Crossing the Line: Direct Estimation of Cross-Border Cigarette Sales and the Effect on Tax Revenues

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Abstract

Differences in excise taxes across jurisdictions create incentives for consumers to cross the border and to purchase in lower-tax jurisdictions. This paper introduces a discrete choice model to examine tax avoidance and state border crossing in the market for cigarettes. We exploit a rich dataset of consumer location choices and demographics to estimate a consumer's tradeoff between distance and price when choosing a location to maximize utility. Using the estimates from our location and demand models, we reconsider a recent public policy issue among states and simulate tax avoidance under alternative cigarette excise tax levels.

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1 Introduction

Differences in cigarette taxes create incentives for consumers to cross borders, either physically or online, and purchase in lower-tax jurisdictions. The potential savings to smokers are significant - in many cases, cigarette excise taxes vary substantially in neighboring states. For example, in January 2003, state cigarette taxes differed by $1.26 per pack in New Jersey and Delaware (at $1.50 and $0.24 per pack), by $0.99 per pack in Massachusetts and New Hampshire (at $1.51 and $0.52 per pack), and by $0.70 per pack in Michigan and Ohio (at $1.25 and $0.55 per pack). Moreover, tax differentials between states have increased over the past decade. In 1997, 46 states bordered a neighbor with a lower cigarette excise tax - in real terms, the mean difference between a state's cigarette excise tax and the lowest excise tax in a neighboring state was 21.9 cents per pack with a maximum differential of 71 cents per pack. By 2003, the mean differential increased to 39 cents per pack, and the maximum differential has increased to 126 cents per pack.[1]

State policy makers recognize the implications of border crossing for both fiscal and health policy. As noted during Maryland's 2003 debate over increasing cigarette taxes,

> Increasing the tobacco tax by $.36 to $1.36 will increase revenues by $73.9 million ... Currently there is an incentive for Maryland residents to travel to Delaware, Virginia, Pennsylvania or West Virginia because of the lower tax rates in the states. Increasing the tobacco tax will further increase this incentive.
>
> -Maryland General Assembly,
> Department of Legislative Services,
> 2003 Session, SB 324.

The degree to which cigarette taxes deter smoking or generate tax revenue depends upon the extent to which smokers are able to avoid higher taxes by crossing state borders. While consumer avoidance of cigarette taxes (and other excise or sales taxes more generally) have important fiscal and health policy implications, relatively little research has been able to directly observe and estimate border crossing by individual consumers. Although many studies

[1]In many cases, tax differentials have increased since 2003. By March 2007, the tax differential between New Jersey and Delaware had increased to $2.03 per pack, and the tax differential between Michigan and its current lowest-tax neighbor, Indiana, was $1.45 per pack. Following a tax increase in New Hampshire, the tax differential between Massachusetts and New Hampshire has fallen to $0.71 per pack.

have documented evidence consistent with border crossing, the few studies that estimate consumer border crossing do so indirectly, by inferring border crossing from smoking behavior of individuals who live close to and far from jurisdictional boundaries.

In this paper, we revisit the estimation of consumer response to differential state taxation by using a dataset in which we directly observe the location of purchase and price paid by each individual. This rich dataset allows us to directly estimate a consumer's choice of location of purchase as a function of travel costs, demographics, and the incentive created by differential taxation; we specify a discrete choice model where a consumer's choice of jurisdiction is part of a utility maximization problem.

We are able to separately identify the effect of price and income on an individual's propensity to cross the border from their effects on an individual's quantity of consumption. In our discrete choice model, each individual chooses among several alternatives; they can purchase cigarettes within their home state, online, or at any neighboring state. We exploit variation in consumers' choice sets to identify the effects of price and income on the decision to cross the border. For instance, we can compare the purchase location decisions of similar consumers who live near and far from borders to identify the effect of distance on the probability of purchasing out of state. We can also examine individuals with high and low incomes who live within the same proximity of borders to identify the effect of income on the propensity to travel.

Our approach innovates over the existing literature in four important ways. First, consumer-level information on demographics allow us to estimate how individual characteristics affect a consumer's propensity to travel.[2] To our knowledge, these are the first direct estimates of travel incentives for cigarettes. Using estimates from our location model, we find that an individual is willing to travel 3 miles to save one dollar on a pack of cigarettes, and the marginal cost of travel for the average consumer is approximately 32 cents per mile. Given that the average difference in state taxes is 64 cents per pack for consumers who live near borders, a consumer purchasing a single pack of cigarettes would be willing to travel 1.3 miles to a lower tax jurisdiction.

By directly estimating a discrete choice model of purchase location, we derive more reliable estimates of border crossing than the previous literature, which indirectly infers border crossing from smoking intensity. Using our approach, we estimate that 4 percent of smokers will purchase cigarettes out of

[2]In this paper, we focus on casual smuggling where consumers travel across borders to purchase cigarettes. This differs from "long distance" smuggling, which involves the illegal transportation of large quantities of cigarettes across state borders.

state. Our estimates lie between those by Lovenheim (2008) and Stehr (2005). Lovenheim (2008) finds that between 13 and 25 percent of all individuals within an MSA close to the border will purchase cigarettes in border localities. In contrast, Stehr finds less border crossing; he estimates that border crossing accounts for less than one percent of all sales of cigarettes.

Secondly, this is the first paper to provide an estimate of how stockpiling behavior differs between light and heavy smokers, a relationship plausibly of interest for policy if the health costs of smoking vary with smoking intensity. Previous literature implicitly assumes that light and heavy smokers face similar incentives to cross borders. With our data, we are able to relax this assumption and separately estimate travel costs for light and heavy smokers in order to calculate differences in stockpiling behavior. We estimate that heavy smokers purchase approximately 3 times more cigarettes when crossing borders than light smokers. As a result, the incentive for heavy smokers to travel to lower tax jurisdictions is substantially stronger than the incentive for more casual smokers. Empirical approaches that implicitly assume a common incentive will tend to overestimate border crossing by light smokers and underestimate border crossing by heavy smokers.

Thirdly, we can estimate the elasticity of cigarette demand while explicitly controlling for the actual price paid by consumers. Previous studies do not observe the choice of location or the price paid by consumers and had to create additional metrics to control for the strength of the incentive to cross borders. Using state-level price data from the *Tax Burden and Tobacco* (TBT), we find that our estimated elasticities of demand using the price from the location of purchase are similar to estimates using techniques from previous studies that infer the paid price. However, using prices reported by individuals in the CPS Tobacco Use Supplement (TUS), we find that demand is more inelastic.

While the TUS prices may subject to reporting bias, they may better capture within-state variation in prices paid by consumers. By comparing the TUS and TBT prices, we find evidence that the tax-inclusive price in a state declines as an individual lives closer to a border with a lower tax jurisdiction, and rises as an individual lives closer to a border with a higher tax jurisdiction. This relationship also holds for individuals who report purchasing cigarettes within their home state. Given that this variation in prices within a state is correlated with an individual's proximity to the border, cross-sectional studies that do not observe the location purchase and use state-level prices may mistakenly attribute part of the increase in consumption for individuals near borders to cross-border behavior instead of the reduction in the price cigarettes; consequently, these studies may overestimate the amount of border crossing.

Finally, by observing a consumer's location of residence and purchase, we can separately estimate the effect of a tax increase on state sales and revenues in the presence of border crossing and also in the counterfactual scenario with the absence of border crossing. To our knowledge, this is the first paper to consider both margins using the same micro-level dataset.

We find that a tax increase in a given state has a differential impact on tax revenues for its neighboring states, depending on the distribution of the location and demographics of a state's consumers. To illustrate the magnitude of these effects, we examine the particular case of Maryland, which in 2003 considered increasing the state tobacco tax from \$1.00 to \$1.36 per pack. Legislators debated over the impact of these changes on tax revenues for Maryland and worried about whether Maryland residents would cross the border to a lower-tax jurisdiction and thereby avoid the tax increase. We find that Maryland's tax revenues would increase by 34 percent in the absence of border crossing compared to 31 percent when consumers can cross borders. If we consider the impact on a smaller jurisdiction where consumers have more ample opportunities to cross borders, such as the District of Columbia, the difference is even more stark; D.C.'s tax revenues would rise by only 17 percent in the presence of border crossing after a 36 cent increase instead of the predicted 34 percent.

We also consider an extension to our discrete choice model of location. Since we are able to observe individuals who choose to purchase cigarettes from "other" locations, which include the Internet, Indian reservations, and international purchases (e.g., Canada)[3], our benchmark model of location choice allows for substitution between purchasing in-state, physically crossing a border to a lower tax jurisdiction, and virtually crossing a border by purchasing cigarettes over the Internet. We extend this model by incorporating varying access to the Internet; we allow for the possibility that the online option may not exist in certain consumers' choice sets.

The paper is presented as follows. Section 2 discusses the previous literature. Section 3 provides descriptive statistics of the data and state cigarette excise taxes, and Section 4 develops our model of location choice and presents the empirical results. In section 5, we discuss the counterfactual experiments and the accompanying quantity regressions. Section 6 discusses an extension to our baseline model of location choice, and Section 7 concludes.

[3]Some online merchants are located on Indian reservations (Goolsbee, Lovenheim, and Slemrod, 2007).

