^{n} \frac{price\ last\ paid_{i*} \frac{cigarette\ smoked\ over\ past\ month_i}{mean\ cigarettes\ smoked\ over\ past\ month_a}}{n}$$

We also use cigarette prices from Nielsen retail data (available from the Kilts Center at the University of Chicago). Data from approximately 35,000 participating grocery, drug, mass merchandiser, and other stores are included in the Nielsen retail data system, and each individual store reports weekly data for every UPC code that had any sales volume during the week. According to Nielsen

[3] We did not use a small number of self-reported cigarette prices in creating an area-specific average price. We did not use prices below the federal excise tax of 0.39 in 2006-07 and $1.01 in 2010-11, or cigarette prices greater than three standard deviations from the mean within a given state/wave.

documentation, as of year-end 2011, the amount of commodity volume captured by each store type was 53% for food stores, 55% for drug stores, 32% for mass merchandise, 1% for liquor, and 2% for convenience store. Excise taxes and retailer coupons are factored into the price, but manufacturer coupons are not.

The Nielsen and TUS-CPS prices are different in their ability to capture reduced prices from tax avoidance opportunities both inside and outside of the area of residence. The Nielsen data captures the prices of cigarettes purchased within the sub-state area of residence at select retail establishments, whereas the TUS-CPS data captures the prices that smokers pay that reside in that sub-state area, allowing smokers the opportunity to purchase cigarettes from reduced price sources unique to that particular area and at a greater variety of retail stores.[4] Unlike the TBOT prices, both the TUS-CPS and Nielsen data compensate for smokers purchasing more frequently from reduced-price sources.

We aggregate both the TUS-CPS prices and the Nielsen retail data prices at both the state-month and sub-state-month levels. Local cigarette prices are assigned for counties or core based statistical areas (CBSA) that had at least one smoker with a valid cigarette price during each of the six months of data: May, 2006; August, 2006; January, 2007; May, 2010; August, 2010; January, 2011. Remaining respondents were assigned a price using remaining TUS-CPS self-reported prices in the state for the TUS-CPS local price, or the prices in remaining counties not previously assigned to individuals for the Nielsen local price. We identified 446 sub-state areas that we could consistently assign a wave-month specific local price. County and CBSA codes are less likely to be provided by the CPS for individuals living in rural areas, so rural-residing individuals are more likely to be assigned the residual price. In the descriptive statistics on Table 2, we show that 46.6% of our weighted sample were assigned

[4] The TUS-CPS price also captures the use of both retailer and manufacturer coupons, whereas the Nielsen data only captures the use of retailer coupons.

to a valid county, 33.6% of our sample was provided a valid CBSA, and the remaining 19.7% were assigned to the remaining counties in the state.

We map local price variation in Figures 1 and 2. In Figure 1, we show a map of the TUS-CPS local prices for the final wave-month of our data, January, 2011, at the level of county. Panel A shows the raw prices, and Panel B shows variation within states by examining differences as a percent of the state mean. Figure 2 shows these same two maps using the Nielsen retail data, also for January, 2011. In Online Figures 1-2, we show these maps for January, 2007. Maps for the remaining four months for both prices are available upon request. We see in these maps evidence of substantial heterogeneity in prices within states. For example, Cook County/Chicago and New York City pay higher prices for cigarettes than in surrounding areas, likely due to New York City excise tax of $1.50 per pack and Chicago-Cook County excise tax of $2.68 per pack (Centers for Disease Control and Prevention 2012). As expected, the TUS-CPS local prices has greater heterogeneity across states and within states than the Nielsen local prices due to the TUS-CPS local prices allowing for area-level tax avoidance-related travel opportunities.

Descriptive statistics for the various cigarette prices are provided on Table 2. State and federal cigarette excise taxes were, on average, $1.71 per pack. The TBOT price average was $4.83 per pack, which is higher than the TUS-CPS state price of $4.11 and the Nielsen state price of $4.38. The TBOT price could be higher due to not accounting for opportunities to price minimize by purchasing in states with lower cigarette excise taxes, and not capturing individual's propensity to consume more heavily from reduced price sources. There are three differences between the TUS-CPS state price and the Nielsen state price: 1) the Nielsen data does not capture out-of-state or within-state tax avoidance-related travel opportunities, 2) only select stores are included in the Nielsen data, and 3) the Nielsen data does not capture manufacturer coupons. These reasons contribute to the mean Nielsen price being $0.27 higher.

Local prices are $0.09 higher for TUS-CPS state prices than local prices, and $0.03 higher for Nielsen local prices than Nielsen state prices. For the Nielsen prices, the higher local price relative to the state price is due to individuals residing in higher-price areas being more likely to be sampled within the TUS-CPS. This sampling issue does not affect the TUS-CPS prices, but state prices are lower here because areas with higher prices have lower consumption, which reduces the state price relative to the local price.

C. Anti-Smoking Sentiment

Anti-smoking sentiment is an important control variable in studies examining cigarette price responsiveness due to the ability of anti-smoking sentiment to influence both the treatment (e.g. cigarette prices, by applying pressure on governments to raise taxes) and the outcome of smoking (by raising the social costs of smoking, or enacting other unobserved policies that affect smoking). Studies of adult tobacco use typically include year and state fixed effects to control anti-smoking sentiment that is not varying within states across time, but this will not control for anti-smoking sentiment that does vary within states across time. Others have included proxies for changing anti-smoking sentiment such as indoor use laws (Callison and Kaestner 2014) and state-specific linear time trends (Goldin and Homonoff 2013). More recently, studies have begun to use smoking attitude data available directly in the TUS-CPS to create state-specific measures of anti-smoking sentiment that vary over time (Maclean, Webber, and Marti 2014; Maclean, Kessler, and Kenkel 2015). We adopt this approach, using questions that ask all respondents if smoking should be allowed in 1) outdoor children's playgrounds and sports fields, and 2) in bars and cocktail lounges.[5] In these areas, respondents report if smoking should be allowed in all areas, allowed in some areas, or not allowed at all. We take the mean (using values of 0, 1, and 2) for both variables within each area and year/month for all individuals residing in the area besides the

[5] These were the two smoking attitude questions consistently collected in both waves of the data.

respondent, and include both of these means (which does not include the respondent's anti-smoking sentiment) in regression models to control for changing anti-smoking sentiment over time. These area-level anti-smoking sentiment variables are listed on Table 2. Additionally, we control for state and wave/month fixed effects to further control for unobserved components of anti-smoking sentiment.

III. Methods

We model a traditional cigarette demand equation, with price included as an independent variable of primary interest. We first calculate a two-part model, separately calculating price elasticities for smoking participation (extensive margin) and the number of cigarettes consumed monthly among current smokers (intensive margin). We then estimate a combined model for all respondents, using cigarettes consumed monthly as the dependent variable and setting this equal to 0 for non-smokers. We estimate the following three models:

(2) $smoke\ participation_{iat} = a + X_{iat} + price_{at} + antismoking\ sent_{at} + \gamma_a + \gamma_s + \gamma_t + e_{iat}$

(3) $conditional\ cig\ use_{iat} = a + X_{iat} + price_{at} + antismoking\ sent_{at} + \gamma_a + \gamma_s + \gamma_t + e_{iat}$

(4) $total\ cig\ use_{iat} = a + X_{iat} + price_{at} + antismoking\ sent_{at} + \gamma_a + \gamma_s + \gamma_t + e_{iat}$

where subscripts denote individual *i* living in area *a* of state *s* at time *t*. The sub-state areas are one of 446 units (either a county, core based statistical area, or remaining counties within the state) present in all six months of the data. Depending on the specification, we use either a state-level cigarette excise tax or price measure, or a sub-state-level price measure.

The dependent variable *smoke participation*$_{iat}$ captures smoking at the extensive margin. It takes a value of 0 for individuals that have not smoked at all over the past 30 days, and 1 for individuals that have. For individuals that have smoked over the past 30 days, the intensive margin of cigarette smoking is represented by the number of cigarettes that they have smoked over the past month in (2). Finally,

smoking at both the intensive and extensive margin is captured by (3), which is the number of cigarettes that individuals have consumed over the past month, with 0 used for non-smokers.

$Price_{at}$ is one of either six cigarette tax/price variables: 1) state/federal tax level, 2) TBOT state-level cigarette price, 3) TUS-CPS cigarette price formed from self-reported cigarette prices at the state level, 4) TUS-CPS cigarette price formed from self-reported cigarette prices at the levels of county, CBSA, or rest of the state, 5) Nielsen cigarette price at the state level, 6) Nielsen cigarette price at the levels of county, CBSA, or rest of the state. For all six prices, the prices vary within the six wave-months present in the data, either across states for the four state-level cigarette price measures or across sub-state areas for the two local cigarette price measures. For the two local price measures, local taxes and Native American purchasing opportunities will contribute to the variation in these prices, and the TUS-CPS price will also include variation from tax-avoidance-related travel opportunities. By using market-level prices to predict individual cigarette purchasing, we reduce the influence of search costs as a potential source of omitted variable bias (e.g. prices are treated as exogenous to an individuals' purchasing).

In all regressions, we control for individual-level socio-demographic characteristics and two sub-state-level anti-smoking sentiment measures. Additionally, we control for the square of income and age to control for the likely nonlinear effects of these variables on smoking. We also control for state fixed effects (γ_s), area type fixed effects (γ_a), and wave-month fixed effects (γ_t).

We estimate $any_smoking_{iat}$ using a logit model. We estimate *conditional cig* use_{iat} and *total cig* use_{iat} using a GLM model with a log link and a Poisson distribution as chosen by modified Park tests (Manning and Mullahy 2001). Standard errors are clustered at the sub-state level, and self-response weights are used in all regression analyses to assist in making the results representative of the US population.

