How Far to the Border?: The Extent and Impact of Cross–Border Casual Cigarette Smuggling

Abstract - *This paper uses data on cigarette consumption in the Current Population Survey Tobacco Supplements to estimate cigarette demand models that incorporate the decision of whether to smuggle cigarettes across a lower–price border. I find demand elasticities with respect to the home state price are indistinguishable from zero on average and vary significantly with the distance individuals live to a lower–price border. However, when smuggling incentives are eradicated, the price elasticity is negative but still inelastic. I also estimate between 13 and 25 percent of consumers purchase cigarettes in border localities. The central implication of this study is cross–border smuggling confounds many of the potential health and revenue gains from cigarette taxation.*

INTRODUCTION

Cigarette taxes have garnered increasing interest in the United States by both government and public health officials over the past 30 years. The former are interested in using state–level excise taxes to increase government revenues, while the latter believe increased taxes could be used to reduce smoking behavior. The degree to which each of these goals can be met is a function of the demand elasticity of cigarettes. If cigarette demand is price elastic, then increasing taxes will reduce the amount of smoking but will be less effective in raising revenues. Conversely, if cigarette demand is price inelastic, then tax increases will succeed in raising revenues but not in reducing smoking behavior.

Due to the potential gains from cigarette taxation, many states have increased their cigarette taxes markedly since the 1970s (Orzechowski and Walker, 2006). The differential increase across states in the United States has caused large interstate price differences in many areas of the country. For example, as of November 2001, there was a seventy–three cents per pack tax difference between Washington, D.C. and Virginia, despite the fact that the average consumer in Washington, D.C. lives less than four miles from the Virginia border. Of the five states that had cigarette taxes over one dollar per pack in 2001, there was an average tax difference of eighty–three cents between them and the closest lower–price

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border. The median consumer in these states was less than 38 miles from the nearest lower–priced jurisdiction.

This cross–state price variation can confound many of the potential gains from cigarette taxation as increased taxes may cause individuals to purchase cigarettes in a nearby lower–price locality. Such "casual smuggling" behavior can limit the effectiveness of state–level cigarette excise taxes in reducing smoking and in increasing state tax revenues.[1] This study seeks to estimate the extent of casual smuggling as well as its effect on cigarette demand elasticities in order to assess how this type of tax avoidance impacts the revenue–generating potential and the smoking reduction benefits of cigarette taxes.

There is much evidence from previous literature regarding the existence of casual cigarette smuggling, though few studies have been able to estimate the extent of such behavior or its effect on demand elasticities. Because smuggling causes a bias in sales as a measure of consumption, the majority of cigarette demand studies using taxed sales data control for smuggling incentives. Many studies have found a negative relationship between the average border state tax or price differentials weighted by border populations and taxed sales (Chaloupka and Saffer, 1992; Keeler, Hu, Manning, and Sung, 2001; Coates, 1995; Yurekli and Zhang, 2000). Coates (1995) uses this specification to estimate sales elasticities with respect to both the home state price and all cigarette prices. He finds 80 percent of the sales elasticity is due to cross–border sales. Alternatively, Baltagi and Levin (1986, 1992) control for the minimum border state price and conclude an increase in this minimum price increases home state sales.

There are a small number of studies that utilize individual consumption data paired with sales data in order to identify the existence of cigarette smuggling. In their detailed study of smoking in Canada, Gruber, Sen, and Stabile (2003) compare taxed sales elasticities from provinces in which smuggling is low to consumption elasticities from household expenditure data. Since prices do not vary appreciably across provinces, the authors argue these methods are effective in controlling for the biases associated with demand estimation when there is smuggling. They find ignoring smuggling causes them to overstate the price elasticity of cigarettes in absolute value[2] and estimate smuggling–corrected elasticities between –0.45 and –0.47.

Stehr (2005) uses a similar methodology in the United States to explain the per–capita differences in reported consumption and taxed sales as a function of the difference between home and the border state taxes from states in which the tax is higher than in the home state (i.e., the "export" states). He finds between 59 and 85 percent of the taxable sales elasticity is due to changes in the locality of purchase and almost 13 percent of cigarettes in 2001 were purchased without payment of the home state tax. While he attributes only 0.7 percent of the smuggling behavior to casual smuggling,[3] his casual smuggling

[1] In most states, consumers can purchase legally a small quantity of cigarettes, usually no more than two or three cartons, from a lower–priced state. Purchasing more than that amount and avoiding local tax payments on the purchase is illegal.

[2] When taxed sales are used as the measure of consumption, smuggling will cause one to overstate the full price elasticity of cigarettes in absolute value. Conversely, when micro–level data on cigarette consumption are used as the measure of consumption, the bias in the elasticity due to smuggling will tend to understate the full price elasticity in absolute value

[3] There are two types of smuggling commonly discussed in the literature: organized smuggling and casual smuggling. The former type of smuggling typically involves illegally transporting large quantities of cigarettes from one of the tobacco producing states (such as North Carolina, Virginia, and Kentucky) for illegal resale in another state. Organized smuggling became a federal crime in 1978 with the *Contraband Cigarette Act* and

estimates are based on variation in the average difference between home and export states' taxes over time, which is likely to cause a downward bias in his estimates.[4] Further, he is unable to account for where consumers live in each state with respect to the lower–price borders, which limits his ability to identify casual smuggling behavior. Individuals may also be traveling to nearby lower–price jurisdictions that are not border states.

This paper uses micro–data on cigarette consumption from the 1992–1993, 1995–1996, 1998–1999, and 2001–2002 Current Population Survey (CPS) Tobacco Supplements combined with geographic information on the location of consumers with respect to lower–price jurisdictions to estimate cigarette demand models that incorporate the decision of whether to smuggle cigarettes across a state or Native American Reservation border. This is, therefore, the first study to estimate the extent and impact of casual smuggling using only micro data on consumption. I also address a central empirical problem inherent in using such data: the state of cigarette purchase for each consumer is not identified. In the presence of casual smuggling, using the home state cigarette price as a proxy for the true cigarette price can bias the estimate of the effect of price changes on cigarette demand.[5] The bias stems from the fact the home state price is a biased estimator of the "true" price at which consumers purchase cigarettes, and this bias is systematically correlated with smuggling incentives. I present regression residuals from traditional cigarette demand regressions by quartile of distance to a lower–price border that argue strongly for the existence of this type of bias.

To correct for the home state price bias, I explicitly model the decision to smuggle and then incorporate the parameters of this decision into the demand model. The distance to a lower–price locality is then used to proxy for unobserved heterogeneity in the response of demand to changes in the home state price that has been ignored by previous studies.

In the presence of smuggling, there are three elasticities of interest: the home state price elasticity, the home state sales elasticity, and the full price elasticity. The home state price elasticity is the percent change in consumption of state residents when the home state price changes by one percent, the home state sales elasticity is the percent change in home state sales when the home state price changes by one percent, and the full price elasticity is the percent change in consumption or sales when all prices change by one percent such that smuggling incentives are unaffected. The home state elasticities yield insight into how home state prices actually affect consumption and sales, holding constant the price of cigarettes in border localities, while the full price elasticity reveals the potential for cigarette prices to impact consumption or sales in the absence of smuggling.[6]

From either a state tax or a public health policy perspective, all three elasticities are of interest. Most studies that attempt to correct for smuggling biases are implicitly attempting to estimate the full price elasticity as this is the elasticity in the absence of smuggling. Coates (1995) is the only previous study to distinguish

was followed by a marked decrease in interstate bootlegging (ACIR, 1985). Thursby and Thursby (2000) estimate between three to seven percent of cigarette sales can be attributed to organized smuggling, which is lower than the estimates in Stehr (2005).

4 See the sixth section on smoking increases, casual smuggling percentages, and net sales effects for a further discussion of this issue.

5 I call this the "home state price bias."

6 In the absence of smuggling, the full price elasticity is identical with respect to sales and consumption.

between the home state sales and full price elasticities using taxed sales data.[7] This analysis presents the first estimates of the home state price elasticity in the literature, which is arguably of more value to state policy makers than the full price elasticity as they cannot control prices in border localities.

I find home state price elasticities vary significantly with the geographic distribution of each state and are indistinguishable from zero on average, due primarily to the close proximity of most individuals to the closest lower–price border. The full price elasticities tell a much different story, however, and are universally negative and non–negligible in magnitude.

The final contribution of this analysis is to estimate the impact of smuggling on cigarette consumption and the percentage of consumers who casually smuggle.[8] I find cross–border sales cause a modest increase in consumption, and between 13 and 25 percent of consumers purchase cigarettes in border localities in the CPS sample. While these estimates are large relative to previous studies (Stehr, 2005), they are consistent with the significant savings potential from purchasing cross–borders and with the close proximity of many individuals to these borders. Though I cannot estimate the home state sales elasticity, my estimates indicate large differences across states in the effects of casual smuggling on taxed cigarette sales, with states such as New Hampshire, Kentucky, and Virginia gaining sales and states such as New York, Kansas, and Maryland losing significant sales due to cross–border purchases.

The remainder of this paper is organized as follows. The second section provides a description of the data used throughout the analysis. The third section presents evidence on the home state price bias, and the fourth section derives the demand model used throughout this study and discusses its implications. The estimation strategy is described in the fifth section, and all results are presented in the sixth section. The seventh section concludes.

DATA

The individual–level data in this analysis come from the CPS Tobacco Supplements: September 1992, 1995, and 1998; January 1993, 1996, and 1999; March 1993, 1996, and 1999; June and November 2001; and February 2002. These surveys span nine years in four waves given approximately every two years. Because I am interested in combining these data with a measure of smuggling distance, I restrict the sample to those living in an identified metropolitan statisical area (MSA); this is the most specific level of geographic identification available in the CPS. As there are MSAs that split state lines, each identifiable state–MSA combination is taken as a separate MSA.[9] I will use state–MSA and MSA interchangeably.