2 Previous Literature

A well-developed literature studies consumer tax avoidance in response to differential excise taxation of cigarettes. The literature examines how differences in state cigarette taxes create incentives for consumers to cross the border from high tax states (such as Massachusetts) to low tax states (such as New Hampshire). The standard approach in the existing literature, including Yurekli and Zhang (2000) and Coats (1995), exploits state-level data and regresses per capita cigarette sales on cigarette price, tax, demographics, and metrics capturing the strength of the incentive for smokers to travel to or from a particular state. Stehr (2005) uses a similar approach, but incorporates cigarette consumption from the Behavioral Risk Factor Surveillance System to better measure untaxed sales of cigarettes. The metrics tend to be functions of the difference between the home-state and neighboring tax rates as well as the size of the population near boundaries of low tax jurisdictions. Several studies also investigate tax avoidance and cross-border sales of alcohol (Baltagi and Goel, 1990; Baltagi and Griffin, 1995; Beard et al., 1997; Stehr, 2007). The previous literature on cigarettes and alcohol finds consistent evidence of a significant negative correlation between sales and the magnitude of the incentive for consumers to travel to neighboring states; this is consistent with a story in which residents of high-tax jurisdictions purchase their goods in low tax jurisdictions.[4]

A smaller set of papers infer cross-border sales from consumer-level data. Lovenheim (2008) develops a model that includes an individual's probability of border crossing and estimates a reduced form regression of consumption. He finds evidence that consumers nearby lower-cost jurisdictions consume more cigarettes, and he estimates some of the primitives of his model.[5] Hyland et al. (2005) use the COMMIT study to investigate responses by cigarette smokers when asked whether they purchased cigarettes from different lower-tax jurisdictions (including nearby states, countries, tribal lands, or the Internet); his sample consists of twelve communities in the U.S. He finds that tax avoidance varies considerably in the population, depending on an individual's proximity to a lower-priced jurisdiction. Emery, White, Gilpin and Pierce (2000) also

[4]Other empirical papers on cigarette demand include the incentive for border crossing by consumers. Sung, Hu, and Keeler (1994) empirically estimate cigarette demand under a rational addition model, and Keeler, Hu, Barnett, Manning, and Sung (1996) study price discrimination by manufacturers in response to state excise taxes.

[5]A related paper is Manuszak and Moul (2006) which examines gas and cigarette taxes in the Chicago area. They use data on the location and density of gas stations in Chicago to infer willingness to travel to avoid gasoline and/or cigarette excise taxes.

examine individual survey data and study the extent to which California smokers avoided a $0.50 per pack increase in the excise taxes by purchasing from lower-tax jurisdictions. They find that very few California smokers avoided the excise tax by purchasing cigarettes from the Internet, military bases, or out-of-state outlets. Finally, Crawford and Tanner (1995) use household expenditure data for the United Kingdom to identify whether households close to France are more sensitive to local alcohol taxes. They find that after relaxing alcohol importing quotas, the demand for alcohol became more elastic for British consumers near lower-tax jurisdictions than those who lived far.

In contrast to the previous literature, our data has the advantage that it reports both location and quantity choice for a large representative sample of U.S. smokers. We use data on the smoking habits and purchase decisions of individual smokers to estimate a discrete model of location choice and a continuous model of cigarette consumption. Rather than inferring border crossing from reduced-form regressions of consumption decisions, we explicitly model a consumer's choice of venue as a tradeoff between the price and distance to each neighboring state.[6] Our approach allows us to identify substitution between home-state purchases, cross-border purchases, and Internet purchases.

Our paper also relates closely to work on the competition across different retail venues. For example, Goolsbee (2000) studies competition between online and traditional retailers. He finds that eliminating the sales tax differential between online and traditional retailers would reduce the number of online buyers by 24 percent. Goolsbee, Lovenheim, and Slemrod (2007) quantify the extent to which consumers avoid state taxation through Internet purchases. In other markets, Chiou (2008) examines a consumer's choice of retailer for DVDs, and Ellison and Ellison (2007) also examine the extent of consumer tax avoidance in the market for offline and online computer parts. Our approach allows for multiple venue choices for each consumer (not just in-state versus out-of-state), and we combine this discrete choice model with estimates of quantity consumed to predict sales under different counterfactual scenarios.

3 Data

We obtained information on individual purchase quantities and locations from

[6]Although our paper focuses on avoidance by consumers rather than "long distance" or commercial cigarette smuggling, Gruber, Sen, and Stabile (2003) and Thursby and Thursby (2000) find evidence of commercial cigarette smuggling in response to heterogenous taxation.

the CPS Tobacco Use Supplement (TUS) for February, June, and November 2003. The 2003 wave of the TUS asks each individual the last quantity of cigarettes purchased, price paid per pack of cigarettes, and the location of the purchase. The dataset also includes questions on the frequency of smoking (e.g., daily, occasional) and the history of smoking within the past year. We restrict our sample to individuals with non-missing data on demographics and who report their county of residence. The final dataset consists of 9745 smokers who report the location of their last cigarette purchase and 9588 smokers who report their daily quantity of cigarettes consumed.

The main advantage of our dataset is that we directly observe each consumer's location of purchase. The TUS asks individuals to report the state of their last purchase or "other" if they purchased from the Internet, Indian reservations, or another country (e.g., Canada). For each individual, we compute the distance to each of the nearby states using the latitude and longitude of her county's centroid and the nearest county in a neighboring state. As shown in Table 1, approximately forty percent of consumers live within 40 miles of another state, and 17 percent live nearby at least 3 other states. Consumers do not report traveling very far to purchase cigarettes.

Table 1. Number of States In Individual Choice Sets

number of states in choice sets	Percent
1	61
2	22
3	14
4	3

Notes: This includes the individual's home state and all states within 40 miles radius of the individual's county of residence. The outside good is omitted in this table.

Table 2. Sources of reported border-crossing

source	Percentage
another state	83.5
other	16.5

Notes: Percentages are reported for the final sample of consumers in Tobacco Use Supplement 2003 that report their location of purchase and have a non-missing county of residence.

Approximately 98 percent of consumers in our sample traveled less than 40 miles to purchase their cigarettes, and 96 percent purchased from within their home state. As Table 2 indicates, of those consumers who report purchasing outside their home state, approximately 16.5 percent report purchasing cigarettes from “other” locations, which include the Internet, Indian reservations, and international purchases (e.g., Canada).

In this context, we are concerned with two sources of reporting bias, which would lead the TUS survey to underreport online-purchases, on-reservation purchases and border crossing. First, an individual might be reluctant to report purchasing over the internet, on-reservation, internationally, or from another state if she perceives border crossing as quasi-illegal. Second, our classification of “other” sales as online or on-reservation may understate the true level of sales if individuals report the state of origination for internet purchases or the state surrounding tribal lands, rather than “other”.

To assess the first type of reporting bias, we aggregate self-reported purchases in the TUS to the state of purchase. We then compare the aggregated data to state-level sales data from TBT. Since the sales data in the TBT is based on state-reported tax receipts, it is not prone to the form of potential reporting bias present in the TUS. If self-reporting substantially underreports border crossing or online purchases, we would expect that the aggregate TUS data would relatively overreport sales in high tax jurisdictions, and relatively underreport sales in low-tax jurisdictions, when compared with the tax receipt data from TBT. When we examine high tax states in our sample, we do not find strong, systematic evidence of reporting bias. The aggregate TUS data report relatively higher sales in New York and Washington than the TBT data, but report relatively *lower* sales in New Jersey, the District of Columbia, Connecticut and Rhode Island. When we estimate the correlation coefficient between the tax rate in a jurisdiction and the degree to which the TUS overreports sales relative to the TBT, we find a small positive (r=0.08), but not statistically significant relationship. Thus, we do not find strong evidence of the presence of systematic underreporting of either physical or virtual border crossing.

Examining the second potential source of bias, we do find some evidence that consumers may report the state of origination for online sales. We find that roughly one quarter of respondents who reported purchasing out-of-state list a state more than 240 miles away from their home county. In addition, approximately 10 percent of sales in North Carolina, Virginia, and Kentucky (the three states with the lowest taxes in our sample), were from out-of-state consumers in non-neighboring states. While cannot rule out that these consumers may drive long-distances to purchase lower-tax cigarettes, this evidence is certainly suggestive that simply using the “other” classification may underreport online purchases. To address this, we consider an sensitivity test in which we define any out-of-state sales in a non-neighboring jurisdiction more than 240 miles way as “online.” We find that the change of definition does not substantively affect our results.

Tables 3, 4, and 5 give various summary statistics for the data. Individuals whose closest states are within to 10-20, 20-30, or 30-40 miles exhibit similar demographics, and non-married and non-white individuals comprise a larger fraction of those who live within 0-10 miles to the nearest state.This pattern is partly attributed to differences in demographics across states and the fact that smaller jurisdictions with population concentrations near borders, e.g., D.C., will account for a majority of these observations within 0-10 miles near a state.[7] Characteristics are similar for individuals whose closest state within 40 miles has a higher or lower tax. Heavy smokers are slightly older on average than light smokers and more likely to be married; the average heavy smoker smokes approximately one pack of cigarettes daily while a light smoker smokes approximately a third of a pack per day.Consumers are located across a wide variety of states with 20 percent in the northeast, 20 percent in the midwest, 30 percent in the south, and 30 percent in the west. The largest state represented in the sample is California with 11 percent of all sales.

In addition to the TUS data, we use 2003 state-level data on cigarette taxes and average cigarette prices from *Tax Burden on Tobacco* (TBT). The cigarette price data from *Tax Burden on Tobacco* are the most commonly used data source for studies of border crossing in response to cigarette taxes.[8] Although the prices individuals report paying in the TUS and state-level average cigarette prices are positively correlated, the state-level average cigarette prices mask important intrastate variation in tax-inclusive prices close to state boundaries.[9]

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[7]Our specification check of the location model in column (3) of Table 7 indicates that when we allow the effect of distance to vary by 0-10, 10-20, 20-30, and 30-40 miles, our qualitative results remain the same with the expected signs and magnitudes. This suggests that the fraction of consumers living within 0-10 miles of the nearest state are not driving our results.