In our results, we present the associations between cigarette prices and cigarette use as price elasticities. In addition to showing average price elasticity estimates, we follow the best practices

suggested by DeCicca and Kenkel (2015) and calculate price elasticity estimates at different price levels. We present both the average price elasticity and the price elasticity at different price levels in the same visual displays. We also present the marginal effect at different price levels in separate visual displays.

To explore heterogeneity in cigarette price responsiveness by income, age, and education, we calculate stratified models above and below the median household income (<$40,000, ≥$40,000), age (<45, ≥45), and education (completed high school or less, some college or more). Time preferences may be different for individuals of different income, age, and education levels, so cigarette price elasticity estimates may vary along these lines, too. Studies suggest that price responsiveness among adults is higher for adults that are low-income (Farrelly et al. 2001; Franks et al. 2007; Colman and Remler 2008; Goldin and Homonoff 2013), younger (Farrelly et al. 2001), and low-educated (Chaloupka 1991).

IV. **Results**

In Figure 3, we calculate price elasticities at the extensive margin for our six cigarette price measures. We use the same estimation sample across all plots. We observe a statistically-insignificant extensive margin cigarette tax elasticity estimate of -0.03. This estimate may be biased downwards if low-tax states disproportionately use local taxes, or if high-tax states disproportionately have Native American reservations that permit avoiding the state and local taxes. The extensive margin price elasticity estimates for cigarette purchases within the state were -0.10 for the TBOT price and -0.04 the Nielsen price. The extensive margin price elasticity estimates for within and out-of-state purchases, using the TUS-CPS state price, was -0.07. Extensive margin price elasticities were higher in absolute magnitude when we allowed area-level price variation that includes variation from the local tax environment. The extensive margin price elasticity for purchases within sub-state areas was -0.20 (p<0.05) using the Nielsen local price measure and the extensive margin price elasticity estimate for purchases within sub-state areas and outside these areas was -0.19 (p<0.05) using the TUS-CPS local

price measure. The latter two estimates using sub-state area price variation closely matches the consensus extensive margin price elasticity estimate of -0.20 (Chaloupka and Warner 2000).

In Figure 4, we calculate price elasticities at the intensive margin. The intensive margin cigarette tax elasticity of demand was -0.01, and the intensive margin price elasticity estimates were -0.03 or -0.04 for the three state-level price measures. When allowing for area-level price variation, we observe an intensive margin price elasticity estimate of -0.06 for within-area purchases (using the Nielsen local price), and an intensive margin price elasticity estimate of -0.11 (p<0.05) for within-area purchases and out-of-area purchases (using the TUS-CPS local price measure).

In Figure 5, we calculate price elasticities of total cigarette demand. The price elasticity estimate using cigarette taxes was -0.03 and is consistent with small and statistically insignificant tax elasticity estimate found using recent data (DeCicca and Kenkel 2015; Callison and Kaestner 2014; Maclean, Kessler, and Kenkel 2015). Cigarette price elasticities for within-state cigarette purchases were -0.11 for the TBOT price and -0.06 for the Nielsen price. The cigarette price elasticity for within and out-of-state purchases, using the TUS-CPS state price, was -0.10. Price elasticities approximately tripled when allowing for within-area price variation: -0.31 for the TUS-CPS local price (p<0.05) and -0.25 for the Nielsen price (p<0.05).

For the TUS-CPS local price measure that allows for tax avoidance-related travel opportunities, we observe that price elasticity estimates increase in absolute magnitude as prices rise.[6] In particular, this price elasticity ranges from -0.22 at a price level of $3 to -0.67 at a price level of $9. The price elasticities at $6.50 and beyond are statistically different (p<0.05) than the price elasticity at $3. While these changing price elasticities should not be interpreted as differences in price responsiveness, they

[6] By using a GLM model with a log link and a Poisson distribution as chosen by a modified Park test, this contributed to efficiently estimating our model and more accurately estimating cigarette price elasticities at different price levels.

do provide caution in extrapolating results of price changes using the mean price elasticity estimate, if the actual price is far from the mean.

In Online Table 1, we provide regression results from the model of total cigarette demand depicted in Figure 3. In this output, both measures of anti-smoking sentiment have a statistically significant negative association with cigarette consumption. The sub-state area indicator coefficients suggest that cigarette consumption is lower in urban areas (e.g. counties and core based statistical areas) compared to residual areas (e.g. rural), which is consistent with known patterns of cigarette use (American Lung Association 2012).

We also plot the price marginal effects at different price levels in Online Figure 3.

One possible mechanism explaining the higher price responsiveness when using the cigarette prices with local price variation is the influence of local tax variation, such as from local taxes or Native American purchasing opportunities. If the local tax environment was removed, we hypothesize that the price elasticity differences when using state or local prices would be less pronounced. We test for this by calculating price elasticities for 16 states without reservations,[7] and for the remaining states with reservations.

Table 3 provides price elasticities for total cigarette demand for each of the six prices, stratified by states with and without reservations. These results are most directly analogous to those presented in Figure 5, where the price elasticity using the TUS-CPS local price was 3.1 times the price elasticity using the state price, and the price elasticity using the Nielsen local price was 4.2 times the price elasticity using the state price. For states with reservations (the first column of Table 3), the price elasticity using the TUS-CPS local price is now -0.34 (p<0.01) and is 15 times the price elasticity using the TUS-CPS state

[7] 16 states within the continental United States do not have Native American reservations (National Park Service, 2016). These states are Arkansas, Delaware, DC, Georgia, Illinois, Indiana, Kentucky, Maryland, Missouri, New Hampshire, New Jersey, Ohio, Pennsylvania, Tennessee, Vermont, and West Virginia.

price of -0.02. The price elasticity using the Nielsen local price is -0.22 (p<0.01), which is also similarly large compared to the price elasticity using the state Nielsen price of -0.01. For states without reservations, the Nielsen price elasticities for state and local prices are similar at -0.20 and -0.25. The TUS-CPS state price actually has a higher price elasticity of -0.40 (p<0.10) versus -0.18 (p<0.10). Collectively, these results suggest that compensating for the local price environment has a strong effect in states with Native American reservations, and has little effect in states without reservations. This is consistent with the idea that the local tax environment is driving the differences in calculated price elasticities when using state or local prices.

In Figure 6, we explore heterogeneity by income, age, and education in total cigarette demand price elasticities using the Nielsen local data and stratified models. The price elasticities were similar across low/high education levels and low/high income levels, but did vary substantially by age. The price elasticity for individuals under the age of 45 was -0.36 (p<0.05), and for individuals 45 and older was -0.15. This finding of greater price responsiveness among younger adults is consistent with Farrelly et al, 2001.

V. Discussion

In this paper, we consider the effects of local variation in cigarette prices on estimates of cigarette price responsiveness. By using local variation in cigarettes prices, we are able to leverage underlying variation in the local tax environment from local taxes and Native American reservations. When controlling for anti-smoking sentiment using a combination of state and time fixed effects, and time-varying anti-smoking sentiment, our estimates imply that a 10% change in the TUS-CPS local price results in a 3.1% decline in cigarette consumption. This result is near to the consensus price elasticity estimate of a 4.0%. A 10% change in the Nielsen local price results in a 2.5% reduction in cigarette consumption. State-level cigarette price measures were not statistically significant, perhaps because

they are not as effective in capturing the influence of the local tax environment. This is supported by the finding of wide price elasticity differences when using state or local prices in only states with Native American reservations.

When using the TUS-CPS local price that allows for out-of-area tax avoidance-related travel opportunities versus the Nielsen local price that does not, the cigarette price elasticity estimate increases from -0.25 to -0.31. This suggests an important role in combatting tax avoidance-related travel opportunities. One practical recommendation is that policy efforts aimed at tax harmonization may be more effective than non-coordinated tax increases that contribute to greater local price variation.

Using the TUS-CPS local price, we observe that price elasticities are higher in absolute magnitude at higher prices than at lower prices. This suggests caution in predicting revenue or health effects of cigarette price changes using the mean price elasticity estimate (if the actual cigarette price is far from the mean).

Finally, our results provide evidence of heterogeneity in cigarette prices depending on age. A 10% increase in cigarette prices results in a 3.6% reduction in total cigarettes consumed for individuals younger than 45. It is often assumed that younger individuals, lower income individuals, and lower educated individuals will be more present-oriented than future-oriented; and we see some evidence of this in terms of how younger adults respond to cigarette taxes. If the pattern of higher price responsiveness for younger individuals holds for youth (whom we do not examine in this study), then youth may be the largest public health beneficiaries of future cigarette tax increases.