I combine these data with state average price and tax data from *The Tax Burden on Tobacco* compilation (Orzechowski and Walker, 2006). All prices are inflated to real 2004 dollars using the gross domestic product (GDP) implicit price deflator. Prices listed in this compilation are spot

[7] I am unable to estimate the home state sales elasticity as I do not have geographically disaggregated sales data at below the state level. Coates (1995) estimates a home state sales elasticity of –0.81.

[8] This study focuses on casual smuggling, as the distance to a lower–price border state will most influence this type of behavior. However, to the extent this measure is correlated with organized smuggling, bootlegging activity will be included in the study as well.

[9] There are upwards of 40 MSAs that split state lines. However, for all but 11 cases, the CPS only identifies the more populous part of the state–MSA combination. Where these portions of the MSA are not identified, they are excluded from the analysis. A complete list of MSAs used in this study is available from the author upon request.

prices as of November of that year. To construct a more accurate price series, I subtract the November excise tax in each state from the listed price and smooth the pre–tax price changes evenly over the entire year. I then add in the appropriate excise and sales taxes for each state and month in the Tobacco Supplement.[10]

The central variable in the analysis is the distance to a lower–price locality. I use 2000 Census geographic data to estimate a population–weighted average distance from each state–MSA combination to the closest lower–price border.[11] This calculation is done by finding the "crow–flies" distance from each census block point in a state–MSA to each intersection between a state border and "major road."[12] Once I calculate the distance from each block point to each road crossing, I take the closest crossing from each block point to a given border state and calculate a population–weighted average across block points for each border state. By measuring distance from the population center rather than the geographic center of a given MSA, I am able to more accurately characterize the distance an average individual must travel to smuggle cigarettes. In the tables that follow, the distance measure is the distance to the closest lower–price border, which is often, but not always, a border state.[13]

In addition to neighboring states, many individuals can obtain lower–price cigarettes from Native American Reservations. Native American Reservations are considered separate legal entities from the United States and are thus not subject to sales and excise taxes. In 1976, the U.S. Supreme Court ruled in *Moe v. Confederated Salish and Kootenai* that states have the right to impose sales and excise taxes on cigarette sales occurring on reservations to non–tribal members. Although evidence suggests a substantial amount of sales occur on reservations to non–tribal members (ACIR, 1985; FACT Alliance, 2005), only 12 states have passed legislation that allows taxation of these sales. Table 1 contains information on which states tax non–tribal reservation sales and the case law or regulation that legitimates these taxes. I collected these data using *Cigarette Tax Evasion: A Second Look* (ACIR, 1985), which documents much of the case law and state legislation through 1985 on Native American cigarette sales. I augmented and updated this information using state taxation statutes found through LexisNexis. Reservations in the states listed in Table 1 are excluded from the analysis.[14]

Table 2 presents means of distance, price differences, and tax differences for

[10] There are a number of counties and cities that have local cigarette taxes. Unfortunately, no data exist on the history of these taxes back to 1992. I thus exclude these taxes from the analysis and only utilize state–level taxes. As a consequence, the cross–state price differences may be understated in some cases, causing an attenuation bias in the estimate of the effect of the price difference on cigarettes demanded.

[11] While MSA definitions were constant over the time period covered by this analysis and while CPS sampling is representative of the geographic distribution of the population, populations within MSAs might have shifted. I ignore such shifts due to lack of data on within–MSA population mobility.

[12] A major road is a census classification and contains most non–residential roads. The exclusion of residential roads is trivial as the vast majority of interstate travel does not occur on such roads.

[13] In many MSAs, there are farther lower–price jurisdictions with lower prices than the closest lower–price locality. Using the closest lower–price state will cause measurement error in the distance variable if people are willing to travel a little farther to obtain a slightly better price. The results from this paper suggest individuals are quite sensitive to the distance to a lower–price border but not the level of the price difference. Further, for most MSAs, the distance to a better price than the closest lower–price is quite substantial. Thus, the use of the closest lower–price border is consistent with the data and likely causes little measurement error.

[14] See Appendix A in Lovenheim (2007) for a discussion of Native American Reservation tax enforcement as well as information on the data and methodology used to calculate distance to Native American Reservations. Due to potential measurement error in this variable, I conduct the analysis below both including and excluding reservation smuggling incentives.

TABLE 1
STATES THAT TAX CIGARETTE SALES TO NON–TRIBAL MEMBERS ON NATIVE AMERICAN RESERVATIONS

State	Statute/Case Name	Year
Arizona	A.R.S. 42–3302	1997
Kansas	*State v. Oyler*	1990
Michigan	MCLS 205.30c/Individual Tribal Compacts	1947
Minnesota	Minn. Statute 297F.07/Individual Tribal Compacts	1997/Pre–1992
Montana	*Moe v. Confederated Salish and Kootenai*	1976
Nebraska	Nebraska Department of Revenue (1996)	Pre–1992
Nevada	NRS 370.280	1947
Oklahoma	Okl. St. 349	Pre–1992
Oregon	ORS 323.401	1979
South Dakota	Individual Tribal Compacts	Pre–1992
Washington	*Washington v. Confederated Colville Tribes*	1980
Wisconsin	Wis. Stat. 139.323/Individual Tribal Compacts	1984

Source: ACIR (1985) updated using LexisNexis searches for state cigarette taxation laws.

all identified MSAs by state. The table also lists the number of tax changes observed in the data as well as all of the closest lower–price localities for each state. Table 2 illustrates the heterogeneity across states in smuggling incentives. For example, consumers in Massachusetts, New York, Illinois, and Wisconsin live close to areas in which cigarettes are substantially less expensive. However, in states such as Delaware, Nevada, and Oregon, consumers likely live too far away from the lower–priced jurisdictions to realize the savings from purchasing cigarettes there.

Because my empirical models all include MSA fixed effects (see the fifth section on estimation strategy), I will be restricted to using within–MSA variation in distance over time. Cross–time variation in distance within a state–MSA is driven by price changes; when a home or border state changes its cigarette price, the closest lower–price border can change, thereby generating variation in distance. Table 3 contains the number of distance changes, the average change in distance, and the standard deviation of the distance changes between each CPS survey. While the majority of MSAs experience no distance change between each period, there is a substantial amount of variation in the distance measure of varying sign and magnitudes.

HOME STATE PRICE BIAS

When the opportunity to purchase cigarettes in lower–price localities exists, demand models that utilize the home state price as the measure of the true price paid by consumers can generate biased estimates of the average partial effect of price on consumption if there are unobserved differences in how individuals respond to home state price changes. The heterogeneity in demand response is a function of smuggling incentives that typically are not included in models of cigarette demand using micro–data. This problem essentially equates to an omitted variables bias as the propensity to smuggle is likely correlated with home state cigarette prices. I term this source of bias the "home state price bias" because it stems from an inability of the home state price to correctly measure the true price paid by consumers.[15]

While many studies using individual cigarette data assert the existence of this

[15] See Gruber et al. (2003) for further discussion of the effect of this bias on elasticity estimates.

TABLE 2
TAX CHANGES, PRICE DIFFERENTIALS, AND DISTANCE BY STATE

Home State	Average Home State Tax	Tax Changes	Closest Lower Price Jurisdictions	Average Distance (miles)	Average Price Difference	Average Tax Difference
Alabama	0.30	0	GA, MS, TN	50.2	0.19	0.08
Arkansas	0.45	3	MO, MS, OK	65.4	0.14	0.13
Arizona	0.69	1	CA, NM, NV, NAR	85.5	0.50	0.47
California	0.84	2	AZ, NV, NAR	72.8	0.78	0.78
Colorado	0.30	0	KS, NM, OK, WY, NAR	113.8	0.13	0.12
Connecticut	0.72	1	MA, NH, NJ, NY, PA, RI, VT, NAR	25.7	0.60	0.59
Washington, D.C.	0.86	1	VA	3.5	0.80	0.73
Delaware	0.27	0	NC, VA	118.4	0.10	0.13
Florida	0.53	0	AL, GA, NAR	52.7	0.47	0.47
Georgia	0.20	0	NC, SC, NAR	91.7	0.08	0.04
Iowa	0.53	0	IL, MO, NE, NAR	52.9	0.46	0.46
Idaho	0.41	1	MT, NAR	101.7	0.41	0.41
Illinois	0.70	2	IA, IN, MO, WI	29.3	0.49	0.39
Indiana	0.29	0	KY	108.6	0.11	0.12
Kansas	0.39	0	KY, MO, NC, OK	124.3	0.13	0.12
Kentucky	0.16	0	VA, WV, NAR	204.3	0.13	0.12
Louisiana	0.32	1	AR, GA, MO, MS, NAR	64.2	0.25	0.23
Massachusetts	0.80	2	CT, NH, RI	11.9	0.53	0.37
Maryland	0.65	1	PA, VA, WV	20.42	0.36	0.31
Maine	0.80	2	NH	32.4	0.41	0.39
Michigan	0.82	1	IN, OH	61.2	0.65	0.47
Minnesota	0.72	0	IA, ND, WI	71.2	0.25	0.16
Missouri	0.27	1	KS, KY	204.4	0.13	0.10
Mississippi	0.36	0	LA, TN, NAR	44.4	0.12	0.12
North Carolina	0.14	0	KY, SC, VA, NAR	105.1	0.09	0.08
North Dakota	0.63	1	SD, NAR	63.2	0.63	0.63
Nebraska	0.48	1	IA, KS	45.0	0.06	0.03
New Hampshire	0.42	2	DE, VA, NAR	110.1	0.42	0.42
New Jersey	0.79	1	CT, DE, NY, PA	24.0	0.33	0.24
New Mexico	0.34	1	CO, WY, NAR	36.4	0.34	0.34
Nevada	0.57	0	AZ, ID, OR, UT, NAR	188.8	0.50	0.50
New York	0.76	2	CT, NJ, PA, VT, NAR	26.0	0.50	0.44
Ohio	0.38	1	IN, KY, WV	78.3	0.11	0.12
Oklahoma	0.37	0	KS, MO	122.0	0.11	0.06
Oregon	0.57	2	CA, ID, NV	274.5	0.23	0.13
Pennsylvania	0.49	0	DE, OH, WV	38.3	0.17	0.20
Rhode Island	0.90	3	CT, MA, NH, NAR	16.0	0.19	0.27
South Carolina	0.19	0	GA, KY, NC, NAR	54.8	0.09	0.07
South Dakota	0.43	1	IA, MO, ND, NAR	138.0	0.36	0.33
Tennessee	0.33	0	GA, KY, MO, NC, VA, NAR	46.3	0.24	0.18
Texas	0.63	0	LA, NM, OK, NAR	116.5	0.44	0.43
Utah	0.56	1	WY, NAR	43.0	0.56	0.56
Virginia	0.13	0	KY, NC, WV, NAR	59.8	0.13	0.05
Vermont	0.58	1	NH	61.2	0.22	0.17
Washington	1.00	3	ID, OR	118.6	0.64	0.44
Wisconsin	0.77	3	IA, IL, MI, MN, NAR	43.1	0.42	0.37
West Virginia	0.33	0	KY, OH, VA	43.4	0.08	0.08