[8]Recent work using prices from *Tax Burden on Tobacco* include Lovenheim (2008) and Stehr (2005). To obtain the effective price for each corresponding month of the TUS, we found the reported average prices for the years 2002-2004 from the *Tax Burden on Tobacco* and linearly interpolated the pre-tax price in each state evenly across these years; then we selected the appropriate pre-tax price in each state for the survey month of the TUS and added in the prevailing taxes for that month.

[9]This intra-state variation may be important for studies using cross-sectional data.

Table 3. Summary statistics of individuals whose closest neighboring state is within 0-10, 10-20, 20-30, and 30-40 miles

	Obs	Mean	Std. Dev.
distance<10 miles			
income >= $60,000	590	0.24	0.43
age	662	44.61	14.70
male	662	0.51	0.50
married	662	0.25	0.43
white	662	0.38	0.49
black	662	0.47	0.50
hispanic	662	0.13	0.33
daily quantity of cigarettes	631	11.52	8.35
price paid (dollars per pack)	515	4.69	1.48
10<distance<20 miles			
income >= $60,000	1209	0.35	0.48
age	1376	43.42	14.50
male	1376	0.47	0.50
married	1376	0.42	0.49
white	1376	0.70	0.46
black	1376	0.18	0.38
hispanic	1376	0.08	0.28
daily quantity of cigarettes	1321	14.12	9.73
price paid (dollars per pack)	951	4.21	1.36
20<=distance<30 miles			
income >= $60,000	1332	0.30	0.46
age	1517	42.42	14.73
male	1517	0.48	0.50
married	1517	0.45	0.50
white	1517	0.85	0.36
black	1517	0.08	0.28
hispanic	1517	0.02	0.15
daily quantity of cigarettes	1486	15.31	9.83
price paid (dollars per pack)	910	3.37	0.87
30<=distance<=40 miles			
income >= $60,000	655	0.28	0.45
age	752	42.44	14.40
male	752	0.46	0.50
married	752	0.45	0.50
white	752	0.86	0.35
black	752	0.09	0.29
hispanic	752	0.03	0.16
daily quantity of cigarettes	732	16.48	9.64
price paid (dollars per pack)	470	3.52	0.86

Note: Demographics calculated from the Tobacco Use Supplement. 2003. The omitted race category is “other”.

Table 4. Summary statistics of individuals whose closest neighboring state has a lower vs. higher tax

Variable	Obs	Mean	Std. Dev.
Closest state has lower tax			
income >= $60,000	1184	0.25	0.43
age	1351	43.27	14.99
male	1351	0.48	0.50
married	1351	0.36	0.48
white	1351	0.70	0.46
black	1351	0.23	0.42
hispanic	1351	0.04	0.19
daily quantity of cigarettes	1304	14.35	9.71
price paid (dollars per pack)	899	3.82	0.96
Closest state has higher tax			
income >= $60,000	1814	0.30	0.46
age	2070	42.61	14.32
male	2070	0.47	0.50
married	2070	0.44	0.50
white	2070	0.78	0.42
black	2070	0.14	0.35
hispanic	2070	0.05	0.22
daily quantity of cigarettes	2009	15.13	9.79
price paid (dollars per pack)	1293	3.54	1.24

Notes: Demographics were calculated from the Tobacco Use Supplement 2003; tax data was obtained from *Tax Burden on Tobacco*. The omitted race category is “other”.

These calculations are for individuals that have a neighboring state within 40 miles of their county of residence.

Table 5. Summary statistics for heavy vs. light smokers

Variable	Obs	Mean	Std. Dev.
Light smoker			
income >= $60,000	4805	0.27	0.45
age	5320	40.83	0.50
male	5320	0.44	15.14
married	5320	0.39	0.49
white	5320	0.62	0.48
black	5320	0.16	0.36
hispanic	5320	0.14	0.35
daily quantity of cigarettes	5320	6.86	3.42
price paid (dollars per pack)	4159	3.73	1.09
Heavy smoker			
income >= $60,000	4783	0.28	0.45
age	5314	44.71	0.50
male	5314	0.54	13.91
married	5314	0.44	0.50
white	5314	0.84	0.37
black	5314	0.06	0.24
hispanic	5314	0.05	0.22
daily quantity of cigarettes	5314	22.21	7.68
price paid (dollars per pack)	2729	3.57	1.02

Notes: A "heavy" smoker is defined as an individual who consumes at least 14 cigarettes daily. The omitted race category is "other". Demographics were calculated from the Tobacco Use Supplement 2003.

To examine intrastate variation in the tax-inclusive price, we estimate how an individual's reported per pack price in the TUS changes as the distance to the border of a higher or lower tax jurisdiction increases. Specifically, we regress the price that individual i reports paying for her last pack of cigarettes in the TUS on the average price listed for her state of purchase j in *Tax Burden on Tobacco*, her demographics, the tax-inclusive price differential between her state of purchase j and the closest alternative location k, the inverse of distance to the alternative jurisdiction, and an interaction between the price differential and inverse of distance.[10] Our primary coefficient of interest is on the interaction term, which captures the relative strength of competition from a neighboring jurisdiction with a (potentially) different tax. As the distance to the border increases, we expect the effect of the neighboring jurisdiction

[10] If an individual reports purchasing out-of-state, we assume that the purchase was made one mile over the border. In these cases, the "alternative" location would be an in-state purchase.

to decrease in magnitude. Table 6 reports the estimated coefficients from the regression

$$\begin{aligned} p_i^{TUS} &= \alpha + \beta_1 p_j^{TBT} + \theta Demo_i + \gamma_1 (p_j^{TBT} - p_k^{TBT}) \\ &\quad + \gamma_2 \frac{1}{Dist\ to\ Alt\ k} + \gamma_3 \frac{p_j^{TBT} - p_k^{TBT}}{Dist\ to\ Alt\ k} + \epsilon_i. \end{aligned} \tag{1}$$

In columns (1) and (2), we estimate OLS and IV specifications including only the interaction term. In columns (3) and (4), we estimate OLS and IV specification including the interaction term, as well as the tax-inclusive price differential and distance to the border. For the IV regressions, we use the tax differential between neighboring jurisdictions to instrument for the price differential. We find relatively strong evidence that the prices reported in the TUS are close on average to the state-level prices in TBT. In all five specifications, our point estimates suggest close to a one-to-one relationship between the average price reported by smokers in the TUS and the state-level average prices reported in TBT. In addition, we find evidence of a correlation between prices reported in the TUS and some of the demographics characteristics - older smokers and married smokers report purchasing less expensive cigarettes, whereas wealthy, black and hispanic smokers report purchasing more expensive cigarettes.[11]

We find that consumers who purchase in-state report prices which are influenced by the tax-inclusive price in nearest neighboring jurisdiction. Consistent with our prediction, the effect becomes stronger as distance to the jurisdiction decreases. A consumer who purchases instate, 5 miles from the border of a neighboring jurisdiction pays a different price than a consumer who purchases far from the border of the neighboring jurisdiction. The difference in tax inclusive prices 5 miles from the border and far from the border is equivalent to five percent of the price differential between a high tax state and the low tax state. These results are broadly consistent with the results from Doyle and Samphantharak (2008), who find evidence that the incidences of the 2001 gasoline tax moratoria in Illinois and Indiana vary near jurisdictional boundaries.

Combined state and federal cigarette taxes differ considerably across locations. The average cigarette tax across all 50 states and the District of Columbia is \$1.05 per pack, varying from a high of \$1.90 in Massachusetts to 41.5 cents in Virginia. For consumers that live within a 40-mile radius of

[11]It is important to note that although statistically significant, the magnitudes of the demographic variables are not likely to be economically significant. A one standard deviation in wealth or age corresponds to an eight cent per pack increase and an eight cent per pack decrease in reported prices on average. This corresponds to a 2-3 percent change over the average tax-inclusive price of \$3.66 reported in our sample.

Table 6: Intrastate Variation in Tax-Inclusive Price

	(1) OLS	(2) IV	(3) OLS	(4) IV
TBT Average State Price	1.052**	1.069**	1.080**	1.094**
	(0.019)	(0.022)	(0.020)	(0.023)
Price Differential / Distance	-0.320**	-0.994**	-0.081	-0.245+
	(0.113)	(0.282)	(0.149)	(0.142)
Tax-Inclusive Price Differential			-0.093**	-0.109**
			(0.019)	(0.022)
Inverse Distance to Nearest State			17.065+	8.865
			(9.896)	(9.875)
Age	-0.666**	-0.665**	-0.667**	-0.668**
	(0.075)	(0.076)	(0.075)	(0.075)
Married	-6.766**	-7.286**	-6.619**	-6.728**
	(2.079)	(2.089)	(2.073)	(2.075)
Male	-2.257	-1.711	-2.217	-2.127
	(1.897)	(1.908)	(1.892)	(1.894)
White	-0.346	-0.094	-0.081	0.017
	(4.296)	(4.244)	(4.299)	(4.290)
Black	11.947*	13.865**	11.148*	11.753*
	(4.911)	(4.953)	(5.010)	(5.001)
Hispanic	20.108**	20.235**	21.054**	21.403**
	(5.037)	(4.993)	(5.032)	(5.031)
Income	10.589**	10.280**	10.059**	9.954**
	(1.284)	(1.294)	(1.276)	(1.288)
Observations	6317	6174	6317	6317
R-squared	0.49	0.49	0.49	0.49

Notes: + significant at 10%; * significant at 5%; ** significant at 1%

The dependent variable is the reported price (in cents) per pack from the Tobacco Use Supplement.

another state, taxes vary across borders on an average of 64 cents per pack. Conditional on having a neighboring state with a higher or lower tax, the average difference between the tax in the home state and the tax of the neighbors with the highest and lowest taxes are 56 cents and 63 cents. Substantial savings potentially exist from border crossing to a lower tax jurisdiction; given that daily cigarette consumption is 15 cigarettes on average (approximately 0.75 of a pack of 20 cigarettes), total savings in a year could amount to $130. As reported in TBT, the average cigarette prices (inclusive of tax) also vary by state from $3.07 per pack in Kentucky to $5.63 per pack in New York.