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Table 1: Smoking Among Adults

Year	Smoking Rate	Conditional 30 Day Cigarette Consumption	Mean Population-Weighted Fed. and State Cigarette Excise Taxes
1992-93	24.46	519.56	$0.79
1995-96	23.55	509.89	$0.84
1998-99	22.06	486.95	$0.89
2001-02	20.96	456.94	$1.06
2003	18.90	445.49	$1.34
2006-07	18.49	426.13	$1.46
2010-11	16.08	382.17	$2.46

Table 2: Descriptive Statistics for Adults in the TUS-CPS, Years 2006-2011, N = 346,979

	Mean	Standard Deviation
TUS-CPS Data		
Male	0.518	-
Age	45.826	17.466
White	0.817	-
Black	0.118	-
American Indian, Alaskan Native	0.007	-
Asian, Hawaiian Pacific Islander	0.045	-
Other Race	0.013	-
Hispanic	0.134	-
Less than High School	0.142	-
High School Only	0.300	-
More than High School	0.558	-
Family Income (Top Coded at $75,000)	51,483.33	27,847.81
Family Income Top Category	0.253	-
Married (No)	0.536	-
Married (Yes)	0.464	-
Employed and Working	0.637	-
Unemployed	0.044	-
Not In Labor Force	0.319	-
Area Type: Residual	0.467	0.498
Area Type: County	0.336	0.472
Area Type: Core Based Statistical Area	0.197	0.398
Area Anti-Smoking Sentiment for Bars/Clubs (range: 0-2)	1.313	0.205
Area Anti-Smoking Sentiment for Children's Playgrounds/Sports Fields (range: 0-2)	1.751	0.107
		-
Cigarette Prices		
State and Federal Taxes	1.71	0.86
Tax Burden on Tobacco Cigarette Prices	4.83	1.10
TUS-CPS State Price	4.11	0.99
TUS-CPS Local Price	4.20	1.18
Nielsen State Price	4.38	1.11
Nielsen Local Price	4.41	1.17

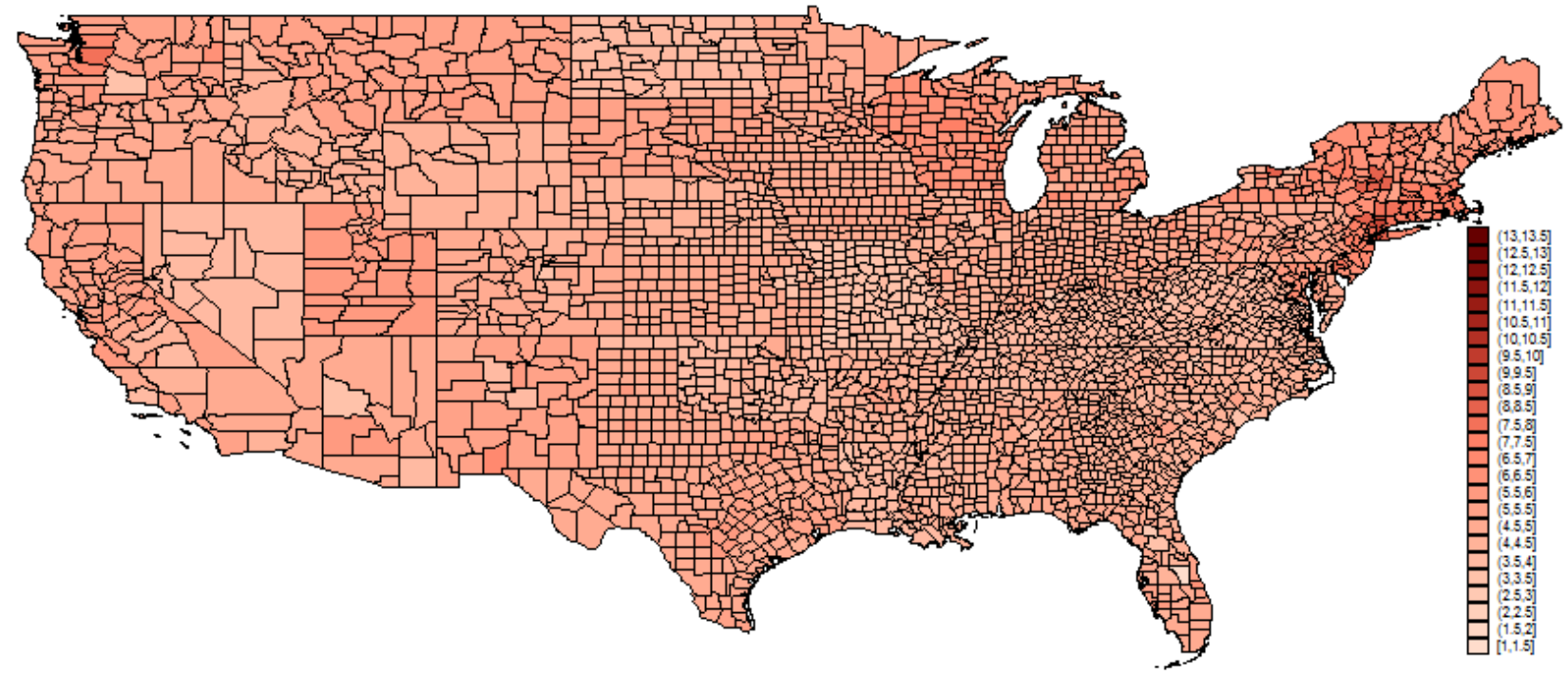
Table 3: Total Cigarette Demand Price Elasticities Using Six Cigarette Price Measures, 2006-2011, for States with and without Native American Reservations

	States with Reservations	**States without Reservations**
Price Measure		
State and Federal Taxes	-0.019	-0.047
	[0.032]	[0.106]
Tax Burden on Tobacco Cigarette Prices	-0.069	-0.204
	[0.084]	[0.276]
TUS-CPS State Price	-0.022	-0.399*
	[0.094]	[0.231]
TUS-CPS Local Price	-0.336***	-0.184*
	[0.087]	[0.112]
Nielsen State Price	-0.005	-0.200
	[0.083]	[0.222]
Nielsen Local Price	-0.222**	-0.247
	[0.108]	[0.142]
Sample Size	228,513	102,708

Notes: Total cigarette demand sets 30-day cigarette consumption for non-smokers to 0 and is estimated using a GLM model with a log link and a Poisson distribution. Each cell presents the price elasticity or price elasticity standard error from a different regression. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

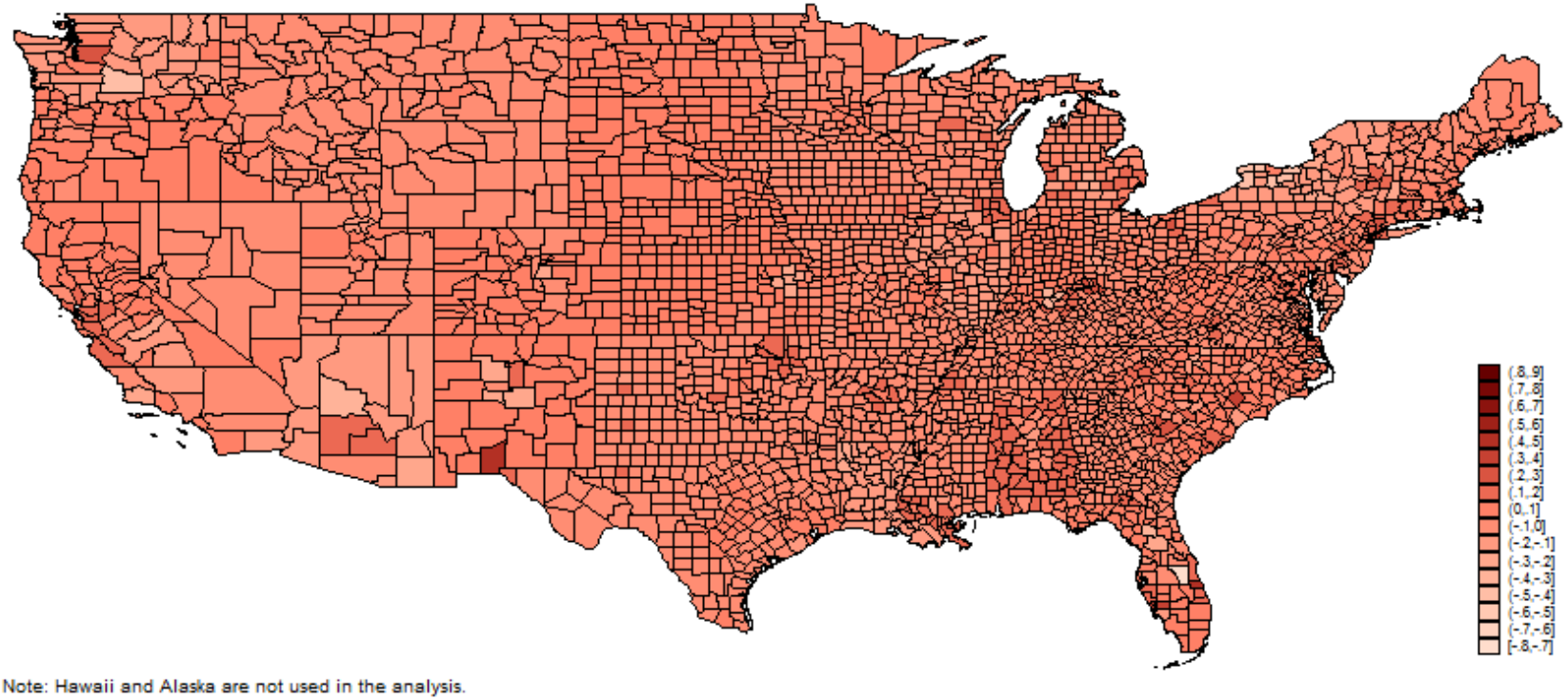
Figure 1: Map of Self-Reported Cigarette Prices from the Tobacco Use Supplement of the Current Population Survey, January 2011

Panel A: Cigarette Prices in Dollars



Note: Hawaii and Alaska are not used in the analysis.