Note: Prices and taxes are in real 2004 dollars. Closest lower–price jurisdictions are all localities that have a lower–price than the home state at some time during the sample period. “NAR” refers to Native American Reservations.
Source: Author's calculation as described in the text. Averages refer to average values across MSAs within each state.

bias (Lewit, Coate, and Grossman, 1981; Lewit and Coate, 1982; Chaloupka, 1991; Gruber et al., 2003), there has been no documentation of how the responsiveness of consumption to the home state price varies with smuggling incentives. Table 4 contains mean residuals by distance quartile from a regression of log mean MSA cigarette consumption on log home state cigarette prices, MSA demographic characteristics, and MSA fixed effects using the CPS data described in the pre-

TABLE 3
CHANGES IN DISTANCE TO LOWER–PRICE BORDERS BETWEEN EACH CPS SURVEY

	Survey Dates										
Change	9/92–1/93	1/93–5/93	5/93–9/95	9/95–1/96	1/96–5/96	5/96–9/98	9/98–1/99	1/99–5/99	5/99–6/01	6/01–11/01	11/01–2/02
Number with no distance change	236	256	236	249	266	193	246	264	249	208	261
Number with increase <25 miles	4	2	5	3	0	10	2	1	1	7	7
Number with increase >25 miles	11	5	16	3	2	30	7	2	7	22	4
Number with decrease <25 miles	2	2	1	6	0	7	3	0	3	3	1
Number with decrease >25 miles	15	3	10	7	0	28	10	1	8	28	1
Average change in distance	–18.16	60.23	–13.44	–29.25	111.41	–13.04	–10.23	23.82	–18.14	28.84	129.65
Standard deviation of change in distance	81.35	143.62	114.45	71.79	38.37	136.67	92.09	59.88	99.66	162.81	158.50

Source: Author's calculation of distance to the closest lower–priced border state, excluding Native American Reservations.

TABLE 4
MEAN LOG CIGARETTE RESIDUALS FROM CIGARETTE DEMAND MODELS EXCLUDING SMUGGLING VARIABLES, BY DISTANCE QUARTILE

Independent Variable	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Full log cigarette residual	0.005	0.003	–0.011	–0.005
	(0.329)	(0.334)	(0.345)	(0.359)
Intensive log cigarette residual	0.004	0.0002	–0.008	–0.010
	(0.176)	(0.185)	(0.191)	(0.215)
Extensive log cigarette residual	0.0003	–0.0001	–0.0005	0.0007
	(0.026)	(0.035)	(0.031)	(0.032)

Notes:
1. The table shows mean residuals from a regression of log mean MSA cigarette consumption on log home state cigarette price and mean MSA demographic characteristics by quartile of distance to a lower–price locality. Standard deviations are in parentheses.
2. All regressions include fixed effects for each unique state–MSA combination and are weighted by the number of observations that constitute each MSA–level mean. MSA means of the following variables are included in the regressions: age, percent male, percent married, weekly wage, percent Black, percent Native American, percent Hispanic, percent Asian, percent high school diploma, percent some college, percent associates degree, percent BA, percent graduate school, percent working, and percent unemployed as well as a linear year trend. Full regression estimates are available from the author upon request.
3. Home state cigarette prices are instrumented with home state cigarette taxes in all regressions.

vious section and in the fifth section. The residuals from this regression represent the within–MSA variation in cigarette consumption that is unexplained by demographics and home state prices. I calculate mean log cigarette residuals by quartile of distance to the nearest lower–price border state for three margins of demand: intensive, extensive, and full.[16] As Table 4 illustrates, the residuals are positive in MSAs that are closer to the border and negative for those farther away from the border. These signs are consistent with a home state price bias because consumers who live closer to the border smoke more than suggested by the home state price.[17] In order to obtain parameters of the cigarette demand function that are less prone to this source of bias, I explicitly model the heterogeneity in home state price effects due to varying smuggling incentives. In lieu of directly observing smuggling activity (which is unobservable in the data), I construct a model of cigarette demand that incorporates the decision of whether to smuggle based on observable consumer characteristics.

A MODEL OF CIGARETTE DEMAND WITH CROSS–BORDER PURCHASES

Assume each consumer faces two prices: the price of cigarettes in the home state (P_h) and the price of cigarettes in the closest lower–price locality (P_b). Additionally, assume the parameters of the demand function are the same regardless of the place of purchase. In other words, consumers differ solely by the price they pay

[16] The intensive margin is the number of cigarettes smoked by smokers, the extensive margin is the smoking participation rate, and the full margin is the number of cigarettes smoked by all consumers, including non–smokers.

[17] I also compare consumption responses to changes in home state and border state prices for those living on the high–price side and low–price side of the border in the 11 identified MSAs that split state lines. The results from this comparison are consistent with the existence of the home state price bias: those living on the high–price side of the border respond to changes in the border state price more than the home state price, and those living on the low–price side respond more to changes in the home state price than the border state price.

for cigarettes. Let demand of consumer i be given by

$$[1]\quad E[\ln(Q_i) \mid P_j, X_i] = \beta_0 + \beta_1 \ln(P_j) + \gamma X_i, \quad j = b, h$$

where X is a vector of individual characteristics. Demand can then be written as

$$[2]\quad E[\ln(Q_i) \mid P_h, P_b, X_i] = (\beta_0 + \beta_1 \ln(P_h) + \gamma X_i)(1 - S_i) + (\beta_0 + \beta_1 \ln(P_b) + \gamma X_i)(S_i) = \beta_0 + \beta_1(\ln(P_h)(1 - S_i) + \ln(P_b) S_i) + \gamma X_i,$$

where S_i is an indicator function that equals one if an individual smuggles and zero otherwise. One can see from equation [2] the biases associated with treating the home state cigarette price as the actual price paid by all consumers. The elasticity with respect to the home state price (hereafter the "home state price elasticity") is given by

$$[3]\quad \varepsilon_H = \beta_1(1 - S_i) - \frac{\Delta S_i}{\Delta \ln(P_h)} \beta_1 \ln\left(\frac{P_h}{P_b}\right).$$

Note that unless $S_i = 0$ and the price change does not induce consumer i to smuggle, the home state price elasticity will be less than β_1 in absolute value as the home state price is higher than the border price by construction.

The other elasticity of interest is the "full price elasticity," which yields the percent change in cigarette demand when the full price of cigarettes changes by one percent. In other words, the full price elasticity measures the responsiveness of demand when all prices change such that the smuggling decision is unaltered. This elasticity is given by β_1 in equation [2].

The central difficulty in estimating the parameters of equation [2] is S_i is unobserved; location of purchase is not in the data. My solution to this problem is to parameterize the S function and then incorporate these parameters into equation [2]. Instead of a deterministic indicator function governing the decision to smuggle, the parameterization yields the probability, conditional on the observables, that individual i purchases cigarettes in a border locality. Specifically, I assume the probability an individual smuggles is decreasing in the cost of smuggling and increasing in the marginal gains from smuggling.

I model the smuggling cost of obtaining cigarettes in a lower–price locality as $\delta\ln(D) - \phi$, where D is the distance to the closest lower–price border state. The other cost parameter is ϕ, which indexes the fixed cost individual i would incur by purchasing in the home state regardless of his location with respect to the lower–price border.

Note that I assume all smugglers make the same number of trips, which is akin to assuming smuggling costs are independent of the number of cigarettes purchased. Thus, conditional on the consumer's location, smuggling costs are fixed and vary only with the distance to a lower–price border. The data corroborate this assumption by strongly rejecting any correlation between distance and consumption absent any price difference across localities.