In 2003, sixteen states increased their cigarette excise taxes. The average tax increase during the study period was $0.35 per pack. New Mexico increased cigarette taxes by the most, by $0.70 per pack, while, conditional on increasing the tax, Kansas increased cigarette prices least, by $0.09 per pack. In 2003, taxes more than doubled in eight of the sixteen states: Delaware, Georgia, Idaho, Montana, Nevada, New Mexico, West Virginia, and Wyoming. Relative to the taxes in 2002, the change in taxes represents an average increase of 133 percent.

4 Location Choice

The main empirical exercise of this paper estimates a consumer's smoking intensity and choice of purchase location, by exploiting individual-level data on cigarette purchases from the Tobacco Use Survey. We then use the structural model to simulate several counterfactuals of policy interest. First, we simulate smoking intensity in the absence of cross-border sales. Then we use our predictions of cross-border activity to estimate own-price elasticities of state cigarette sales and consequently the tax revenue elasticity for each state. Finally, we examine a particular case, the 2003 Maryland debate over whether to raise cigarette taxes by $0.36 per pack, and simulate the effect of such a change on tax revenues and sales for Maryland and neighboring states. As an extension, we examine the robustness of our results to heterogenous online access, based upon individual measures of computer and internet access from the Current Population Survey.

4.1 Model

In our model of demand, each consumer faces prices and excise taxes that vary by location of purchase. First, we consider a consumer's choice of location conditional on the decision to purchase cigarettes. We assume that consumer i perfectly observes prices p_j and taxes τ_j for cigarettes in each of the jurisdictions. The utility of consumer i purchasing from location j is given by:

$$U_{ij} = \delta_1(p_j + \tau_j) + \delta_2(p_j + \tau_j) * INC_i - \alpha d_{ij} * INC_i - \gamma f(d_{ij}) + \epsilon_{ij} \quad (2)$$

where p_j and τ_j are the tax-exclusive price and tax (in cents per pack) reported in *Tax Burden on Tobacco* for state j, INC_i is a dummy for whether consumer i's income is above $\$60,000$[12], d_{ij} is the distance in miles between consumer i's county of residence reported in the TUS data and the nearest county in state j.[13] The variable ϵ_{ij} is an idiosyncratic error term that captures preferences for purchase jurisdiction, and it follows a Type I Extreme Value distribution.

It is important to note that a consumer's expected choice of quantity affects her location decision - faced with a lower tax-inclusive price, the consumer will purchase more of the taxed good in a lower tax jurisdiction. While quantity does not explicitly enter the location model, the current baseline model captures this effect in a reduced-form way through the coefficient of price on the probability of choosing a location. A higher price makes it less likely that a consumer will travel to that location, presumably due to decreased consumption (and disposable income - i.e., consumption of other goods). In addition, the changes in consumption across locations are likely to be small as the demand for cigarettes is inelastic. For elastic goods, a consumer's quantity may change substantially when purchasing in a lower tax jurisdiction. For less elastic goods, like cigarettes, the change in purchase behavior when traveling to a lower tax jurisdiction will be less.[14]

Consistent with the TUS reporting, we define the outside good as purchasing cigarettes from a location other than the 50 states and D.C., such as the Internet, an Indian reservation, or international purchases (e.g., Canada). Since we do not observe the specific nature of the outside good, we normalize the price and distance of the outside good to zero, and we incorporate a dummy for the outside good into the location model to capture its attractiveness relative to other alternatives. We restrict a consumer's choice set to all states that lie within a 40 mile radius of her county of residence.[15]

[12]Our qualitative results are not sensitive to the income threshold we use - $\$50,000$, $\$60,000$, or $\$70,000$.

[13]Although a subset of individuals in the TUS report the price for their last pack of cigarettes, we use prices from *Tax Burden on Tobacco* because we need to observe prices for all alternatives in a consumer's choice set.

[14]In Section 5.1, we estimate an intensive elasticity between -0.11 and -0.36.

[15]While we observe an individual's county of residence, we only observe her state of purchase. Our results are robust to whether we choose a radius of 25, 30, 35, 40, 45, or 50

We include interactions of price and distance with income to allow an individual's price sensitivity and disutility of distance to vary by income. In addition, we allow distance to enter into the utility function linearly, quadratically, and non-parametrically through successive 10-mile incremental dummy variables.

We estimate the model using Maximum Likelihood. For each consumer, we calculate the predicted probability of her making her observed location choice. Conditional on the vector $\theta = (\delta_1, \delta_2, \alpha, \gamma)$ of parameters to be estimated and right-hand side variables X, we can express the predicted probability of consumer i choosing location j as:

$$prob_{ij}(\theta) = \frac{exp(X_{ij}\theta)}{\sum_{k=1}^{K}\ exp(X_{ik}\theta)} \tag{3}$$

We form the log likelihood function from the predicted probabilities and maximize this expression over θ.

4.2 Identification and Results

Identification of the effects of price and distance on location choice is achieved by comparing the behavior of consumers under different choice sets - i.e., different number of alternatives or potential purchase locations. The estimation strategy compares the choices of consumers who live "far" from borders (and can only purchase online or within their home state) to those who live "close" to borders and may be able to purchase from several other localities. Essentially, this comparison is done while conditioning on a consumer's demographics. For instance, the effect of distance on location choice can be identified by observing the behavior of individuals with similar demographics that live far from the border to those that live near borders. The effect of income on the probability of traveling is found by comparing high and low income individuals who live within the same proximity to a border.

Table 7 reports the results of the discrete choice model; standard errors are clustered by an individual's state of residence. Columns (1)-(3) give the estimates under different specifications for distance. As expected, the negative coefficients on price indicate that individuals are less likely to travel to a location with a higher price.[16] We use the estimated coefficients to: (1) calculate measures of a consumer's propensity to travel across borders and evade

miles. We also obtain similar results when we use population-weighted county distances.

[16]The coefficients on the logit model can also be interpreted as marginal utilities. Utility declines by approximately 0.006 units for every one cent increase in price per pack.

Table 7. Baseline Location Choice Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
price+tax	-0.006*	-0.008**	-0.010**	-0.007*	-0.003	-0.005	-0.008**	-0.008**
	(0.003)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
(price+tax)*income	-0.001	-0.001	-0.000	-0.001	-0.001	-0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
distance	-0.191**	-0.348**		-0.181**	-0.248**	-0.223**	-0.162**	-0.190**
	(0.025)	(0.041)		(0.021)	(0.050)	(0.036)	(0.019)	(0.025)
distance*income	0.028	0.013+	0.010	0.026	0.044	0.040	0.015	0.030
	(0.019)	(0.007)	(0.009)	(0.017)	(0.057)	(0.030)	(0.021)	(0.019)
outside good	-7.375**	-8.039**	-9.215**	-7.760**	-6.239**	-6.692**	-8.489**	-7.996**
	(1.299)	(0.962)	(1.009)	(1.285)	(1.396)	(1.301)	(1.334)	(1.340)
distance^2		0.007**						
		(0.001)						
0<=distance<=10 miles			-0.473**					
			(0.034)					
10<distance<=20 miles			-0.241**					
			(0.025)					
20<distance<=30 miles			-0.149**					
			(0.013)					
30<distance<=40 miles			-0.136**					
			(0.011)					
TBT or TUS prices	TBT	TBT	TBT	TBT	TBT	TBT	TBT	TUS
Sample of smokers	All	All	All	everyday	some days	quantity<=14	quantity>14	All
Observations	9656	9656	9656	7293	1772	4738	4694	9574

Notes: This table gives the estimates of the logit model describing an individual's choice of location of purchase.
Standard errors in parentheses are clustered by individual's state of residence..
+ significant at 10%; * significant at 5%; ** significant at 1%
Price and tax are measured in cents per pack and calculated from *Tax Burden on Tobacco*. Demographics are obtained from the Tobacco Use Supplement 2003.

taxes in their home state, (2) predict the fraction of consumers who will cross borders, and (3) calculate how stockpiling differes between light and heavy smokers.

To explore the first question, we consider alternative specifications of the distance function $f(.)$. Column (2) gives the estimates under a quadratic specification of distance.[17] For the most part, the coefficients on the interactions of income with price and distance are not significant. In column (3), we obtain similar results when we allow the effect of distance to vary linearly among different ranges of distance: 0-10 miles, 10-20 miles, 20-30 miles, and 30-40 miles.

The impact of a state tax change on instate purchase decisions depends upon the tradeoffs that consumers face between price and distance. Taking the ratio of the coefficients (marginal disutilities) on price and distance, we can calculate the number of miles a consumer is willing to travel to save $1 per pack of cigarettes. Under our benchmark specification in column (1), a consumer is willing to travel 3 miles to save $1 on a pack of cigarettes. Given that the average difference in state taxes is approximately 64 cent per pack for consumers who live near borders, a consumer purchasing a single pack of cigarettes would be willing to travel approximately 2 miles to a lower tax jurisdiction.