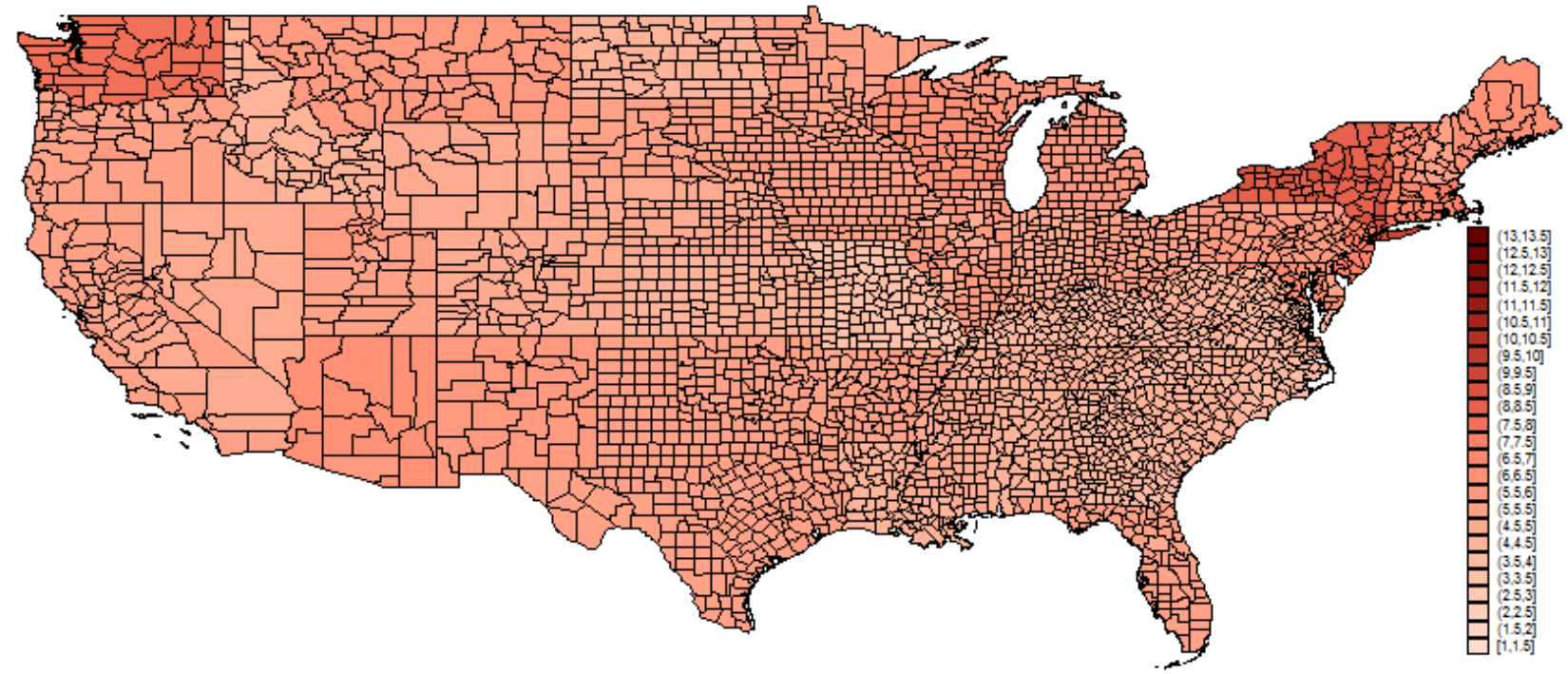
Panel B: Cigarette Prices as Percent of State Price



Notes: The prices reported in these maps were constructed by first averaging (by month) self-reported per pack cigarette prices for counties and core based statistical areas that are consistently reported in both the 2006-07 and 2010-11 waves of the TUS-CPS. Core based statistical areas overlapping state borders are treated as separate units. Remaining prices not part of a consistently-collected county or core based statistical area are averaged within states for remaining counties.

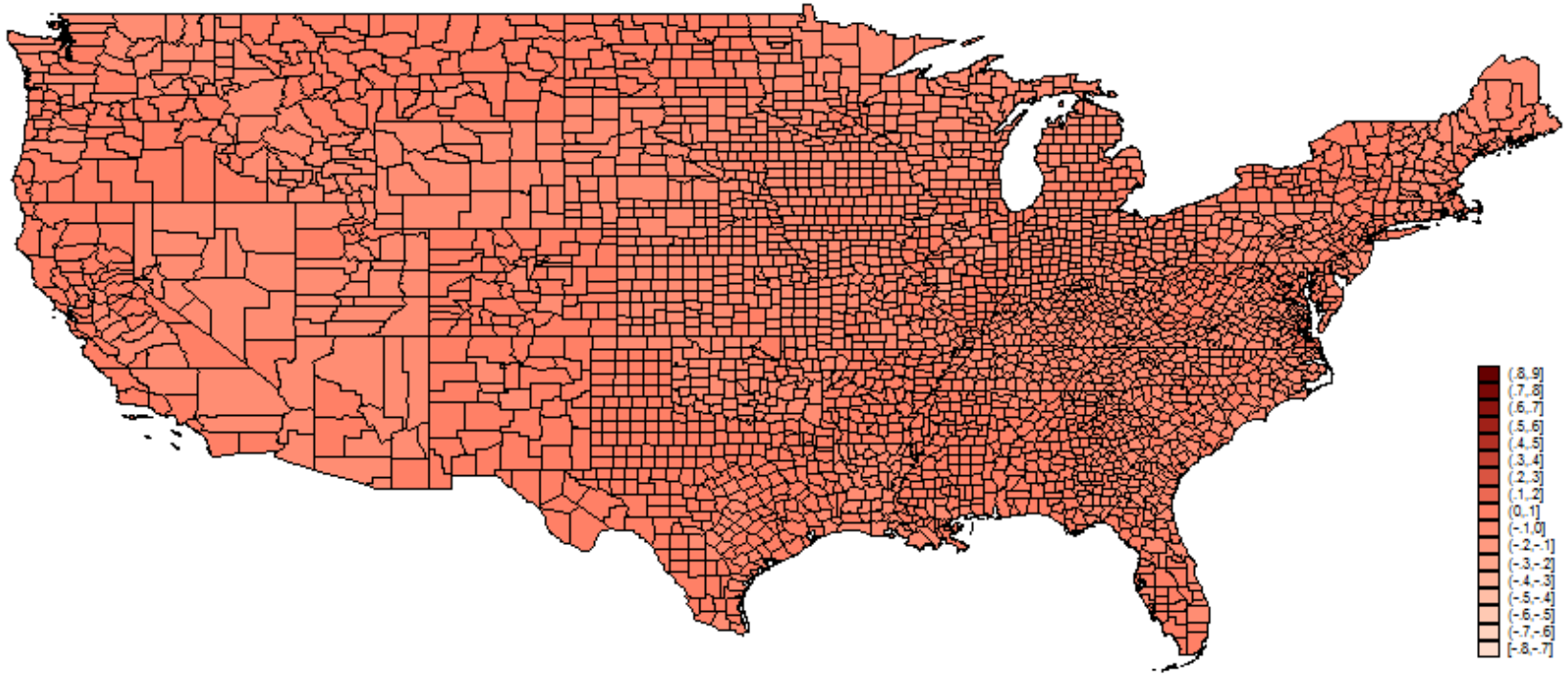
Figure 2: Map of Cigarette Prices from Nielsen Retail Data, January 2011

Panel A: Cigarette Prices in Dollars



Note: Hawaii and Alaska are not used in the analysis.

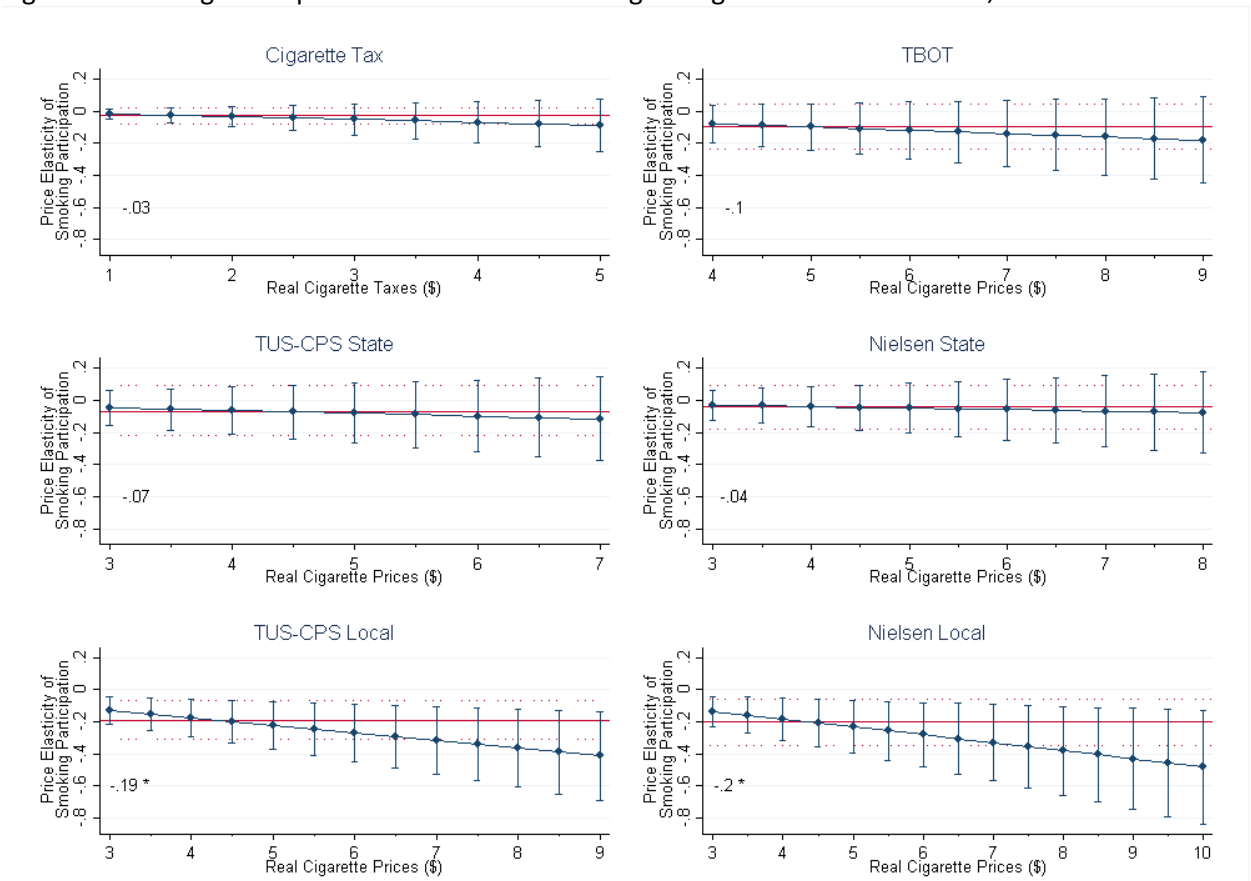
Panel B: Cigarette Prices as Percent of State Price



Note: Hawaii and Alaska are not used in the analysis.