I assume the savings from purchasing in a lower–price jurisdiction is proportional to the difference in log home and log border state prices. Assuming the probability one smuggles can be approximated using a linear probability model,[18] the smuggling equation is

[18] More specifically, assume there is a random component to the cost of smuggling, ε, which has a distribution $F(\varepsilon)$. Assuming a consumer will smuggle if the cost is greater than the benefit, $P(S_i = 1) = P(\alpha(\ln(P_h) - \ln(P_b)) > \delta\ln(D) - \phi + \varepsilon) = P(\varepsilon > \phi + \alpha(\ln(P_h) - \ln(P_b)) - \delta\ln(D))$. This expression is identical to equation [4] under the assumption that ε is uniformly distributed on [0,1].

$$[4] \quad P(S_i = 1) = \phi + \alpha(\ln(P_h) - \ln(P_b)) - \delta \ln(D_i) \equiv \rho.$$

Using the law of iterated expectations, equation [2] becomes

$$[5] \quad \beta_0 + \beta_1(\ln(P_h)(1 - P(S_i = 1)) + \ln(P_b)P(S_i = 1)) + \gamma X_i = \beta_0 + \beta_1 \ln(P_h) - \beta_1(\ln(P_h) - \ln(P_b))\rho + \gamma X_i.$$

Equation [5] represents a regression of log cigarette consumption on expected price given log distance, difference in log price, and ϕ. If ρ equals zero such that the consumer purchases at home with certainty, then only the home price matters. Conversely, if ρ is one and the consumer smuggles with certainty, then only the border price matters.

In previous studies using consumption data, Lewit et al. (1981) and Lewit and Coate (1982) assume full smuggling in a 20–mile band, which implies $\rho = 1$ if individuals live within 20 miles of the border and $\rho = 0$ if they do not. Similarly, by using an average price within 25 miles for all consumers, Chaloupka (1991) implicitly sets $\rho = 1/2$ for those within 25 miles of a border and assumes $\rho = 0$ for the rest of the sample. My approach provides a less arbitrary and more reasonable account of casual smuggling than previous models as it allows the probability of smuggling (i.e., the weights on home and border state prices) to vary over the entire population based on differences in smuggling incentives.

Substituting equation [4] into equation [5] yields the reduced form demand equation used throughout this study:[19]

$$[6] \quad \Pi_0 + \Pi_1 \ln(P_h) + \Pi_2(\ln(P_h) - \ln(P_b)) + \Pi_3(\ln(P_h) - \ln(P_b))^2 + \Pi_4 \ln(D_i)(\ln(P_h) - \ln(P_b)) + \gamma X_i.$$

One concern with the reduced form demand function given by equation [6] is the log distance measure.[20] This is a potential problem because one might expect the impact of distance on demand to go to zero as distance approaches infinity. The log distance term implies as distance becomes arbitrarily large, log demand decreases to negative infinity. While such a critique could be levied against any log–log model, it is important to note using log distance is a simplifying assumption,[21] and equation [6] represents a parametric approximation to the true demand function. To address this problem when calculating the home state price elasticities, I constrain the home state price elasticity to be weakly smaller in absolute value than the full price elasticity. In effect, this restricts cross–state purchases to be zero when the cross–border price differential is low

[19] This substitution implies $\Pi_1 \equiv \beta_1, \Pi_2 \equiv -\beta_1 * \phi, \Pi_3 \equiv -\beta_1 * \alpha,$ and $\Pi_4 \equiv \beta_1 * \delta$.

[20] Another way to proceed would be to relax the constraints imposed by a log distance measure and use a polynomial in distance or dummy variables for different ranges of distance. These specifications are attractive as they allow the relationship between demand and distance to be relatively flexible as distance changes. I estimate demand functions using such specifications, but the small sample sizes in the data do not allow meaningful statistical inferences to be drawn from the results. Taking the point estimates at face value yields results that are similar to the ones presented.

[21] The main advantage of using log distance rather than distance is when distance is used in the regression, the effect of distance on the responsiveness of consumption to the home state price is the same no matter how far the consumer is to a lower–price border. Using log distance, the impact of distance on consumption decreases with distance. Thus, a one–mile increase in distance to a lower–price state will impact the home state price elasticity more for a consumer living five miles from the border than for a consumer living 500 miles from the border.

and/or the consumer lives far from the border.[22]

As the model is constructed, the expectation is δ, ϕ, and α are all positive because the probability of smuggling should be decreasing in distance from a lower–price border, increasing in price difference, and increasing in the fixed cost parameter. It is natural to expect β_1 to be negative, which implies $\Pi_1 < 0$, $\Pi_2 > 0$, $\Pi_3 > 0$, and $\Pi_4 < 0$.

The expected signs of Π_1 through Π_4 illustrate the predictions of the model for the responsiveness of consumption to the home state price. Conditional on distance, an increase in the price difference should render consumption less sensitive to the home state price. Conversely, an increase in distance to a lower–price border should make demand more responsive to the home state price as the cost of obtaining a given amount of savings has risen.

ESTIMATION STRATEGY

I estimate demand functions on the intensive margin (Q = number of cigarettes smoked per day by smokers), extensive margin (Q = smoking participation rate), and full margin (Q = number of cigarettes smoked per day, including non–smokers). I employ state–MSA fixed effects in all regressions, so only within–MSA across–time variation in prices, distance, and price differences are used to identify the parameters of the demand function. It is important to use fixed effects in such regressions because individuals may differ across MSAs and across states in their preferences for smoking, conditional on price. For example, people might be less averse to smoking in a tobacco producing state such as Kentucky than in a high anti–smoking sentiment state like Massachusetts. The fact that Massachusetts is a high cigarette tax state and Kentucky is a low cigarette tax state is likely a function of these same preferences. Without fixed effects, demand regressions attribute some of the preference–related smoking differences across states or MSAs to price differences, causing an upwards omitted variables bias in the coefficient on price.[23]

Because I am interested in estimating demand functions, the price changes that occur in the data need to be independent of the unobservables in the quantity demanded equation, conditional on the observable variables included in the model. Keeler, Hu, Barnett, Manning, and Sung (1996) present evidence that such independence may not hold; they find cigarette producers price discriminate by state based on numerous demographic and state legal factors. If prices are a function of the demographic composition of the state and if these demographic factors play a role in preferences for cigarettes, price changes will be endogenous to cigarette demand. It is unlikely I will be able to control for all factors that jointly affect demand and price discrimination. Thus, using state average prices in the demand regressions is likely to lead to biased parameter estimates on the price vari-

[22] When I relax this restriction, the home state price elasticities become slightly more negative, but the substantive conclusions and findings reported do not change. I perform sensitivity tests by restricting the effect of distance on demand to be zero for those living far away from borders or for whom the savings per mile from smuggling is low. I find these models yield similar results to equation [6], and results are available upon request. Log distance is used in all regression for simplicity, but my results are robust to more complex relationships between smuggling and distance.

[23] One complication with using state or MSA fixed effects is multicollinearity with prices. I run auxiliary regression of home state price on a year trend and state fixed effects and find an R^2 of 0.82. The associated variance inflation factor (VIF = $R^2/1 - R^2$) is 4.42. A VIF less than ten is typically considered an acceptable amount of multicollinearity, so the fixed effects are not soaking up all of the price variation in my regressions.

ables. In order to account for this endogeneity, I instrument all price variables with tax variables.[24] Further, if price differences across MSAs in different states are correlated with distance between the MSAs, there will be measurement error in the price differences as I am using differences in average state prices. Instrumenting the price difference with the tax difference should overcome any biases associated with such measurement error. Note taxes are thus only a valid instrument for prices if state excise taxes are not set in response to the distance between MSAs across states or in response to differing home state price elasticities.[25]

While much of the data are collected at the individual level, the independent variables of interest vary at the state–MSA level. Thus, for each of the 12 tobacco supplements, I collapse the data into MSA–specific means using the non–response weights included in the survey data. This aggregation is justified by interpreting the consumer in the model presented in the fourth section as the representative or "average" consumer in a given MSA.[26] The aggregated data set contains 2,904 observations at the state–MSA level. I also weight all regressions by the number of observations that constitute each MSA mean and estimate heteroskedasticity–robust standard errors.

The demographic variables used in the regressions that follow are the state–MSA mean values of age, sex, weekly wage, marital status, race (with white as the excluded category), education (with no high school diploma as the omitted category), and labor force status (with not in the labor force as the omitted category). Means of all variables by year are presented in Table 5.

As Table 5 illustrates, there is a large decrease in the amount smoked by smokers and a modest decrease in the percentage of smokers over the time span of this analysis. These trends could be due to the price increases that occur over this period, but there are undoubtedly also secular trends stemming from aggregate changes in views and preferences with respect to smoking. Including a linear year trend in the demand models is thus appropriate. I present estimates both including and excluding the year trend for all specifications.[27]

It is important to note distance does not appear as a separate right–hand side variable in equation [6]. This exclusion comes from the assumption that the distance to a lower–price jurisdiction impacts smuggling but not quantity demanded, conditional on the decision to smuggle. In other words, the model predicts distance does not belong in X. In the regressions that follow, I include log distance in X as

[24] Using taxes to instrument for prices is also beneficial because the price variation due to cigarette tax changes more likely identifies the demand curve. Much of the evidence on cigarette taxes suggests these taxes are either fully or more than fully passed on to consumers (Chaloupka and Warner, 2000). Using the price data described in the previous section, I regress real state price on real state taxes with state fixed effects and a year trend for 1992–2002. I estimate a coefficient of 1.28 on the tax variable with a standard error of 0.003. Due to this evidence, I will assume throughout that supply is inelastic and that the parameters estimated in the demand function are not confounding supply and demand. This assumption is prevalent in the literature.

[25] The evidence on how states set cigarette excise taxes, while sparse, supports this assumption. The cross–state variation in excise taxes is driven largely by differences in attitudes towards smoking as well as by economic factors that may lead states to increase excise taxes as a way to raise revenue (ACIR, 1985).