We can calculate the marginal cost of each mile of travel by taking the ratio of the marginal disutility of distance to price. As expected, while the total cost of travel is rising, the marginal cost of travel declines with distance in column (3). For the first 10 miles, the marginal cost of traveling an additional mile is 48 cents; afterwards the marginal cost of travel declines to 24, 15, and 14 cents within the ranges of 10-20, 20-30, and 30-40 miles. These results suggest that consumers have a diminishing marginal cost of travel; travel costs are increasing, but at a decreasing rate. For instance, the cost of traveling the first mile (going from 0 to 1 mile) is high at 48 cents; however, once an individual has already traveled 30 miles, then the cost of traveling an additional mile is much lower - only 14 cents. The magnitudes of the marginal costs seem reasonable, and they capture the cost of transport as well as a consumer's implied value of time. The U.S. General Services Administration estimates this marginal cost as 31 cents per mile in a privately owned vehicle.[18]

Secondly, using our estimates, we can directly predict the probability that an individual will purchase outside of her home state. We estimate that 4 per-

[17] The marginal disutility of distance is given by $-0.348 + 2(0.007)d$ where d denotes distance in miles.

[18] Please refer to U.S. General Service Administration (GSA), May 23, 1996, Federal Register page 25802, Vol. 61, no. 101.

cent of smokers in our sample will purchase cigarettes outside of their home state. Interestingly, we find less border crossing than Lovenheim (2008), who estimates that between 13 and 25 percent of consumers purchase cigarette in border localities, and our estimates lie above those of Stehr (2005), who finds that border crossing accounts for less than one percent of all sales of cigarettes. Although our data contains self-reported measures of quantity smoked as similar to Lovenheim (2008) and Stehr (2005), our identification strategy differs in that we directly estimate travel cost and location of purchase using variation in observed location choices of individuals living "far" and "near" borders. Lovenheim uses variation over time to infer border crossing by individuals in metropolitan statistical areas near borders. Stehr uses differences in average taxes between the home state and nearby states with higher taxes to identify the effect of border crossing. As Lovenheim discusses, these estimates provide a lower-bound for the amount of border crossing because when a state raises its tax level, the average difference will increase by less than the amount of the tax increase; furthermore, raising the tax changes the set of states that have higher taxes, and tax differences may be weakly correlated with price differences across states. Our location model circumvents this issues as consumers choose explicitly among all alternative within a given radius of her residence; the choice set is fixed for a given consumer, and she must decide where to purchase cigarettes based upon her personal tradeoff between distance and the tax inclusive price.

Finally, we find that the propensity of an individual to travel varies significantly according to her quantity of purchase. An implicit assumption in our base model (and other existing studies of cigarette purchases) is that the marginal costs of traveling and the stockpiling behavior for light and heavy smokers are similar. Since heavy smokers purchase more cigarettes, they may capture a greater benefit from the differences in taxes by crossing to a lower cost jurisdiction. In this case, a specification which estimates a common travel cost for all smokers would tend to underestimate the number of heavy smokers who will cross borders and would overestimate the number of light smokers who do.

We separately estimate our earlier specification for smokers that report smoking "everyday" versus "some days" in the TUS. As expected, smokers who report smoking "everyday" have a significantly lower marginal cost of traveling than smokers who only report smoking "some days". Columns (4) and (5) of Table 7 indicate that the marginal cost of travel for an "everyday" and "some days" smoker are 26 cents ($= 0.181/0.007$) and 83 cents ($= 0.248/0.003$).

After conditioning on smokers' characteristics which affect travel costs, we would expect smoking intensity to affect the marginal cost of travel solely through stockpiling decisions. In this case, the ratio of marginal travel costs between "everyday" and "some days" smokers provide an estimate of relative stockpiling behavior of the mean member of each of these groups. Based on the estimated coefficients for marginal cost of travel between these two groups, we estimate that "everyday" smokers purchase approximately 3 times as many cigarettes when crossing a border than do "some days" smokers.

We also consider a finer distinction and separately estimate the location choices of consumers who smoke more and less than the average number of cigarettes (14) in a day.[19] As shown on columns (6)-(7) of Table 7, individuals who smoke less than 14 cigarettes a day have a higher marginal cost of traveling of 73 cents per mile than individuals who smoke more than 14 cigarettes a day of 32 cents per mile. The pattern is similar whether we consider a threshold of 10 or 20 cigarettes as well.

In the previous specifications, we used state-level prices from *Tax Burden on Tobacco*, since we need to observe prices from all alternatives within an individual's choice set. While we only observe the reported price in the TUS from the location of purchase, we can use equation (1) to compute an estimate of the price of each alternative in an individual's choice set; this estimate will allow for within state variation in prices. To capture any intra-state variation in prices, in column (8), we re-estimate the location model using predicted prices from our TUS regression in equation (1).[20] The estimated coefficients on distance and the interactions of distance with income are similar. After accounting for instra-state variation, prices for jurisdictions near borders will tend to converge; as expected, we find that individuals appear slightly more price sensitive as we now observe individuals crossing the border for a smaller given difference in price.

Using these estimates from our location model, we can now consider several counterfactual scenarios and public policy implications in the next section.

5 Counterfactuals

From a public policy perspective, the previous literature has focused on two particular questions: how would cigarette sales be affected by changes in the tax under the absence and presence of smuggling. In this section, we use the

[19] Technically, consumption of cigarettes will vary by location due to differences in prices. Here we take the reported daily consumption given an individual's current purchase location. This measure is intended to identify "heavy" from "light" smokers.

[20] For each alternative j, we find the price and distance to the individual's nearest other location.

results of our location model to tackle these two questions and draw comparisons with results from previous studies. First, we examine how changes in price affect the quantity of cigarettes consumed in the absence of border crossing. Then, we examine how changes in price affect sales by the state and their neighbors while taking into account the incentive for individuals to cross borders. Finally, we explore the magnitude of the difference between these two scenarios in the particular case of the Maryland tax increase.

5.1 Demand for Cigarettes in the Absence of Smuggling

A useful counterfactual to consider is how changes in price would affect an individual's demand in the absence of cross-border effects. This could correspond to a situation in which all states raise their taxes in such a way that the border crossing incentive is unchanged. To calculate the consumer response in the absence of smuggling, we must first estimate the relationship between quantity demanded for cigarettes and an individual's characteristics. In our baseline model, the quantity of cigarettes consumed depends upon the location of purchase only through prices and taxes. To obtain an estimate of the quantity of cigarettes consumed, we regress the daily quantity of cigarettes smoked on the price paid and a consumer's demographics using state tax rates as an instrument for the tax-inclusive price faced by consumers.

Previous studies with micro data had to include additional variables that measured the strength of the border crossing incentive (e.g., average prices of neighboring states), since the exact location of purchase and therefore price paid were not observed (Chaloupka and Warner, 2000). Without correcting for the border crossing incentive, the elasticity of demand will be biased away from zero; individuals may appear more price sensitive due to their ability to cross borders and evade price changes in their home state. In contrast, we do not face this omitted variable problem and do need these additional metrics, since we observe the exact location of purchase for each consumer.

We recover the relationship between the quantity of cigarettes consumed, price, and the demographics of a consumer i through the following regression:

$$logQty_i = \beta Z_i + \gamma_1 log(\tau_i + p_i) + \epsilon_i, \tag{4}$$

where $logQty_i$ is the log of the daily quantity of cigarettes consumed by consumer i, Z_i is a vector of demographics, and p_i and τ_i are the price and tax in consumer i's state of purchase. Following the previous literature, we log the dependent variable. If individuals tend to underreport the quantity of cigarettes smoked by reporting a given percentage of actual consumption, then estimates of the price elasticity will not biased (Stehr, 2005). Since our sample is restricted to smokers, equation (4) estimates the intensive margin on which behavior changes - how smoking intensity changes in response to a change in price, conditional on the decision to smoke.

We estimate the quantity regression using $log(tax)$ as an instrument for the full price paid by consumers. Table 8 reports the results.

Table 8. Log of Quantity Regression

	(1)	(2)	(3)	(4)	(5)
log(price at location of purchase)	-0.112+	-0.360**			
	(0.062)	(0.054)			
log(price in home state)			-0.292**	-0.271**	-0.281**
			(0.051)	(0.060)	(0.080)
price difference				-0.380	
				(0.564)	
income	-0.149**	-0.114**	-0.115**	-0.114**	-0.088**
	(0.026)	(0.019)	(0.019)	(0.019)	(0.025)
log(age)	0.216**	0.343**	0.343**	0.343**	0.363**
	(0.031)	(0.024)	(0.024)	(0.024)	(0.030)
marital	-0.056*	-0.018	-0.018	-0.018	-0.035
	(0.023)	(0.018)	(0.018)	(0.018)	(0.023)
male	0.208**	0.179**	0.179**	0.178**	0.157**
	(0.021)	(0.016)	(0.016)	(0.016)	(0.021)
white	0.299**	0.299**	0.302**	0.304**	0.277**
	(0.046)	(0.037)	(0.037)	(0.037)	(0.042)
black	-0.023	-0.124**	-0.121**	-0.116**	-0.143*
	(0.052)	(0.043)	(0.043)	(0.044)	(0.057)
hispanic	-0.316**	-0.376**	-0.376**	-0.375**	-0.426**
	(0.055)	(0.047)	(0.047)	(0.047)	(0.053)
TBT or TUS prices	TUS	TBT	TBT	TBT	TBT
Sample of smokers	All	All	All	All	Live more than 40 miles from nearest state
Observations	6182	9362	9362	9362	5768
R-squared	0.09	0.11	0.11	0.11	0.12

Notes: The dependent variable is the log of daily quantity of cigarettes smoked.
Robust standard errors in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%
The omitted category for race is "other". Price is measured in cents per cigarette. and is obtained either from the Tobacco Use Supplement 2003 (TUS) or *Tax Burden on Tobacco*.