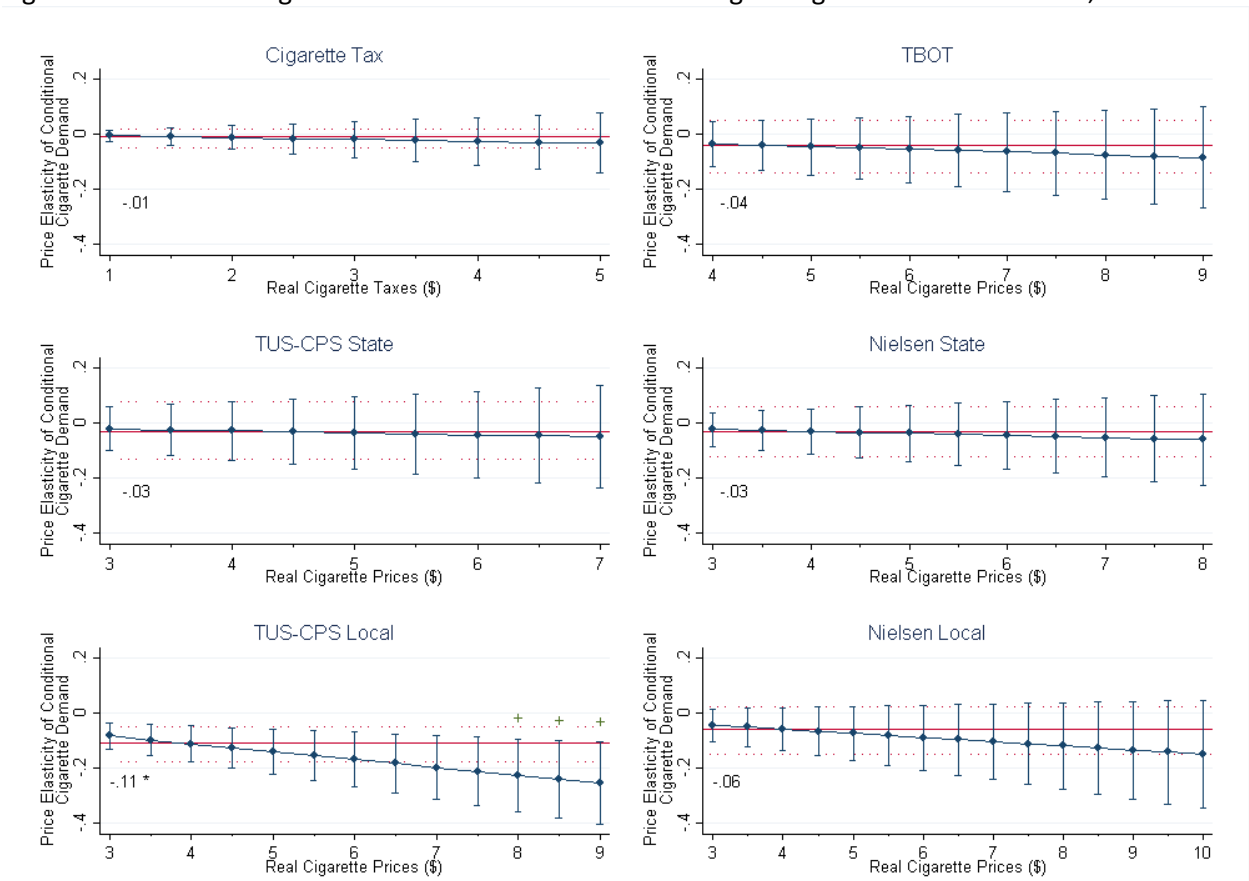
Notes: The prices reported in these maps were constructed by first averaging (by month) per pack cigarette prices from Nielsen retail data for counties and core based statistical areas that are consistently reported in both the 2006-07 and 2010-11 waves of the TUS-CPS. Core based statistical areas overlapping state borders are treated as separate units. Remaining prices not part of a consistently-collected county or core based statistical area are averaged within states for remaining counties.

Figure 3: Smoking Participation Price Elasticities Using Six Cigarette Price Measures, 2006-2011



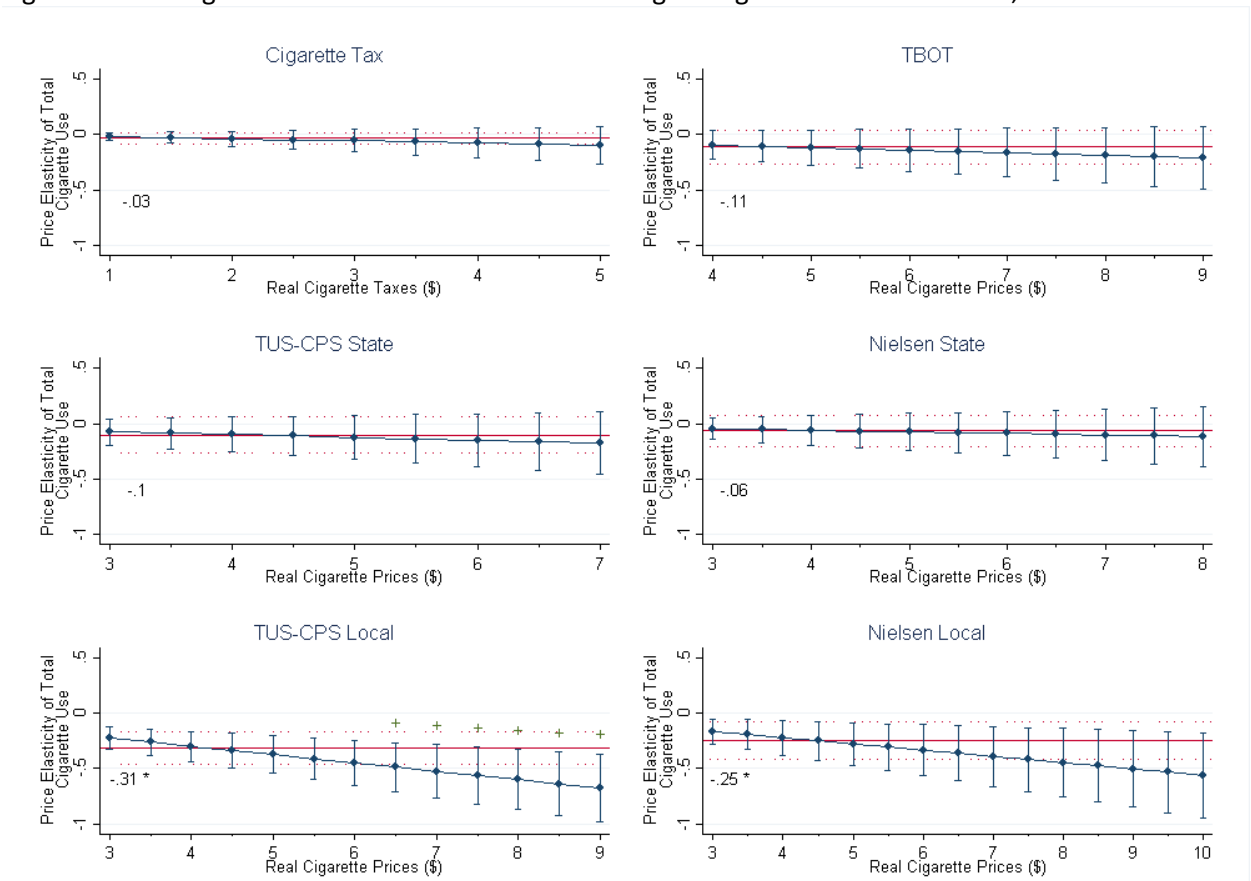
Notes: Smoking prevalence price elasticities are estimated using a logit model. Horizontal lines represent the average price elasticity and its 95% confidence interval. + Marginal effect is significant at the 5 percent level compared to the marginal effect at the lowest price level. * Average price elasticity significant at the 5 percent level.