[26] Results and conclusions are qualitatively similar when I use the individual–level data clustered at the state–MSA level. Results from such regressions are available from the author upon request.

[27] The results and conclusions are unchanged when I use year fixed effects or survey date fixed effects instead of a linear year trend.

TABLE 5
MEANS OF SELECTED CPS VARIABLES FROM THE TOBACCO SUPPLEMENT SURVEYS BY YEAR

Variable	1992–1993	1995–1996	1998–1999	2001–2002
Cigarettes per day (all)	3.25 (1.00)	3.01 (1.07)	2.59 (0.94)	2.29 (1.00)
Cigarettes per day (smokers)	16.91 (2.43)	16.60 (2.84)	15.77 (2.80)	14.83 (2.82)
Percent smokers	0.23 (0.05)	0.22 (0.05)	0.20 (0.05)	0.19 (0.05)
Real home state price	2.27 (0.25)	2.26 (0.30)	2.83 (0.41)	3.67 (0.45)
Price difference (without Native American Reservations)	0.21 (0.14)	0.26 (0.24)	0.31 (0.25)	0.35 (0.27)
Price difference (with Native American Reservations)	0.29 (0.19)	0.35 (0.26)	0.43 (0.31)	0.45 (0.32)
Real home state tax	0.48 (0.16)	0.54 (0.23)	0.63 (0.29)	0.68 (0.32)
Tax difference (without Native American Reservations)	0.14 (0.14)	0.21 (0.19)	0.26 (0.22)	0.28 (0.22)
Tax difference (with Native American Reservations)	0.24 (0.21)	0.30 (0.23)	0.40 (0.30)	0.40 (0.31)
Distance (without Native American Reservations)	89.56 (86.11)	91.74 (87.43)	93.02 (85.68)	98.94 (96.92)
Distance (with Native American Reservations)	65.88 (66.44)	62.95 (63.07)	67.91 (65.49)	74.41 (80.95)
Age	42.67 (2.37)	42.89 (2.40)	42.95 (2.51)	43.15 (2.54)
Percentage male	0.53 (0.03)	0.52 (0.03)	0.52 (0.03)	0.52 (0.03)
Percentage married	0.55 (0.06)	0.55 (0.07)	0.53 (0.06)	0.53 (0.06)
Real weekly wage	70.85 (43.80)	76.29 (22.52)	87.71 (26.74)	72.06 (51.52)
Percentage black	0.13 (0.11)	0.13 (0.12)	0.13 (0.11)	0.12 (0.12)
Percentage Native American	0.003 (0.008)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Percentage Hispanic	0.08 (0.11)	0.09 (0.12)	0.10 (0.13)	0.10 (0.12)
Percentage Asian	0.02 (0.03)	0.03 (0.04)	0.03 (0.04)	0.03 (0.04)
Percentage HS diploma	0.32 (0.06)	0.31 (0.06)	0.30 (0.06)	0.29 (0.06)
Percentage some college	0.18 (0.05)	0.19 (0.04)	0.19 (0.04)	0.19 (0.05)
Percentage associates degree	0.06 (0.02)	0.07 (0.03)	0.07 (0.03)	0.07 (0.03)
Percentage BA	0.14 (0.04)	0.16 (0.05)	0.16 (0.05)	0.17 (0.05)
Percentage graduate school	0.07 (0.03)	0.08 (0.03)	0.08 (0.04)	0.09 (0.04)
Percentage work	0.61 (0.06)	0.63 (0.07)	0.65 (0.06)	0.65 (0.06)
Percentage unemployed	0.05 (0.02)	0.04 (0.02)	0.03 (0.02)	0.04 (0.02)

Source: CPS Tobacco Supplements. Means include individuals living only in an identified MSA. Standard deviations of each variable are in parentheses.

an over–identification test of the exclusion restriction.[28]

RESULTS

Coefficient Estimates

Table 6 presents the results from the estimation of demand function [6]. Panels A–C contain estimates for the intensive, extensive, and full demand models, respectively. All three panels contain six columns of results; I control for year trends in only even numbered columns. Columns i and ii present estimates from the demand model ignoring all smuggling incentives and geographic variability. Such a model is similar to what other researchers have used when studying cigarette demand using micro data and is useful in understanding the impact of accounting for smuggling behavior. Columns iii–vi contain estimates from the demand model outlined in the previous sections, with the final two columns including Native American Reservations in the price difference and distance variables.

In the specifications that account for smuggling, the coefficient on log real home state price is negative and significant at either the five or ten percent level. As this coefficient also represents the full price elasticity, Table 6 illustrates, absent smuggling, that there is a consistent negative relationship between price and consumption on the intensive, extensive, and full margins.

The coefficient on the difference in log price, log distance interaction variable is a central parameter in this study because it describes how the responsiveness of demand to home state price changes varies with distance to a lower–price border. In all relevant columns of Table 6 (columns iii–vi), this coefficient is negative and is significant at the five percent level in all but the final two columns of Panel B. I estimate this coefficient to be around –0.2 in the intensive and extensive demand models and between –0.58 and –0.42 for the full model. Thus, the relationship between quantity demanded and the home state price is quite sensitive to the distance to the closest lower–price border.[29]

The coefficient on the difference in log price variable is positive in all specifications, but is often not significant at either the five or ten percent level. The estimates range from 0.69 to 1.06 on the intensive and extensive margins and 2.17 to 2.55 on the full margin. Finally, across all specifications in Table 6, the coefficient on the difference in log price squared varies in sign but is not statistically significant.

As discussed in the fifth section, the log distance variable does not appear in equation [6] as a separate explanatory

[28] Including log distance as a regressor, equation [6] can be interpreted as a specific form of a more general log–linear second order demand function approximation. The second order approximation includes the $\ln(P_h)$, $\ln(P_h) - \ln(P_b)$ and $\ln(D)$ terms as well as all squared terms and cross–products. While there are some quantitative differences, the elasticity estimates from the full second order log linear approximation are qualitatively similar to the ones presented and are available upon request. Thus, while the demand model presented in the fourth section is useful in providing an interpretation of the regression coefficients, my results are robust to a more general demand function approximation that embodies fewer assumptions.

[29] One potential bias in identifying the parameter on the log distance, log price difference variable is the existence of Internet smuggling. Goolsbee, Lovenheim, and Slemrod (2007) find evidence using CPS Internet data and taxed state sales of substantial Internet smuggling, which would bias my estimates because one would expect as distance to a lower–price locality increases, the likelihood of smuggling over the Internet would also increase, *ceteris paribus*. Excluding Internet smuggling might cause an overstatement of the estimated impact of distance on demand. To check whether this is the case, I interact average MSA Internet connectivity calculated from the CPS as described in Goolsbee et al. (2007) with the price difference, log distance interaction term. If the exclusion of the Internet is a source of bias, the coefficient on the triple interaction term should be positive and significant. The point estimates are negative, small and not significant, however, and the other coefficients are quite similar to those in Table 6. Results are available from the author upon request.

TABLE 6
IV ESTIMATES OF CIGARETTE DEMAND MODELS, 1992–2002

Native American Reservations Included?:	No	No	No	No	Yes	Yes
Independent Variable	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Panel A: Intensive Margin Dependent Variable = Log Mean MSA Daily Cigarette Consumption of Smokers						
Log real home state price (Π_1)	–0.148** (0.023)	–0.058 (0.048)	–0.175** (0.022)	–0.115* (0.059)	–0.181** (0.022)	–0.098 (0.071)
Difference in log price (Π_2)			0.882* (0.494)	0.767 (0.481)	0.748* (0.452)	0.690 (0.445)
Difference in log price squared (Π_3)			0.449 (0.818)	0.546 (0.808)	0.369 (0.786)	0.412 (0.772)
Log distance			0.003 (0.007)	0.004 (0.007)	0.003 (0.009)	0.003 (0.009)
Log distance × difference in log price (Π_4)			–0.226** (0.080)	–0.213** (0.079)	–0.180** (0.091)	–0.177** (0.090)
Year		–0.013** (0.004)		–0.007 (0.005)		–0.006 (0.006)
Panel B: Extensive Margin Dependent Variable = Log Mean MSA Smoking Participation Rate						
Log real home state price (Π_1)	–0.210** (0.030)	–0.176** (0.061)	–0.231** (0.029)	–0.227** (0.084)	–0.229** (0.034)	–0.295** (0.104)
Difference in log price (Π_2)			1.059 (0.673)	1.051 (0.662)	0.836 (0.633)	0.913 (0.644)
Difference in log price squared (Π_3)			–0.393 (1.049)	–0.388 (1.036)	–0.639 (0.960)	–0.128 (0.122)
Log distance			0.004 (0.008)	0.004 (0.008)	–0.015 (0.011)	–0.016 (0.011)
Log distance × difference in log price (Π_4)			–0.211** (0.108)	–0.210** (0.106)	–0.120 (0.121)	–0.208* (0.128)
Year		–0.005 (0.006)		–0.001 (0.006)		0.009 (0.010)
Panel C: Full Margin Dependent Variable = Log Mean MSA Daily Cigarette Consumption of All Individuals						
Log real home state price (Π_1)	–0.437** (0.046)	–0.326** (0.093)	–0.489** (0.045)	–0.457** (0.125)	–0.444** (0.052)	–0.527** (0.154)
Difference in log price (Π_2)			2.547** (1.064)	2.483** (1.044)	2.171** (0.892)	2.269** (0.894)
Difference in log price squared (Π_3)			0.114 (1.772)	0.151 (1.703)	–0.416 (1.391)	–0.435 (1.384)
Log distance			0.011 (0.011)	0.011 (0.012)	–0.010 (0.016)	–0.011 (0.017)
Log distance × difference in log price (Π_4)			–0.584** (0.161)	–0.576** (0.158)	–0.420** (0.171)	–0.430** (0.173)
Year		–0.017** (0.009)		–0.004 (0.012)		0.011 (0.015)

Notes:
1. All regressions include fixed effects for each unique state–MSA combination and are weighted by the number of observations that constitute each MSA–level mean. MSA means of the following variables are also included in the regressions: age, percent male, percent married, weekly wage, percent Black, percent Native American, percent Hispanic, percent Asian, percent high school diploma, percent some college, percent associates degree, percent BA, percent graduate school, percent working, and percent unemployed. Full regression estimates are available from the author upon request.
2. Price variables are instrumented with tax variables as described in the text.
3. Robust standard errors are in parentheses: * indicates significance at the 10 percent level and ** indicates significance at the 5 percent level.
Source: Parameter estimates from the author's estimation of equation [6] in the text using the 1992–2002 CPS Tobacco Supplements. Only those living in identified MSAs are included in the regressions.

variable. The inclusion of this coefficient provides an over–identification test that excluding distance from the demand model is appropriate. In all three panels, I find the coefficient on log distance to be small and not statistically significant at the five or ten percent level.[30] This is evidence that changes in distance do not affect consumption if the price difference is zero; conditional on the decision to smuggle, distance has no impact on quantity demanded.