Column (1) uses the prices as reported by consumers in the Tobacco Use Supplement. Column (2) uses the average prices at the consumer's reported purchase locations as calculated from *Tax Burden on Tobacco*.[21] In columns (3)-(5), we replicate the individual-level regressions of previous studies using our dataset. Column (3) contains the naive regression where quantity demanded is a function of the home state price; this assumes that consumers do not engage in border crossing. Column (4) contains the OLS estimates of a regression similar to Chaloupka and Pacula (1998) and Lewit et al. (1981) where quantity purchased by an individual is a function of her home state price and a measure of her incentive to cross the border. This measure is the price difference between the individual's home state and the lowest price state within 40 miles of the consumer; note that if an individual does not live within 40 miles of a lower-priced state, then this variable is equal to 0. Column (5) presents the OLS estimates for a regression similar to Lewit and Coate (1982) where the sample is restricted to consumers who live "far" from state borders and therefore do not face any incentive to travel.

Across specifications (2) to (5), we find that accounting for border crossing does not alter the estimated elasticities significantly when using state-level price data (*Tax Burden on Tobacco*).[22] When we use the reported prices from the TUS, we find a more inelastic demand for cigarettes compared to the estimates from *Tax Burden on Tobacco*; our estimated price elasticity from the TUS is similar to Lovenheim (2008), who reports an intensive elasticity of -0.175. Although the TUS reported price may suffer from reporting error, if it is a more accurate measure of the true price paid by the consumer, then the demand elasticities from these estimates will better capture the true underlying change in consumption.

In fact, using state-level price data (TBT) may bias the demand elasticities away from zero. As discussed previously in Table 6, the tax-inclusive price varies near borders with lower or higher tax jurisdictions. Using the individual-level price data (TUS) may more accurately capture the true price that consumers pay, taking into account the incidence of the tax on cigarette prices. Previous work implicitly assumes that individuals within a state pay

[21] For the TUS regressions, we omit online purchases to facilitate comparison of the results with the sample using data from *Tax Burden on Tobacco*. Note that the *Tax Burden on Tobacco* dataset does not contain prices for cigarettes purchased online whereas the TUS does. The results are qualitatively similar when we include online purchases with the TUS reported prices and use $log(tax + 1)$ as an instrument, since we assume that taxes are zero for the outside good.

[22] We obtain qualitatively similar results when we include direct controls for anti-smoking sentiment in our regression. Following DeCicca et al. (2008), we included variables from the TUS to directly capture anti-smoking sentiment in the cross-section. The 2003 TUS asks respondents whether smoking is allowed in their homes and whether they think it should be allowed in bars and cocktail lounges.

Table 9. Smoking Participation

	(1)	(2)
home state price	-0.008**	-0.007**
	(0.002)	(0.002)
tax difference	-0.072**	-0.010*
	(0.003)	(0.005)
income	-0.001**	-0.072**
	(0.000)	(0.003)
age	-0.032**	-0.001**
	(0.003)	(0.000)
married	0.042**	-0.032**
	(0.003)	(0.003)
male	0.051**	0.042**
	(0.005)	(0.003)
white	0.001	0.051**
	(0.006)	(0.005)
black	-0.058**	0.003
	(0.005)	(0.006)
hispanic		-0.058**
		(0.005)
Observations	79800	79800

Notes: This tables reports the marginal effects (evaluated at the variable means) from the probit model describing whether an individual smokes or not. The marginal effects for the dummy variables represent a discrete change of the variable from 0 to 1. Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
The home state price and tax difference are measured in dollars per pack and calculated from *Tax Burden on Tobacco*. The omitted race category is "other".

the same tax-inclusive price (from TBT) regardless of proximity to the border.

We can obtain the full price elasticity of smoking by estimating the extensive margin - how prices affect the decision to smoke. Table 9 reports the results from the probit estimation of the decision to smoke on price and several demographic factors. The regression follows the standard specification in the literature (Lewit and Coate, 1982 and Lewit et al., 1981) with demographics and home state price. In column (2), we include the tax difference between the home state and the lowest tax in a neighboring state to capture the border crossing incentive. In our two specifications, we estimate negative and signficant elasticities of participation of -0.2 and -0.18, respectively.[23]

[23] We obtain qualitatively similar results when we include direct controls for anti-smoking sentiment in our estimation. Following DeCicca et al. (2008), we include variables from the TUS to directly capture anti-smoking sentiment in the cross-section. The 2003 TUS asks respondents whether smoking is allowed in their homes and whether they think it should be allowed in bars and cocktail lounges.

We find the total price elasticity of smoking by adding the conditional price elasticity of smoking to the elasticity of the intensive margin (conditional on smoking). The total price elasticity of smoking lies between -0.29 to -0.56.[24] Our estimates lie within the spectrum of elasticities found by previous studies, which range from -0.14 to -1.23 with most studies falling in a narrower range from -0.3 to -0.5 (Chaloupka and Warner, 2000).[25] As discussed previously, the elasticity estimates from the individual-level prices in the TUS are smaller in magnitude than the elasticities from the state-level prices in the TBT.

5.2 State Sales of Cigarettes in the Presence of Smuggling

In the previous section, we estimated the consumer response in the absence of border crossing or casual smuggling. Policymakers are often interested in how changes in their taxes will affect their revenues in the presence of border crossing. With the estimates from our location and quantity choice models, we can calculate the own- and cross-price elasticities among states, and we can also examine the change in tax revenues under different counterfactual scenarios.

We predict the expected quantity of purchase for an individual at each possible location. Conditional on traveling to location j, consumer i's quantity of purchase depends upon her demographics Z_i as well as the price and tax of cigarettes at that location p_j and τ_j. Under our model, a consumer's quantity of consumption varies by location only through the differences in prices and taxes. Her expected consumption at location j is given by:

$$q^e_{ij} = \hat{q}(Z_i, p_j, \tau_j) * \hat{prob}_{ij} \tag{5}$$

where $\hat{q}(Z_i, p_j, \tau_j)$ is her optimal choice of cigarettes at location j, and $\hat{prob}_{ij}$ is her predicted probability of traveling to location j.[26]

[24] The full margin (quantity of cigarettes smoked by all individuals) consists of two parts: the decision to smoke (extensive margin) and the quantity smoked conditional on smoking (intensive margin). Let Q be the quantity of cigarettes smoked. Then $Q = Prob(smoke)(Q|smoke)$ where $Q|smoke$ is the quantity of cigarettes smoked, conditional on the decision to smoke. Since $dlnQ/dlnPrice = dlnQsmoke/dlnPrice + dlnProb(smoke)/dlnPrice$, we can calculate the total price elasticity by summing the conditional price elasticity and the participation price elasticity.

[25] There has been evidence of increasing (in absolute value) elasticities over time.

[26] The log quantity regression is given by $log(q) = X\beta + \epsilon$ where N = number of observations and k = number of independent variables. Then the equation for quantity is given by $q = exp(X\beta + \epsilon) = exp(X\beta)Exp(\epsilon)$, and $E[q|X] = exp(X\beta)E[exp(\epsilon)]$. If ϵ is normally

We can use equation (5) to calculate price elasticities under border crossing. Note that the conditional price elasticity of -0.26 given by our quantity regression in the previous section captures demand responsiveness when there is no change in border crossing behavior. This gives the percentage decrease in the optimal consumption, irrespective of the location of purchase.

The first column of Table 10 reports the own-price elasticities when border crossing can occur.[27] The optimal quantities for each location are now weighted by the probability of an individual traveling to that location. Note that own-price elasticities are higher in states such as West Virginia (-2.3) and Connecticut (-3.3) where individuals live in close proximity to other states. For instance, individuals who live close to or within West Virginia also reside in areas with anywhere from 2 to 4 states nearby - not including the outside option. Over half of individuals living near or within Connecticut also live near 3 other physical states. In more geographically disperse areas such as California, the own-price elasticities are lower (-0.38), consistent with the observations that most of the state population does not reside near other state borders. For states such as Idaho that have lower tax rates and tax-inclusive prices than most of its neighboring states, the own-price elasticity is large in magnitude.[28]

To obtain the full price elasticity, we can add the participation elasticity found in the previous section (-0.2) to the conditional price elasticities for each state in Table 10. Note that certain states do not appear in Table 10, as individuals within those states did not report their location of purchase.

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distributed with variance σ^2, then $E[exp(\epsilon)] = exp(\sigma^2/2)$. As a result, we can calculate predicted quantities as follows: $\hat{q} = exp(X\hat{\beta})exp(s^2/2)$ where $s^2 = \frac{1}{N-k}\sum_{i=1}^{N} e_i^2$ is an unbiased and consistent estimate of σ^2, and e is the residual from the quantity regression.

[27] We calculate the price elasticity of demand for quantity at location k with respect to the price at location j as follows. For each individual, we calculate the percentage change in expected quantity at location k under a 1 percent change in the price of location j. To obtain an estimate of the aggregate price elasticity, we take the average of the percentage change for each individual, weighted by her probability of choosing location k. Please see Ben-Akiva and Lerman (1985) for more details. The aggregate price elasticities for each of the three months of the TUS were calculated in this manner, and the final elasticity estimate is a simple average of these three numbers. We report elasticities for states that were in the final sample and had at least 100 observations. The standard errors of the elasticities were obtained by a parametric bootstrap where we draw from the asymptotic distribution of the estimated parameters 100 times. For each draw, we calculate the elasticity matrix, and then we calculate the sample standard deviation of the elasticities over the draws.

[28] In our sample, the average tax-inclusive price at Idaho, Oregon, and Washington state were \$3.54, \$4.19, and \$4.72, and the average tax was \$0.885, \$1.67, and \$1.815.