Figure 4: Conditional Cigarette Demand Price Elasticities Using Six Cigarette Price Measures, 2006-2011



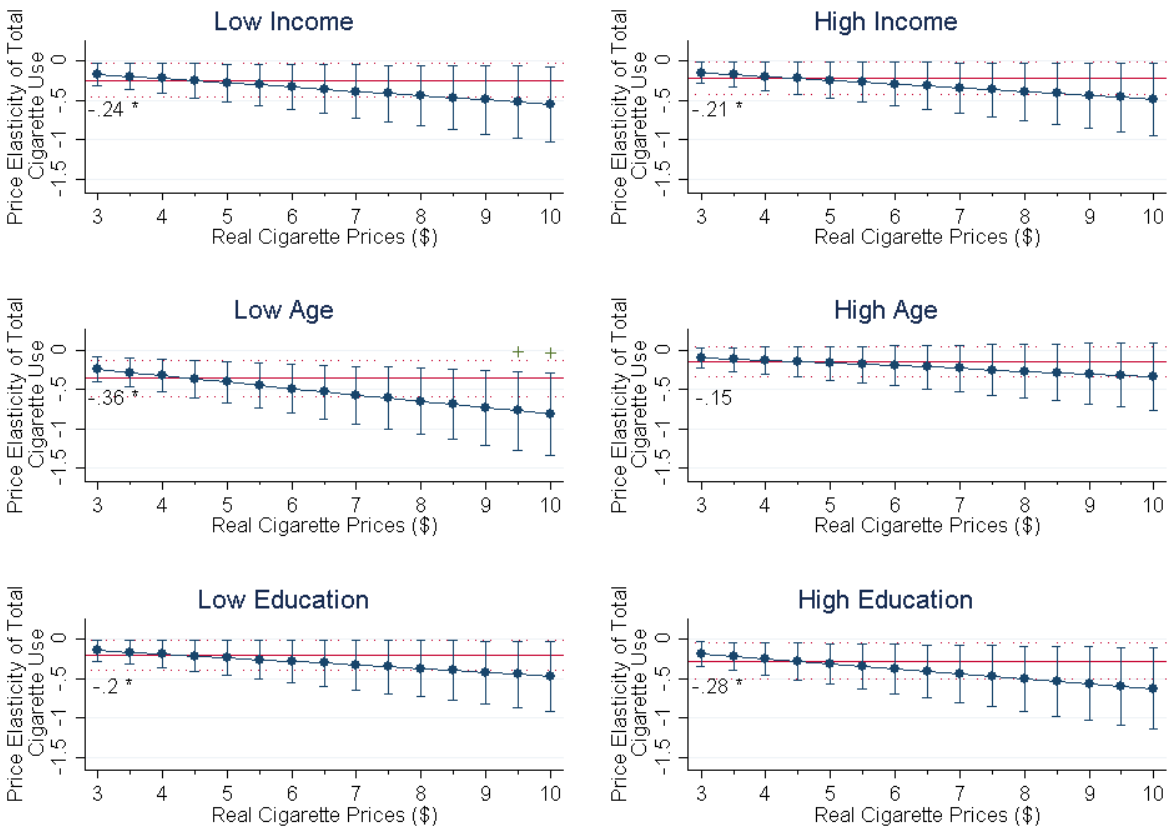
Notes: Conditional cigarette demand price elasticities are estimated using a GLM model with a log link and a Poisson distribution. Horizontal lines represent the average price elasticity and its 95% confidence interval. + Marginal effect is significant at the 5 percent level compared to the marginal effect at the lowest price level. * Average price elasticity significant at the 5 percent level.

Figure 5: Total Cigarette Demand Price Elasticities Using Six Cigarette Price Measures, 2006-2011



Notes: Total cigarette demand sets 30-day cigarette consumption for non-smokers to 0 and is estimated using a GLM model with a log link and a Poisson distribution. Horizontal lines represent the average price elasticity and its 95% confidence interval. + Marginal effect is significant at the 5 percent level compared to the marginal effect at the lowest price level. * Average price elasticity significant at the 5 percent level.

Figure 6: Total Cigarette Demand Price Elasticities by Income, Age, and Education using Nielsen Local Prices, 2006-2011



Notes: Each graph shows a separately estimated equation. Low age is <45, and high age is ≥45. Low household income is <$40,000, and high household income is ≥$40,000. Low education is completed high school or less, and high education is completed some college or more. Total cigarette demand sets 30-day cigarette consumption for non-smokers to 0 and is estimated using a GLM model with a log link and a Poisson distribution. Horizontal lines represent the average price elasticity and its 95% confidence interval. + Marginal effect is significant at the 5 percent level compared to the marginal effect at the lowest price level.

Online Table 1: Total Cigarette Demand Marginal Effects Using Six Cigarette Price Measures, Full Results, 2006-2011

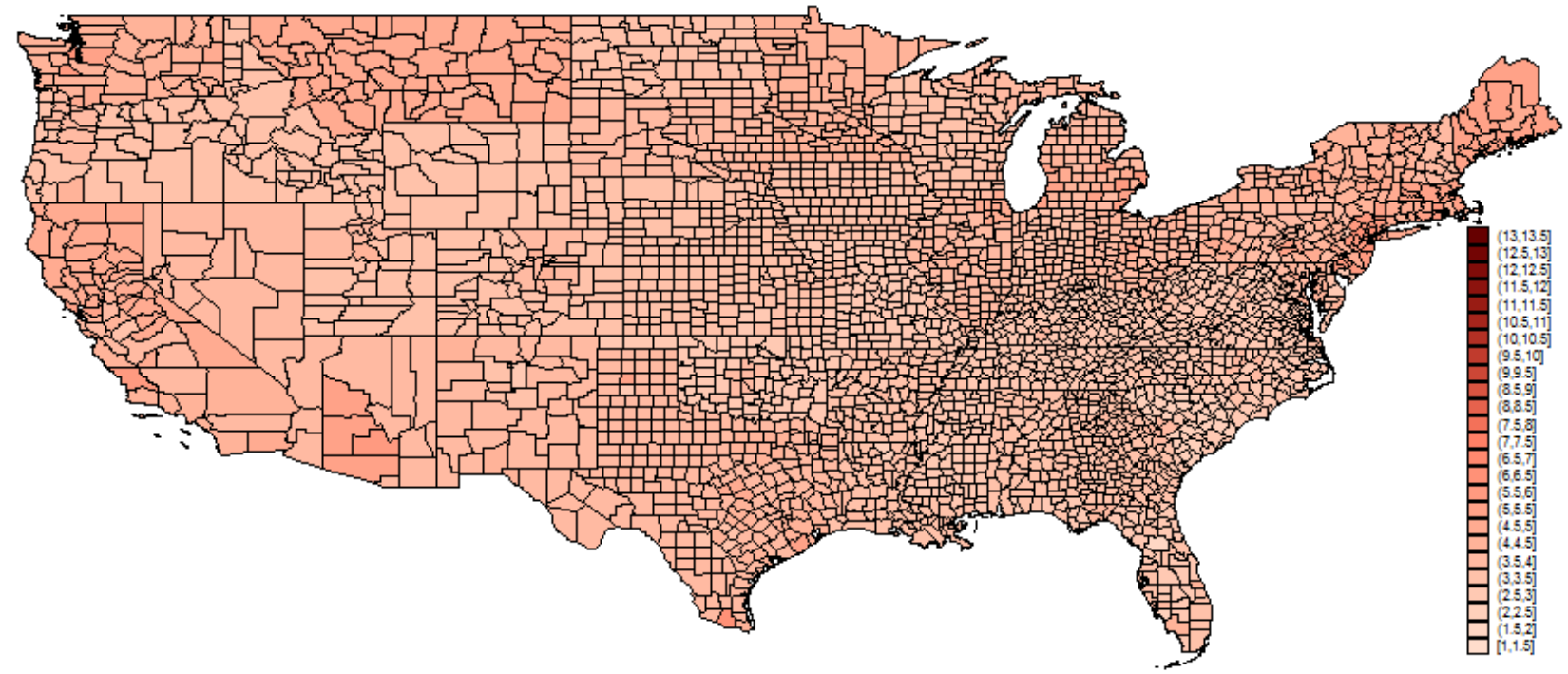
	(1)	(2)	(3)	(4)	(5)	(6)
Male	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Female	-27.24***	-27.24***	-27.24***	-27.24***	-27.24***	-27.25***
	[1.13]	[1.13]	[1.13]	[1.13]	[1.13]	[1.13]
Age	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
White	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Black	-49.37***	-49.37***	-49.37***	-48.91***	-49.37***	-49.21***
	[1.24]	[1.24]	[1.24]	[1.24]	[1.24]	[1.24]
American Indian, Alaskan Native	-7.94	-7.93	-7.94	-7.99	-7.94	-7.91
	[7.83]	[7.83]	[7.83]	[7.80]	[7.83]	[7.82]
Asian, Hawaiian Pacific Islander	-51.89***	-51.89***	-51.89***	-51.23***	-51.89***	-51.69***
	[2.29]	[2.29]	[2.29]	[2.29]	[2.29]	[2.29]
Other Race	13.14**	13.14**	13.15**	13.12**	13.15**	13.12**
	[5.71]	[5.70]	[5.70]	[5.68]	[5.71]	[5.70]
Not Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Hispanic	-64.13***	-64.13***	-64.13***	-63.85***	-64.13***	-64.04***
	[1.61]	[1.61]	[1.61]	[1.62]	[1.61]	[1.61]
Less than High School	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
High School Only	-26.07***	-26.07***	-26.07***	-26.04***	-26.07***	-26.06***
	[2.28]	[2.28]	[2.28]	[2.27]	[2.28]	[2.27]
More than High School	-68.82***	-68.82***	-68.82***	-68.68***	-68.82***	-68.78***
	[2.37]	[2.37]	[2.37]	[2.36]	[2.37]	[2.36]
Family Income (Top Coded at $75,000)	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Family Income Non-Top Categories	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Family Income Top Category	-10.23***	-10.22***	-10.22***	-10.06***	-10.24***	-10.14***
	[2.79]	[2.79]	[2.79]	[2.79]	[2.79]	[2.79]
Married (No)	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Married (Yes)	26.26***	26.26***	26.26***	26.36***	26.26***	26.29***
	[1.14]	[1.14]	[1.14]	[1.15]	[1.14]	[1.14]
Employed and Working	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Unemployed	26.12***	26.12***	26.12***	26.12***	26.12***	26.16***
	[2.16]	[2.16]	[2.16]	[2.16]	[2.16]	[2.16]
Not In Labor Force	6.37***	6.37***	6.37***	6.43***	6.37***	6.40***
	[1.18]	[1.18]	[1.18]	[1.18]	[1.18]	[1.18]
May, 2006	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
August, 2006	1.64	1.61	1.55	1.34	1.63	1.54
	[1.41]	[1.41]	[1.40]	[1.40]	[1.41]	[1.39]
January, 2007	-0.8	-0.65	-0.71	-0.4	-0.73	-0.18
	[1.53]	[1.55]	[1.54]	[1.50]	[1.56]	[1.52]
May, 2010	-8.61***	-7.85***	-7.71***	-3.78*	-8.50***	-4.80**
	[1.97]	[2.13]	[2.44]	[2.21]	[2.29]	[2.42]