Estimated Elasticities

The coefficient estimates shown in Table 6 yield insight into the relationship between cigarette consumption, cigarette prices, and distance. These effects can be summarized more simply by calculating the home state and full price elasticities, which give the percent change in cigarette consumption due to a one percent change in the home state price and in all prices, respectively. Both elasticities can be calculated from equation [6]:

[7] $$\text{Home State Price Elasticity} = \frac{\partial \ln(Q)}{\partial \ln(P_h)} = \Pi_1 + \Pi_2 + 2\Pi_3(\ln(P_h) - \ln(P_b)) + \Pi_4 \ln(D)$$

[8] $$\text{Full Price Elasticity} = \left.\frac{\partial \ln(Q)}{\partial \ln(P_h)}\right|_{d\ln(P_h)=d\ln(P_b)} = \Pi_1.$$

Table 7 presents home state and full price elasticity estimates calculated from the coefficients in Table 6. All panels and columns correspond to the same specification from Table 6. In columns i and ii, where geographic variability and smuggling incentives are ignored, the home state and full price elasticities are identical by definition. Thus, only the former statistic is shown. Robust standard errors are in parentheses.

The home state price elasticities range from –0.03 to 0.08 on the intensive margin, –0.06 to –0.02 on the extensive margin and –0.11 to 0.06 for the full margin. In no specification are these elasticities differentiable from zero at the five or ten percent level. These numbers imply, on average, in the presence of cross–locality price differentials, home state price changes have a negligible effect on cigarette demand.

The home state price elasticities contrast markedly and statistically significantly with the full price elasticities, which range from –0.18 to –0.10 on the intensive margin, –0.30 to –0.23 on the extensive margin, and –0.53 to –0.44 on the full margin. These elasticities are larger in absolute value than the home state price elasticities, and the full margin elasticities are consistent with many of the elasticity estimates from the taxable sales literature.[31] When one adequately controls for cross–border purchases, it is possible for the full price elasticities calculated using micro data to mirror the estimates from the taxable sales literature.

A specific example is illustrative of the difference between the home state and full price elasticities. In the last column of Panel C, the home state price elasticity is 0.03 while the full price elasticity is –0.53. This gap suggests while smoking is unresponsive to changes in the home state price on average in the presence of casual smuggling, if smuggling were eradicated, home state cigarette price elasticities could reduce cigarette consumption. Due to the

[30] Log distance is likely to be correlated with $(\ln(P_h) - \ln(P_b))*\ln(D)$. Thus, although the coefficient on $\ln(D)$ is not statistically differentiable from zero, its exclusion from the regression may affect the coefficients on other variables. I estimate the demand model both including and excluding log distance and find no difference in results.

[31] Chaloupka and Warner (2000) report these studies are consistent in estimating elasticities in a neighborhood of –0.4.

TABLE 7
PRICE ELASTICITIES, SMOKING INCREASES, AND SMUGGLING PERCENTAGES IMPLIED BY PARAMETER ESTIMATES IN TABLE 6

Native American Reservations Included?:	No	No	No	No	Yes	Yes
Elasticity	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Panel A: Intensive Margin—Log Mean MSA Daily Cigarette Consumption of Smokers						
Mean home state price elasticity	–0.148**	–0.058	–0.029	0.004	0.047	0.076
	(0.023)	(0.048)	(0.111)	(0.115)	(0.087)	(0.092)
Mean full price elasticity			–0.175**	–0.115*	–0.150**	–0.098
			(0.022)	(0.059)	(0.024)	(0.071)
Percent increase in smoking due to smuggling			1.516	1.211	2.543	2.164
Panel B: Extensive Margin—Log Mean MSA Smoking Participation Rate						
Mean home state price elasticity	–0.210**	–0.176**	–0.063	–0.061	–0.018	–0.045
	(0.030)	(0.061)	(0.137)	(0.140)	(0.113)	(0.115)
Mean full price elasticity			–0.231**	–0.227**	–0.229**	–0.295**
			(0.029)	(0.084)	(0.034)	(0.104)
Percent increase in smoking due to smuggling			2.036	2.007	3.670	4.277
Panel C: Full Margin—Log Mean MSA Daily Cigarette Consumption of All Individuals						
Mean home state price elasticity	–0.437**	–0.326**	–0.105	–0.088	0.059	0.025
	(0.046)	(0.093)	(0.224)	(0.229)	(0.170)	(0.175)
Mean full price elasticity			–0.489**	–0.457**	–0.444**	–0.527**
			(0.045)	(0.125)	(0.052)	(0.154)
Percent increase in smoking due to smuggling			4.154	3.972	7.520	8.172
Smuggling percent			13.405	13.068	24.048	25.071

Notes:
1. All means in the table are calculated over state–MSA and year and are weighted by the number of observations that constitutes each state–MSA observation.
2. Robust standard errors are in parentheses: * indicates significance at the 10 percent level and ** indicates significance at the 5 percent level.
Source: Elasticity estimates come from the author's calculation of equations [7] and [8] in the text using parameter estimates from Table 6. Smoking increases are calculated from equation [9] in the text and smuggling percentages from equation [10] in the text using the parameter estimates from Table 6 as well.

inelastic nature of the full price elasticity, cigarette taxes could serve as an effective revenue generating mechanism for states as well.

The elasticities in the first two columns range from –0.21 to –0.06 on the intensive and extensive margins and –0.44 to –0.33 on the full margin. They are generally consistent in magnitude and sign with other studies using individual consumption data with fixed effects (Farrelly et al., 2001; Farrelly and Bray, 1998; Coleman and Remler, 2004). In all three panels of Table 7, a comparison of the first two columns with the last four columns illustrates ignoring geographic variability causes one to overstate the home state price elasticity and understate the full price elasticity in absolute value, though the "naïve" elasticity estimates are often quite close to, and are not statistically different from, the full price elasticities.[32]

[32] Interestingly, when I set $\rho = 1$ within 20 miles of the border and $\rho = 0$ outside of 20 miles of the border, I find elasticities that are strictly between my full price elasticities and the "naïve" elasticities in columns i and ii. The same result occurs when I set $\rho = 0.5$ within 25 miles of the border and $\rho = 0$ outside of 25 miles. Such methodologies replicate the strategies of Lewit et al. (1981), Lewit and Coate (1982), and Chaloupka (1991), and the results are evidence that exogenously setting ρ in this manner only partially accounts for smuggling behavior.

The implication of this finding is ignoring smuggling incentives when using micro–data will not produce large biases in estimates of the full price elasticity on average. This is an interesting result as there is no reason to believe, *a priori*, that the bias in the full price elasticity will be small. Further, omitting smuggling incentives from cigarette demand models will preclude one from estimating the home state price elasticity, which is arguably the more important parameter from a state tax policy perspective as it yields the actual effect of a tax increase on consumption in a given state rather than the potential effect absent smuggling.

Smoking Increases, Casual Smuggling Percentages, and Net Sales Effects

Because cross–state price differentials offer consumers access to lower–priced cigarettes, casual smuggling can increase cigarette consumption. I calculate smoking increases due to the effective price reduction from smuggling by comparing the predicted value from each regression to the predicted value from a counterfactual in which there is no casual smuggling. This counterfactual is constructed by setting the price difference equal to zero. More explicitly

[9] Percent Change in Q

$$= \frac{E[Q \mid P_h = p_h, P_b = p_b] - E[Q \mid P_h = P_b]}{E[Q \mid P_h = p_h, P_b = p_b]}.$$

Due to the functional form of the demand function, the preceding expression can be negative for those who live very far from the border. To correct for this problem, I set the percent change equal to zero if it is negative. Note this adjustment produces similar results to constraining the home state price elasticity to be weakly greater than the full price elasticity: those who live far from lower–price borders are assumed not to smuggle. The third row of each panel in Table 7 contains estimates of the percent increase in smoking due to smuggling. Cross–border purchases increase consumption between 1.2 and 2.5 percent on the intensive margin and between 4.0 and 8.2 percent for the full model. Further, the availability of cheaper cigarettes increases the smoking participation rate by 2.0 to 4.3 percent.