Table 10. Elasticities by state

state	own-price elasticity	state tax elasticity	state tax revenue elasticity
AL	-0.37	-0.02	0.98
AK	-0.39	-0.09	0.91
AZ	-0.38	-0.11	0.89
CA	-0.38	-0.08	0.92
CO	-0.37	-0.02	0.98
CT	-3.29	-0.99	0.01
DE	-0.47	-0.05	0.95
DC	-1.67	-0.40	0.60
FL	-0.37	-0.04	0.96
GA	-0.37	-0.02	0.98
HI	-0.39	-0.10	0.90
ID	-2.54	-0.34	0.66
IN	-0.39	-0.06	0.94
LA	-0.37	-0.04	0.96
MD	-1.01	-0.25	0.75
MI	-0.40	-0.11	0.89
MN	-0.39	-0.05	0.95
MO	-0.42	-0.02	0.98
NE	-0.37	-0.06	0.94
NV	-0.37	-0.05	0.95
NJ	-1.02	-0.34	0.66
NY	-0.85	-0.23	0.77
NC	-0.38	-0.01	0.99
ND	-0.40	-0.05	0.95
OH	-0.47	-0.07	0.93
OK	-0.37	-0.03	0.97
PA	-0.50	-0.13	0.87
SC	-0.39	-0.01	0.99
SD	-0.40	-0.05	0.95
TX	-0.37	-0.04	0.96
UT	-0.37	-0.07	0.93
VA	-1.06	-0.01	0.99
WA	-0.46	-0.14	0.86
WV	-2.34	-0.30	0.70
WI	-0.39	-0.08	0.92

Notes: The own-price elasticity of state *j* is the percentage change in quantity sold at state *j* given a 1% change in its total (tax-inclusive) price; the state tax elasticity is the percentage change in quantity sold at state *j* given a 1% change in its state tax; the state tax revenue elasticity is the percentage change in state tax revenues given a 1% change in its state tax. These elasticities are conditional on smoking and represent the percentage change in sales or state tax revenues in the presence of border-crossing. States that appear in the final sample and had at least 100 observations are reported in this table. Authors' calculations are described in the text.

5.3 Simulation and Comparison of Tax Changes in Maryland and D.C.

The two preceding sections calculated the change in sales with and without border crossing. In this section, we apply these techniques to the particular case of Maryland and compare how the consumer response changes under these two scenarios. Recall from the Introduction that we described a particular debate in the Maryland legislature regarding a tax increase from \$1.00 to \$1.36 per pack in 2003. We use Maryland as an example to illustrate the impacts of border crossing behavior on tax revenues because potentially large gains from border crossing exist for Maryland residents due to the proximity of neighboring states, and in our dataset, we observe smokers in Maryland and all its neighboring states.

We use the estimates of price elasticity from the two previous sections to compute the state tax elasticity (responsiveness of sales to changes in the state tax) and the state revenue tax elasticity (the percentage change in state tax revenues due to a state tax increase) in the presence and absence of border crossing. Under the first scenario, we examine what would happen if no change in the border crossing incentive occurred. This resembles a situation where either no border crossing occurs, or this could correspond to a scenario where all states surrounding Maryland coordinated and increased their taxes in such a way that a consumer's choice of location does not change. Alternatively, this can be interpreted as a naive calculation of the effects of a tax change, assuming individuals did not change their current location decisions. In the second scenario, we allow for consumers to cross borders and respond to changes in the tax by changing their location of purchase. We use the estimates from our baseline location model.

Given the own-price elasticity, the state tax elasticity can be calculated as follows:

$$\frac{\partial log(q)}{\partial log(t_s)} = \frac{t_s}{p + t_s + t_f} \frac{\partial log(q)}{\partial log(p + t_s + t_f)} \tag{6}$$

where p is the price of cigarettes, t_s is the state tax, and t_f is the federal tax. The state tax revenue elasticity is then calculated as :

$$\frac{\partial log(t_s q)}{\partial log(t_s)} = 1 + \frac{\partial log(q)}{\partial log(t_s)} \tag{7}$$

Under our first scenario, if no changes occurred in consumers' purchase locations, we can see from equation (5) that the probability of choosing a given location $\hat{prob}$ is held constant. Consequently, the percentage change in expected quantity at each location is due solely to the percentage change in the optimal quantity of cigarettes $\hat{q}$ given by the quantity regression. Recall that the quantity regression from the previous section gives the relationship between the price and the optimal quantity of cigarettes to smoke, irrespective of location of purchase. The estimated state tax revenue elasticity is 0.94.[29]

For our second scenario, we allow for border crossing, and consequently, we need to account for how changes in taxes affect the probability of traveling to a given location. Equation (5) reveals that the overall change in expected quantity can be decomposed into two parts: the change in the probability of choosing a given location $\widehat{prob}$ and in the optimal quantity of cigarettes $\hat{q}$. The own-price elasticities in Table 10 reflect these two margins. Applying the formulas from equations (6) and (7), we calculate the state tax elasticity and state tax revenue elasticity in columns (2) and (3) of Table 10. We find that for Maryland, a one percent increase in its state tax will increase revenues by 0.75 percent when consumers can respond by border crossing as opposed to the naive estimate of 0.94 percent in the absence of changes in border crossing behavior.

For the 36 cent increase in the Maryland tax, we can use these state tax revenue elasticities to approximate and compare the changes in revenues with and without border crossing. We present the results in in Table 11.[30] We estimate that increasing the tax by 36 cents from \$1.00 to \$1.36 per pack in Maryland increases state tax revenues by nearly 31 percent in Maryland, by 11 percent in West Virginia, and by smaller amounts in neighboring states. Absent changes in consumers' border crossing behavior, we estimate that Maryland tax revenues would increase 34 percent.[31]

Table 11 also presents the results from simulating a similar tax increase in D.C. from \$1.00 to \$1.36 per pack. A tax increase of 36 cents in D.C. increases

[29]Using equations (6) and (7), we let $t_s = \$1.00$ and $t_f = \$0.39$. We use \$4.105 for the average price (inclusive of tax) for a pack of cigarettes as reported in *Tax Burden on Tobacco* in 2003 for Maryland. For the own-price elasticity, we consider values between -0.2 and -0.3 as given in Table 8.

[30]Since the elasticities are for small changes in the tax and the counterfactual considers a large change of 36 percent (from \$1.00 to \$1.36), our table presents the results from a simulation of this large change. We project the estimated quantities and state tax revenues before and after a 36 cent increase. These estimates are similar to the approximations obtained by using the tax revenue elasticities. The standard errors of the percentage change in revenues were obtained by a parametric bootstrap where we draw from the asymptotic distribution of the estimated parameters 100 times. For each draw, we calculate the percentage change in revenues, and then we calculate the sample standard deviation of the percentage change over the draws.

[31]Given a state tax revenue elasticity of 0.94, a 36 percent increase in the tax from \$1.00 to \$1.36 will generate a 34 percent increase ($= 0.94 * 0.36$).

Table 11. Simulated Percentage Change in Tax Revenues from a tax increase of 36 cents in Maryland and the District of Columbia

	Maryland	District of Columbia
Delaware	0.311%	-
	(0.192)	
District of Columbia	3.958%	16.917%
	(1.757)	(8.090)
Maryland	25.742%	2.040%
	(3.441)	(0.634)
New Jersey	0.005%	-
	(0.0029)	
Pennsylvania	0.610%	-
	(0.060)	
Virginia	2.231%	4.927%
	(1.197)	(1.853)
West Virginia	10.600%	-
	(4.768)	

Notes: Standard errors in parentheses are reported in percentage points. Simulation is conditional on the decision to smoke.

tax revenues by 34 percent absent a change in border crossing and by only 17 percent once consumers reoptimize their location of purchase.[32]

Our simulation conditions on the decision to smoke[33], and we also assume that the simulated tax changes do not affect the decision to smoke. In addition, we implicitly assume that a one cent increase in the tax will lead to a one-cent increase in the price paid by consumers. Chaloupka and Warner (2000) note that early studies have produced inconsistent findings regarding the relationship between taxes and prices in the U.S.; Keeler et al. (1996) estimated that a one-cent increase in a state's cigarette tax would raise retail prices in that state by 1.11 cents.

[32]Using equations (6) and (7), we let $t_s = \$1.00$ and $t_f = \$0.39$. We use $4.104 for the average price (inclusive of tax) for a pack of cigarettes as reported in *Tax Burden on Tobacco* in 2003 for D.C. For the own-price elasticity, we consider values between -0.2 and -0.3 as given in Table 8. The travel costs from our location model represent the average costs in the population and may tend to understate actual travel costs in dense urban areas such as D.C.; if this is the case, our border crossing estimate will be an upper bound.

[33]If we incorporate the extensive margin (the decision to smoke), then the responsiveness of demand to price changes will depend upon changes in the smoking participation rate. Assuming the participation rate does not change differentially by state, then we would expect the unconditional elasticities to be even larger in magnitude; an increase in the tax-inclusive price will cause some individuals to stop smoking (quantity consumed = 0).

6 Extension: Incorporating Internet Usage

Internet access may vary by consumers, so as an extension to the initial specification, we specify a discrete model of location choice which allows for the possibility that the outside option may not exist in certain consumers' choice sets. We assume that purchases from the outside option are made through the Internet. Our approach is to estimate the discrete choice model in a two step procedure. First, we use data from the CPS Internet usage survey from October 2003 to estimate the probability that an individual has Internet access, conditional on demographics. We then use predicted probability of Internet access to weight the choice probabilities for each individual's decision in our discrete model of location choice.

Let $\hat{r}_i$ denote the predicted probability that individual i has Internet access. Analogous to our utility specification from the previous section, we assume that consumer i's utility from purchasing at location j is given by $U_{ij} = X_{ij}\theta + \epsilon_{ij}$. If an individual has Internet access, then the conditional probability that she chooses location j is given by

$$prob_{ij|Internet} = \frac{exp(X_{ij}\theta)}{\sum_{k=1}^{K} exp(X_{ik}\theta) + exp(X_{ic}\theta)} \tag{8}$$

where choice c denotes purchasing online.