August, 2010	-8.83***	-7.98***	-7.92***	-3.59	-8.68***	-4.46*
	[2.33]	[2.52]	[2.80]	[2.41]	[2.72]	[2.70]
January, 2011	-12.89***	-12.04***	-12.03***	-8.06***	-12.77***	-8.85***
	[2.07]	[2.29]	[2.52]	[2.31]	[2.41]	[2.62]
Area Type: Residual	Ref	Ref	Ref	Ref	Ref	Ref
	-	-	-	-	-	-
Area Type: County	-5.67***	-5.67***	-5.67***	-3.99***	-5.67***	-5.36***
	[1.63]	[1.63]	[1.63]	[1.54]	[1.63]	[1.60]
Area Type: Core Based Statistical Area	-3.85***	-3.85***	-3.86***	-3.01**	-3.85***	-3.65**
	[1.45]	[1.45]	[1.45]	[1.42]	[1.45]	[1.47]
Area Anti-Smoking Sentiment for Bars/Clubs	-33.40***	-33.45***	-33.33***	-30.63***	-33.30***	-32.43***
	[4.34]	[4.34]	[4.34]	[4.21]	[4.34]	[4.31]
Area Anti-Smoking Sentiment for Children's Playgrounds/Sports Fields	-13.78**	-13.77**	-13.83**	-13.24**	-13.82**	-13.54**
	[5.99]	[5.98]	[5.99]	[5.87]	[5.99]	[5.92]
State and Federal Taxes	-1.39					
	[1.24]					
Tax Burden on Tobacco Cigarette Prices		-1.7				
		[1.17]				
TUS-CPS State Price			-1.77			
			[1.47]			
TUS-CPS Local Price				-5.42***		
				[1.24]		
Nielsen State Price					-1.06	
					[1.23]	
Nielsen Local Price						-4.05***
						[1.41]
Sample Size	331,221	331,221	331,221	331,221	331,221	331,221
State Fixed Effects	X	X	X	X	X	X

Notes: Total cigarette demand sets 30-day cigarette consumption for non-smokers to 0 and is estimated using a GLM model with a log link and a Poisson distribution. * Significant at the 10 percent level, ** Significant at the 5 percent level, *** Significant at the 1 percent level.

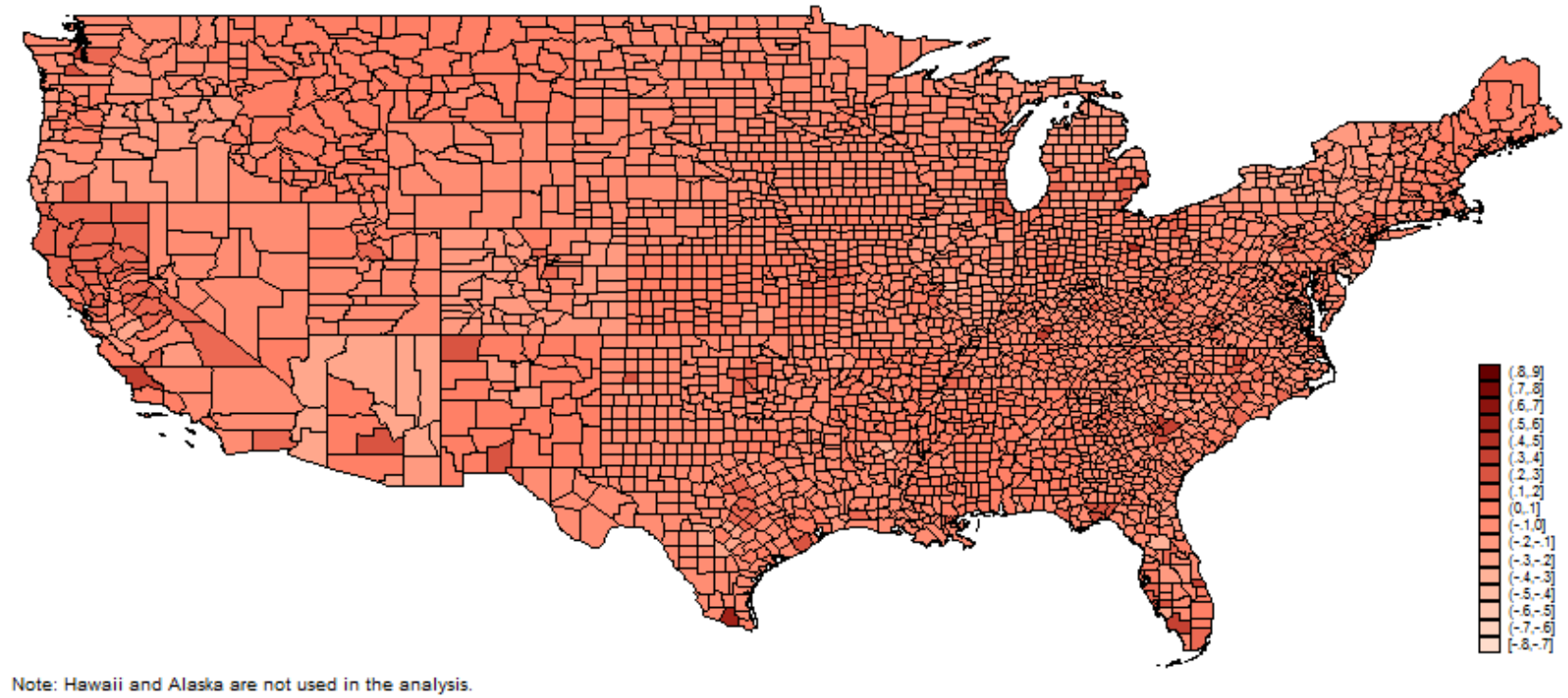
Online Figure 1: Map of Self-Reported Cigarette Prices from the Tobacco Use Supplement of the Current Population Survey, January 2007

Panel A: Cigarette Prices in Dollars



Note: Hawaii and Alaska are not used in the analysis.

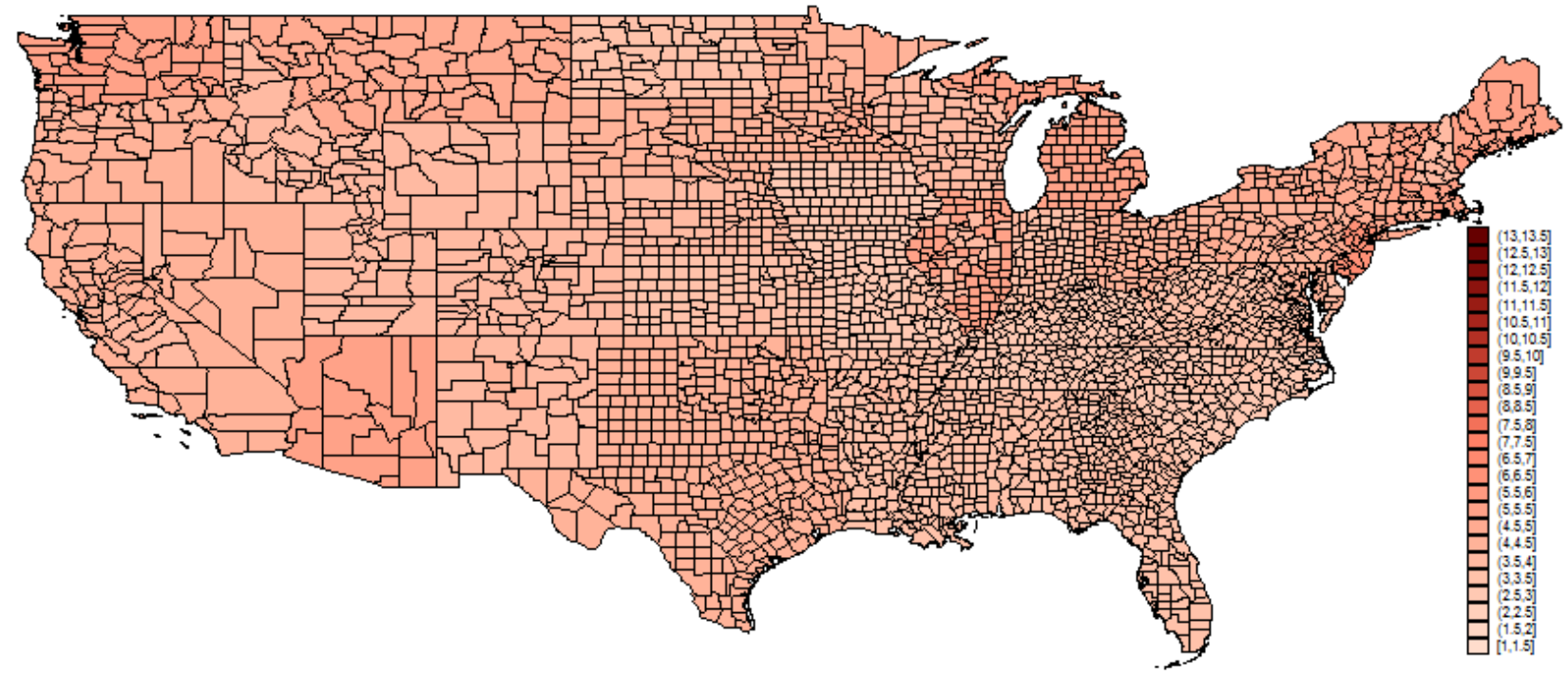
Panel B: Cigarette Prices as Percent of State Price