The demand model given by equation [6] also allows me to calculate the proportion of individuals who purchase cigarettes in border localities in a given MSA. I assume if everyone lived directly on the border, no one would purchase in the higher–price state. Comparing consumption for such individuals with consumption for those who do not live close to the border yields the percentage of consumers who smuggle:

[10] Smuggling Percentage =

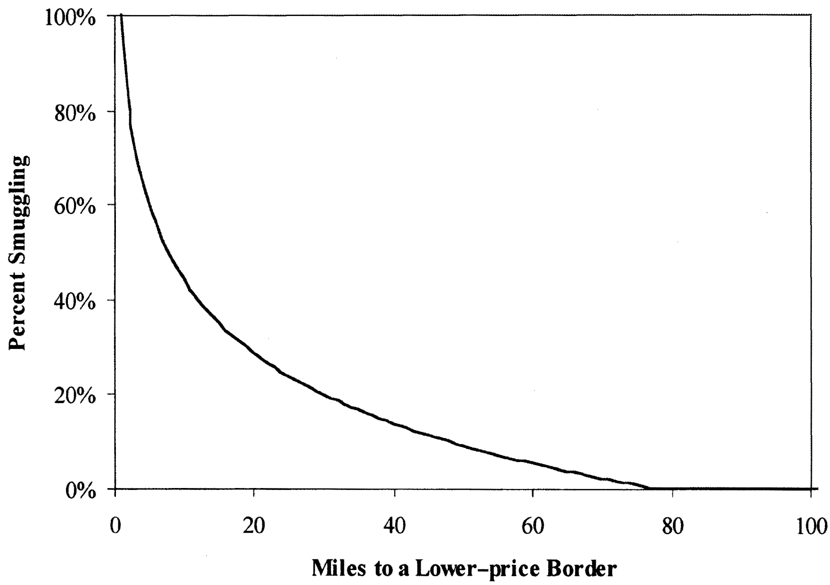
$$\frac{E[Q \mid P_h = p_h, P_b = p_b, \ln(D) = \ln(d)] - E[Q \mid P_h = P_b, \ln(D) = \ln(d)]}{E[Q \mid P_h = p_h, P_b = p_b, \ln(D) = 0] - E[Q \mid P_h = P_b, \ln(D) = \ln(d)]}.$$

If everyone behaves as if they live on the border, so $E[Q \mid P_h = p_h, P_b = p_b, \ln(D) = \ln(d)] = E[Q \mid P_h = p_h, P_b = p_b, \ln(D) = 0]$, then the above equation implies 100 percent smuggling. If, on the other hand, everyone behaves as if they purchase from their home state (meaning that the price difference is zero), then $E[Q \mid P_h = p_h, P_b = p_b, \ln(D) = \ln(d)] = E[Q \mid P_h = P_b, \ln(D) = \ln(d)]$, and there will be zero smuggling. The smuggling percentage is the ratio of these two quantities. Another way to proceed would be to use the parameter estimates from Table 6 to identify the parameters in equation [4] and calculate $P(S_i = 1)$. Since I assume a linear probability model for smuggling, this procedure can create estimates outside of the range 0,1. Equation [10] can be thought of as a rescaling of $P(S_i = 1)$ to be between 0 and 1. I am essentially determining the extent to which individuals behave as if they live in the home state and face only the border price, or live in the home state and face only the home state price. I perform this calculation only for the full demand model, as the statistic does not have the same interpretation if applied to the intensive or extensive margins. Results are presented in Panel C of Table 7.

I find evidence of large amounts of cross–border purchases. Depending on the specification, the preceding calculation implies between 13.1 and 25.1 percent of consumers in MSAs purchase cigarettes in a lower–price state or reservation.[33] The estimates including Native American Reservations are much larger due to the reduction in traveling distance and price when these jurisdictions are included (see Table 5). The estimates in Table 7 are population–weighted averages over all MSAs. It is important to note these percentages can only be generalized to the United States as a whole if the distribution of distance with respect to lower–price borders for MSAs are representative of the distribution for non–MSAs. It is unclear whether the preceding estimates are smaller or larger than they would be for the United States as a whole, and the reader is urged to use caution when applying these estimates out of sample.

Figure 1 presents a simulation of smuggling percentage for different distances at the mean level of all variables aside from distance. The parameter estimates used were those from Table 6, Panel C, column iv. The figure represents how smuggling changes by distance for the average consumer in the sample. The percent smuggling ranges from a high of 100 for those

Figure 1. Simulated Effect of Distance on Percent Smuggling



Source: Author's calculations of equation [10] using parameter estimates from Table 6, Panel C, column iv as described in the text. Equation [10] is evaluated at the mean of all variables aside from distance.

[33] If I do not rescale the negative values to zero in equation [10], I estimate between 7 and 23 percent of consumers purchase cigarettes in lower–price localities. Thus, my results and conclusions are not sensitive to rescaling.

who live on the border to zero for those who live more than 77 miles from the border. While the shape of the figure is imposed by the assumption of a log–linear relationship between distance and smuggling, it is interesting to note that my estimates imply a good deal of smuggling behavior occurs outside of 25 miles, which is the cutoff assumed by Chaloupka (1991). Further, the assumption of 100 percent smuggling within a 20–mile band by Lewit et al. (1981) and Lewit and Coate (1982) appears to fit the data poorly. By allowing smuggling behavior to vary log linearly with respect to distance, my model and parameter estimates yield a more complete picture of cross–state purchasing behavior than previous studies.

Under the assumption cross–state purchasers smoke the same amount as those who purchase cigarettes in their home state, the smuggling percentage also can be interpreted as the proportion of consumed cigarettes that are purchased in border localities. My estimates imply consumers who smuggle will smoke more than those who do not. Thus, the smuggling percentage represents a lower bound on the percentage of cigarettes that are casually smuggled. When interpreted in this manner, these estimates are large, particularly in light of previous estimates of casual smuggling under one percent (Stehr, 2005).[34]

There are some sources of validation for this finding in the state of New York. The Center for a Tobacco–Free New York conducted a survey and found 25 percent of New York State residents purchased cigarettes on a Native American Reservation (FACT Alliance, 2005). Further, the New York Association of Convenience Stores found Western New York cigarette sales dropped between 25 and 50 percent after the 2000 tax increase (FACT Alliance, 2005). There is also anecdotal evidence of high volumes of casual smuggling: when South Dakota increased its cigarette excise tax by one dollar in January 2007, Larchwood Mini Mart in Iowa reported its January cigarette sales tripled total sales for 2006. One consumer reported she makes the 20–mile trip from Sioux Falls once or twice a week (Efrati, 2007).

Together with the average price differences listed in Tables 2 and 5, the distance distributions are consistent with the large predicted smuggling amounts. Although the mean of distance is 93 miles excluding Native American Reservations and 68 miles including Native American Reservations, the median of these variables is 65 and 45 miles, respectively. In the 2001–2002 CPS supplements, the median person living in an MSA lived approximately 49 miles from a lower–price border state or reservation. The average per–pack price difference faced by consumers was forty–five cents (a little over 12 percent of the average real home state price). As the average smoker smoked 15 cigarettes per day (three–fourths of a pack), she would save $123.19 per year by purchasing all of her cigarettes in a border locality and not changing her smoking behavior. This is a fairly substantial amount of average savings given most individuals need only travel 50 miles or less one to two

[34] A central reason for the difference between my estimates and those in Stehr (2005) is due to downward bias in his estimates. He identifies casual smuggling off of the average tax difference between the home state and all border states that have a higher tax than the home state. The main reason for the downward bias is when a state raises its tax level, this average difference will increase by less than the tax increase and can decrease due to the fact the tax increase can change the pool of higher–price states. The first states to drop out will be the lowest price "export" states. My estimates imply a one–cent increase in the home state tax causes a 0.24–cent drop in the average "export" state tax. This effect severely weakens the relationship between ln(consumption) – ln(sales) and the tax difference. Further, utilizing tax differences rather than price differences introduces measurement error as more than ten percent of tax differences have a different sign than the respective price difference. One can expect this measurement error to further obfuscate the smuggling regression in Stehr (2005).

times a year to realize them.[35] The large amount of casual smuggling implied by the empirical estimates is consistent with many consumers taking advantage of the substantial savings from purchasing in lower–priced jurisdictions.

Table 8 presents similar information to Table 7 broken down by state for the full model. The estimates are derived from column iv of Table 6, so they exclude Native American Reservations but include a year trend. Note these estimates are averages of the various statistics over MSAs within a state weighted by the number of observations that constitute each MSA–specific mean, not state–level estimates. Distance is still measured at the MSA level as this is the level of observation in the study. Table 8 illustrates the large differences across states in the responsiveness of consumption to changes in the home state price as well as in the percent of consumers who engage in casual smuggling. These results underscore the importance of accurately accounting for smuggling incentives in cigarette demand models; the "naïve" elasticity estimate of –0.326 in Table 6, Panel C, column ii provides a poor estimate of the home state price elasticity in many states.

The casual smuggling estimates presented in Table 8 vary from a high of 63 percent in Washington, D.C. to a low of zero percent in Delaware, Idaho, Kentucky, Missouri, New Hampshire, and New Mexico. The large value for Washington, D.C. occurs because it is three miles from Virginia, and there is an average difference of eighty–cents per pack between the two locations. Given the location of their MSAs with respect to lower–price borders, at least 25 percent of consumers in Arkansas, Massachusetts, Maryland, New Jersey, Rhode Island, and West Virginia are estimated to engage in smuggling activity. The home state price elasticities reflect these differences, with the low–smuggling states being more home price elastic than the high smuggling states. Similar patterns emerge for the impact of smuggling on smoking.[36]

Using the MSA–specific estimates of the percent of consumers who casually smuggle combined with information on the closest lower–price locality, I calculate the net percent change in sales for each state due to cross–border purchasing activity.[37] Results are reported in the final column of Table 8 and suggest that there are clear winners and losers from the existence of interstate price differentials. At the extreme, New Hampshire sales double because they are the lowest–tax state in New England. Virginia, Indiana, Kentucky, and Delaware also gain substantial sales from cigarette tax evaders. Conversely, Maryland, Kansas, Massachusetts, and Illinois lose significant sales (and thus tax revenue) due to the availability of lower–price cigarettes in nearby jurisdictions. These results imply that in the states with large quantities of smuggling and inelastic home state price elasticities, cigarette taxes are ineffective at both reducing smoking of residents and providing substantial tax revenue to the home state. Instead, these taxes often serve to export both consumers and tax revenues to nearby states.