If an individual does not have Internet access, then the conditional probability of choosing location j is given by

$$prob_{ij|noInternet} = \frac{exp(X_{ij}\theta)}{\sum_{k=1}^{K} exp(X_{ik}\theta)}. \tag{9}$$

Weighting the two, we can derive the unconditional probability that an individual purchases from a particular location or over the Internet.

The unconditional probability of purchasing from location j is given by:

$$prob_{ij} = \hat{r}_i \frac{exp(X_{ij}\theta)}{\sum_{k=1}^{K} exp(X_{ik}\theta) + exp(X_{ic}\theta)} + (1 - \hat{r}_i) \frac{exp(X_{ij}\theta)}{\sum_{k=1}^{K} exp(X_{ik}\theta)}, \tag{10}$$

and the unconditional probability of purchasing online is given by:

$$prob_c = \hat{r}_i \frac{exp(X_{ic}\theta)}{\sum_{k=1}^{K} exp(X_{ik}\theta) + exp(X_{ic}\theta)}. \tag{11}$$

To estimate our first stage, we use data from the CPS Internet usage survey in October 2003 on computer and Internet penetration. We consider four measures of computer and Internet access: (1) home computer ownership, (2) home Internet access, (3) use of e-mail, and (4) purchase of goods online. Sixty-nine percent and 61 percent of respondents own a home computer and have Internet access at home. Forty-seven percent of participants have used e-mail, and 26 percent have made an online purchase.

We use a probit regression to estimate Internet access conditional on an individual's demographics, and we regress each of the four measures of computer and Internet access on educational attainment, gender, income bracket, ethnicity, state of residence, and a quadratic function of age. We find that the explanatory variables do a fairly good job of predicting our Internet use variables; the pseudo R-squared for each of the regressions lies between 0.2 and 0.25.

Table 12 presents the results of the four regressions on online use. We find similar relationships between demographics and each of our four metrics.

Table 12. Marginal Effects of Probit Model for Online Access

	(1) Computer at Home	(2) Internet in Home	(3) Email	(4) Online Purchase
age	0.001**	0.000	-0.008**	0.009**
	(0.000)	(0.001)	(0.001)	(0.001)
age^2	-0.000**	-0.000**	-0.000**	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
High school	0.064**	0.076**	0.143**	0.157**
	(0.004)	(0.005)	(0.005)	(0.006)
Some college	0.165**	0.190**	0.321**	0.321**
	(0.004)	(0.005)	(0.005)	(0.006)
BA degree	0.190**	0.228**	0.409**	0.465**
	(0.004)	(0.005)	(0.004)	(0.006)
MA/Ph.D. degree	0.200**	0.242**	0.411**	0.500**
	(0.004)	(0.005)	(0.004)	(0.007)
Female	0.009**	0.006+	0.079**	0.022**
	(0.003)	(0.004)	(0.004)	(0.003)
Black	-0.111**	-0.135**	-0.150**	-0.141**
	(0.006)	(0.007)	(0.007)	(0.005)
Native American	-0.113**	-0.164**	-0.124**	-0.122**
	(0.018)	(0.019)	(0.019)	(0.015)
Asian	0.014	0.016	-0.055**	-0.086**
	(0.010)	(0.011)	(0.011)	(0.008)
Other	-0.003	-0.014	-0.012	-0.009
	(0.012)	(0.013)	(0.014)	(0.012)
Observations	89701	89701	89701	89701

Notes: This tables reports the marginal effects (evaluated at the variable means) from the probit model describing whether an individual has online access or not. Regressions also include income dummies. Robust standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%

Internet usage is positively and significantly correlated with educational attainment and income. We estimate that women are slightly more likely to have a home computer or home Internet access and are substantially more likely to have used e-mail. Blacks and Native Americans are significantly less likely to have home computers or Internet access, and they are also less likely to have used e-mail or purchased goods online. Finally, we find that the quadratic age term is negative and significant across each of the four regressions, consistent with computer and Internet penetration among younger individuals.

We take the estimated coefficients on Internet use and predict the probability of Internet access for individuals from our TUS sample. Across individuals in the TUS sample, the average predicted probabilities are 66 percent with a computer at home, 59 percent with Internet at home, 51 percent with e-mail, and 30 percent with an online purchase. We incorporate these probabilities and estimate an extension of the location model where the probability of access to the outside good ("Internet") varies by individual. We estimate the model using a Quasi-Newton method with a numeric gradient; we also obtain similar coefficient estimates when we use a non-derivative simplex search instead.

Table 13 contains the results of the extended location model under our four different measures of Internet access.

Table 13. Location Choice with Internet Choice Probabilities

	coefficient
price	-0.0064
	(0.00072)
price*income	0.0003
	(0.00053)
distance	-0.19154
	(0.00692)
distance*income	0.029495
	(0.01033)
outside	-6.8450
	(0.31661)
Number of observations	9656
Log-likelihood	-1348.61

Notes: These estimates are from the logit model describing an individual's choice of location of purchase while accounting for their Internet access. Each consumer's choice set is weighted by the predicted probability that she has Internet access at home. Standard errors in parentheses.

The estimated disutility of price and traveling are approximately the same as our baseline model where all individuals were assumed to have access to the Internet, since variation in price and distance among the states (i.e., offline options) drive the identification of these coefficients.[34] As expected, the disutility of the outside good has declined slightly, since individuals now may not have access to the outside good (online) with some positive probability. The coefficients on the interactions between price and income are now positive, indicating that higher income individuals are less price sensitive. Higher income individuals are more likely to have Internet access and therefore buy online when they face higher offline prices.

7 Conclusion

In this paper, we estimate individuals' decisions to travel across borders in response to differential tax rates. Unlike previous studies, our rich dataset allows us to directly observe a consumer's location of purchase as well as demographics. Consequently, we can apply a discrete choice model to directly estimate a consumer's choice of purchase location.

Our approach contributes to the literature in four important ways. First, the richness of our dataset allows us to estimate how an individual's characteristics affects her propensity to travel. Since we directly observe an individual's location of choice, we can obtain more reliable estimates of the border crossing behavior relative to previous studies, which indirectly infer border crossing from smoking intensity. We find that the average individual who lives nearby a lower-tax jurisdiction is willing to travel 3 miles to save one dollar on a pack of cigarettes. Secondly, this is the first paper to provide an estimate of how stockpiling behavior differs between light and heavy smokers who choose to cross borders to purchase cigarettes. We find evidence that heavy smokers have a stronger incentive to cross borders and purchase in a lower-tax jurisdiction. Thirdly, we find evidence that the tax-inclusive price in a state declines as an individual lives closer to a border with a lower-tax jurisdiction, and rises as she lives closer to a border with a higher tax jurisdiction. Finally, we can separately estimate the effect of a tax increase on state sales and revenues in the presence of border crossing and also in the counterfactual scenario in the absence of border crossing. We find that a given state's increase in tax can differentially impact the sales of its neighboring states, depending on the distribution of the location and demographics of a state's population.

[34] The outside good was assumed to have a price and distance equal to zero; we included an outside good dummy to capture its relative attractiveness.

Our ultimate goal is to investigate the public policy implications of tax changes and differences in taxes across neighboring jurisdictions in the absence and presence of border crossing. We apply the estimated parameters from our location model and consumption regression to simulate several counterfactual tax scenarios. In particular, we examine the effect of a 36 cent increase in the tobacco tax as debated by the Maryland General Assembly.

We find that the effects of border crossing on tax revenues vary substantially by state. Absent a change in border crossing, a 36 cent increase (from $1.00 to $1.36) in Maryland's cigarette tax will increase its state tax revenues by 34 percent. Accounting for border crossing modestly decreases this estimate - Maryland tax revenues will increase by 31 percent after a subset of smokers shift their purchase location to nearby states. In the case of D.C., we find that ignoring border crossing incentives leads to a larger overestimate of the change in tax revenues. Not accounting for border crossing overestimates the increase in tax revenues to be 34 percent instead of only 17 percent for a 36 cent increase in tax per pack (from $1.00 to $1.36).

Cigarette taxes serve two purposes, revenue generation and smoking deterrence. From our estimates of the total price elasticity of demand for cigarette sales, we can determine whether the per pack excise tax in a state falls short of, equals, or exceeds the revenue maximizing tax rate.[35] If we assume a full passthrough of cigarette taxes to the tax-inclusive price[36], the revenue maximizing tax rate in Maryland would be $3.00 per pack on top of an average tax-exclusive price of $2.71 per pack. Although states consider the border crossing effects when determining their tax rates, we find that existing cigarette taxes tend to fall below the tax-revenue maximizing levels.

Our results highlight the regulatory importance of geographic scope and inter-jurisdictional heterogeneity. Cigarette taxes may be levied for a variety of public concerns from reducing smoking to generating tax revenues. The efficacy of any such regulation depends upon the policies of neighboring jurisdictions as well as the geographic distribution of consumers within the jurisdiction. This suggests the need for coordination among policymakers across

[35]Following an analogous derivation to the Lerner Index, the revenue maximizing tax rate t^* satisfies $\frac{t^*}{p+t^*}\left[1+\frac{\partial p}{\partial t}\right]=-\frac{1}{\epsilon}$ where p denotes the tax-exclusive price and ϵ denotes a state's own tax-inclusive price elasticity. Note that we use the total price elasticity of demand that incorporates both the decision to smoke and the quantity to smoke. While the preceding simulations conditioned on the decision to smoke, we need to incorporate the change in the extensive margin when considering potentially larger changes in prices.

[36]If the incidence of taxation falls only partially on consumers, the revenue maximizing tax rate will be greater. If, as Keeler, et al. (1996) finds, cigarette taxes are more than fully passed through to the consumer, the revenue maximizing tax rate will be lower.

different geographic locales or at the very least, incorporating these constraints when determining regulation stringency.

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