Notes: The prices reported in these maps were constructed by first averaging (by month) self-reported per pack cigarette prices for counties and core based statistical areas that are consistently reported in both the 2006-07 and 2010-11 waves of the TUS-CPS. Core based statistical areas overlapping state borders are treated as separate units. Remaining prices not part of a consistently-collected county or core based statistical area are averaged within states for remaining counties.

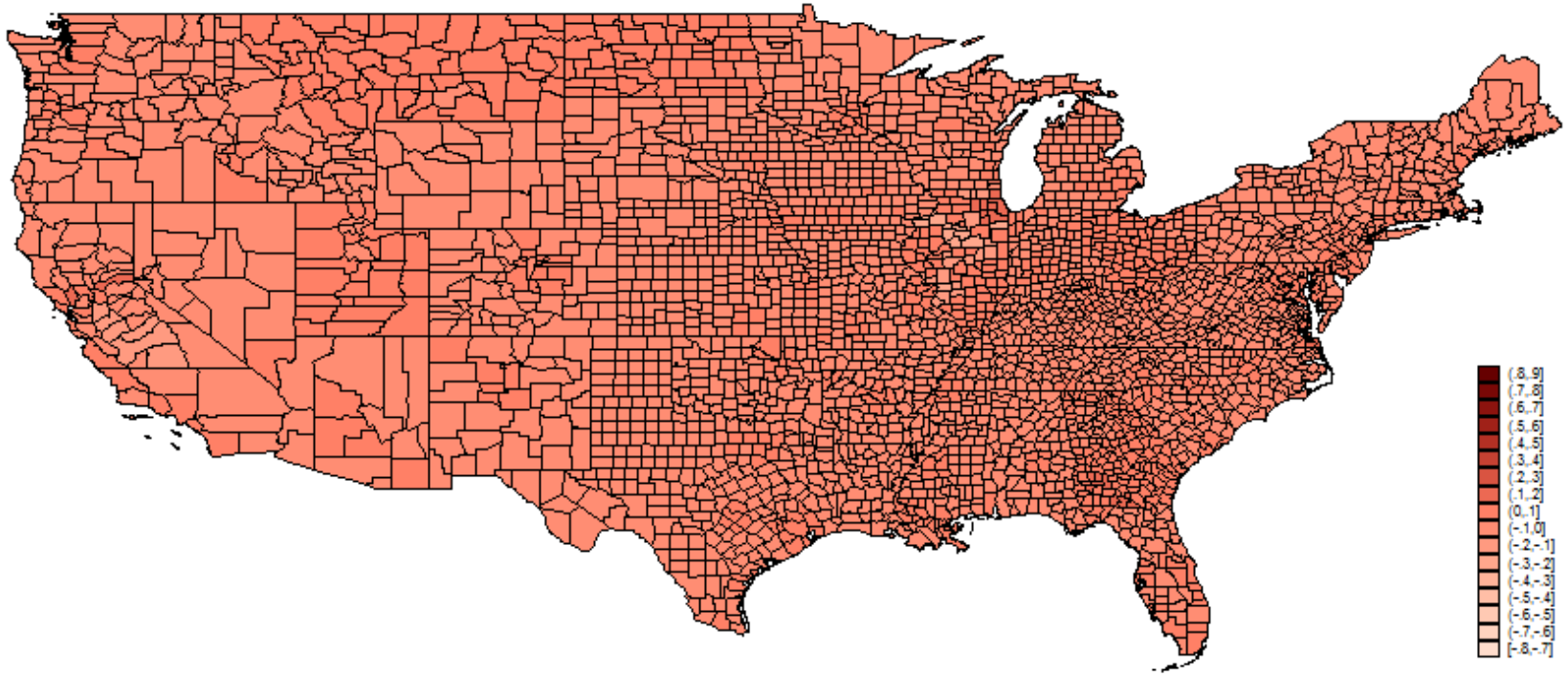
Online Figure 2: Map of Cigarette Prices from Nielsen Retail Data, January 2007

Panel A: Cigarette Prices in Dollars



Note: Hawaii and Alaska are not used in the analysis.

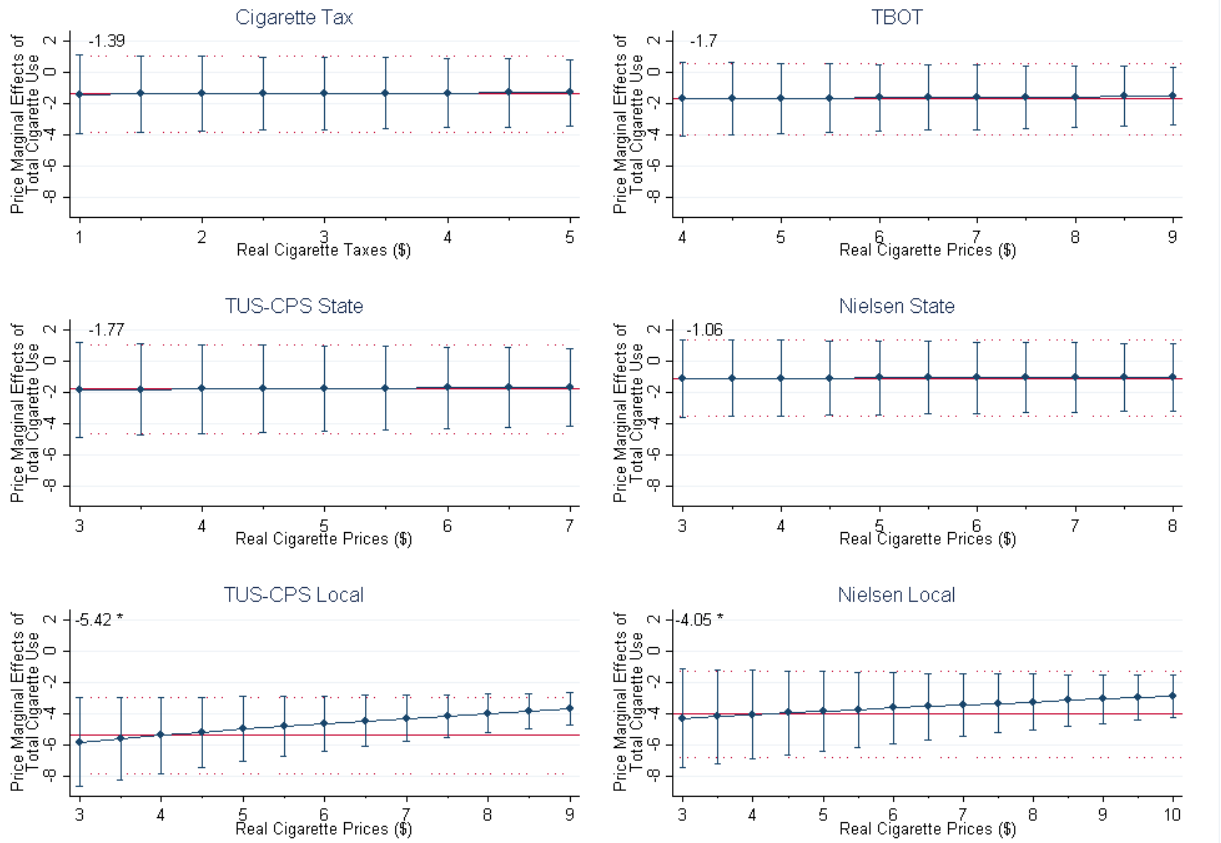
Panel B: Cigarette Prices as Percent of State Price



Note: Hawaii and Alaska are not used in the analysis.

Notes: The prices reported in these maps were constructed by first averaging (by month) per pack cigarette prices from Nielsen retail data for counties and core based statistical areas that are consistently reported in both the 2006-07 and 2010-11 waves of the TUS-CPS. Core based statistical areas overlapping state borders are treated as separate units. Remaining prices not part of a consistently-collected county or core based statistical area are averaged within states for remaining counties.

Online Figure 3: Total Cigarette Demand Marginal Effects Using Six Cigarette Price Measures, 2006-2011



Notes: Total cigarette demand sets 30-day cigarette consumption for non-smokers to 0 and is estimated using a GLM model with a log link and a Poisson distribution. Horizontal lines represent the average price marginal effect and its 95% confidence interval. + Marginal effect is significant at the 5 percent level compared to the marginal effect at the lowest price level. * Average marginal effect significant at the 5 percent level.