[35] This calculation is based on an average cigarette shelf life of eight months (Wong, Ashcraft, and Miller, 1991). They report the shelf life of "normal cigarettes."

[36] Home state price elasticity and percentage smuggling estimates by state–MSA are presented in Appendix Table C–3 in Lovenheim (2007).

[37] For each MSA, I multiply the smuggling percentage by the number of cigarettes smoked. Summing this number within states gives the total number of consumed cigarettes purchased in another jurisdiction. I then attribute these purchases to the closest lower–price state for each MSA to find the sales increases due to smuggling in each state. The denominator in each calculation is the total consumed cigarettes in each state.

TABLE 8
PRICE ELASTICITIES, SMOKING INCREASES, PERCENT SMUGGLING, AND SALES EFFECTS BY STATE

Home State	Home State Price Elasticity	Full Price Elasticity	Percent Increase in Smoking Due to Smuggling	Percent of Consumers Who Smuggle	Percent Change in Net Sales Due to Smuggling
Alabama	–0.071	–0.457	2.52	18.66	–7.44
Arkansas	–0.034	–0.457	3.51	24.85	–16.04
Arizona	–0.427	–0.457	0.79	6.53	5.71
California	–0.455	–0.457	0.01	0.01	0.36
Colorado	–0.414	–0.457	0.45	3.93	–1.37
Connecticut	–0.186	–0.457	2.06	12.68	42.47
Washington, D.C.	1.398	–0.457	41.8	63.48	–63.48
Delaware	–0.457	–0.457	0.00	0.00	52.32
Florida	–0.357	–0.457	1.66	6.49	–4.34
Georgia	–0.367	–0.457	0.79	11.54	10.68
Iowa	–0.283	–0.457	0.88	7.26	49.7
Idaho	–0.457	–0.457	0.00	0.00	8.76
Illinois	0.210	–0.457	6.09	16.31	–15.83
Indiana	–0.240	–0.457	2.17	16.03	53.79
Kansas	0.271	–0.457	3.92	21.21	–24.91
Kentucky	–0.457	–0.457	0.00	0.00	61.33
Louisiana	–0.358	–0.457	0.05	2.54	1.88
Massachusetts	0.329	–0.457	15.45	36.66	–20.24
Maryland	0.402	–0.457	12.73	35.65	–29.18
Maine	0.068	–0.457	7.70	17.02	–17.02
Michigan	–0.223	–0.457	6.94	8.62	–5.95
Minnesota	–0.149	–0.457	2.50	11.35	–11.33
Missouri	–0.457	–0.457	0.00	0.00	35.55
Mississippi	–0.22	–0.457	0.40	9.12	55.17
North Carolina	–0.332	–0.457	0.23	5.55	6.71
North Dakota	–0.355	–0.457	0.68	3.38	–2.53
Nebraska	0.171	–0.457	0.86	19.38	–21.09
New Hampshire	–0.457	–0.457	0.00	0.00	104.21
New Jersey	0.377	–0.457	10.57	31.03	–6.53
New Mexico	–0.457	–0.457	0.00	0.00	10.86
Nevada	–0.341	–0.457	1.09	2.67	–4.60
New York	0.308	–0.457	6.45	19.62	–16.88
Ohio	–0.166	–0.457	1.81	13.02	–3.63
Oklahoma	–0.439	–0.457	0.06	0.70	10.44
Oregon	–0.453	–0.457	0.08	0.47	2.51
Pennsylvania	0.041	–0.457	2.44	13.07	0.44
Rhode Island	0.456	–0.457	4.85	34.85	–20.39
South Carolina	–0.111	–0.457	1.08	14.46	–6.15
South Dakota	–0.244	–0.457	0.49	7.71	–5.48
Tennessee	–0.022	–0.457	5.03	20.41	–6.62
Texas	–0.335	–0.457	1.62	5.69	–3.69
Utah	–0.27	–0.457	1.80	4.42	–6.01
Virginia	–0.244	–0.457	1.40	8.46	65.54
Vermont	–0.317	–0.457	1.24	4.55	18.10
Washington	–0.277	–0.457	7.93	11.84	–5.62
Wisconsin	–0.214	–0.457	0.89	8.63	1.98
West Virginia	0.108	–0.457	1.95	26.15	35.16

Note: All estimates are for years in which a state is not the lowest–priced state. The estimates represent the average across all MSAs within a state, not state–level averages, weighted by the number of observations that constitute each state–MSA observation.
Source: Elasticity estimates come from the author's calculation of equations [7] and [8] in the text using parameter estimates from Panel C, column iv of Table 6. Smoking increases are calculated from equation [9] in the text and smuggling percentages from equation [10] in the text using the parameter estimates from Panel C, column iv in Table 6 as well.

Discussion

The most striking finding in this analysis is that, on average, consumption is non–responsive to variation in the home state price. What the state average results in Table 8 make clear, however, is the substantial heterogeneity in home state price responsiveness that varies according to the geographic distribution of each state's population. Thus, in MSAs that are far from lower–price borders, the home state price elasticity is negative, whereas for those close to the border, my estimates imply a positive home state price elasticity.

There are two potential explanations for the finding that increasing home state prices can actually increase consumption. The first explanation rests on the fact that, conditional on the decision to smuggle, a consumer who smuggles will face a lower per–pack price than the consumer who purchases in her home state. If the fixed cost of smuggling is small relative to the per–pack price savings, it is reasonable to expect consumers who smuggle to smoke more than observationally similar consumers who do not smuggle. My results are consistent with such behavior as those close to lower–price borders are those for whom the fixed cost of smuggling is low, and I estimate home state price increases increase their cigarette consumption.

A second explanation is more behavioral, but also is conditional on the existence of fixed smuggling costs. There is much evidence in the marketing literature of an "inventory effect" on consumption: if a consumer faces larger package sizes or stockpiles the good, consumption will increase (Wansink, 1996; Wansink and Park, 2001; Chandon and Wansink, 2002). Such research is relevant to this study because when individuals purchase cigarettes in border localities, they are more likely to purchase in bulk due to the fixed travel cost of obtaining the cigarettes. The increased inventory after purchase may cause more consumption, especially in light of the fact that cigarettes are addictive. Thus, if those living close to lower–price borders are more likely to stockpile cigarettes due to the fixed costs of obtaining their cigarettes, then the inventory effect would imply those living close to a lower–price border should smoke more than those on the other side of the border. Indeed, while a direct test of the inventory effect is beyond the scope of my data, I calculate in MSAs that split state lines, those on the high–price side smoke, on average, 0.35 cigarettes more per day among smokers and have a smoking rate that is 1.2 percent higher than those on the low–price side. While these tabulations and my results are consistent with the existence of an inventory effect, further research in this area is needed.

CONCLUSION

Using data from the CPS Tobacco Supplement for four years over the period 1992–2002, this paper has developed and estimated a cigarette demand model that explicitly accounts for cross–border purchases. Unlike previous studies using individual consumption data, I am able to distinguish between the elasticity with respect to the home state price and the elasticity with respect to the full price of cigarettes, both of which are important parameters in setting effective state cigarette tax policy.

My estimates imply increasing state cigarette taxes, on average, has little impact on smoking behavior; the home state price elasticity is modest in magnitude across the majority of specifications. In fact, in all specifications, the home state price elasticity is indistinguishable from zero. There is, however, a large amount of heterogeneity across states in the effect of tax increases on consumption that is based on the geographic distribution of the population. In contrast, my findings suggest the full price elasticities are negative and are of sizeable magnitude, though also inelastic.

Using the parameters from my demand model, I estimate directly the percent of consumers who purchase in a lower–price jurisdiction as well as the net change in sales due to such behavior. My results indicate between 13 and 25 percent of consumers purchase cigarettes in a lower–price state or Native American Reservation. These estimates represent a lower bound on the percent of cigarettes purchased in border localities and suggest cross–border sales are significantly more prevalent than has been found in previous work (Stehr, 2005). Further, I find significant heterogeneity across states in the sales and revenue effects of casual smuggling.

The large magnitude of smuggling combined with the inelastic home state price elasticities suggest state–level cigarette taxation may be a poor policy instrument with which to decrease smoking and increase home state tax revenues in many states. However, that the full price elasticities are negative and significant across all specifications implies state–level cigarette excise taxes could be a useful tool to change smoking behavior and raise revenue if smuggling were eradicated. Slemrod (2007) found reducing organized smuggling incentives through a cigarette stamping law in Michigan had just such an effect.

The central implication of this study is, while cigarette taxes are ineffective in many states at achieving the goals for which they were levied, there are significant potential gains from price increases that are confounded by cross–border sales. From a policy standpoint, states with large populations near lower–price borders may be better served by expending resources to reduce casual smuggling or by lowering the excise tax to reduce the smuggling incentives supplied by a positive border price differential. In the absence of such policies, differential price increases across states will continue to be counterproductive for many states attempting to decrease smoking behavior and increase tax revenues.

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