NBER WORKING PAPER SERIES

EXCISE TAX AVOIDANCE:
THE CASE OF STATE CIGARETTE TAXES

Philip DeCicca
Donald S. Kenkel
Feng Liu

Working Paper 15941
http://www.nber.org/papers/w15941

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2010

This research was supported by Award # R01 HD048828 from the National Institutes of Health. We thank Mike Lovenheim, Anindya Sen, Mark Stehr, and participants at seminars at Indiana University - Purdue University at Indianapolis, SUNY- Stony Brook, and the University of Georgia for comments on earlier drafts. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Excise Tax Avoidance: The Case of State Cigarette Taxes
Philip DeCicca, Donald S. Kenkel, and Feng Liu
NBER Working Paper No. 15941
April 2010
JEL No. H21,H26,I18

ABSTRACT

In this paper we contribute new empirical results about consumers' decisions to avoid cigarette excise taxes, and a new applied welfare economic analysis of optimal excise taxation with tax avoidance. We examine direct measures of consumer excise tax avoidance in novel individual-level data from the 2003 and 2006 - 2007 Tobacco Use Supplements to the U.S. Current Population Survey. We estimate reduced-form models and a structural endogenous switching regression model. In the structural border-crossing equation, the decision to cross the border depends on the difference between the endogenous home- and border-state prices. The reduced-form and structural results show that the probability of cross-border cigarette purchases responds in predictable ways to the economic incentives created by the distance to the border and state tax differentials. To our knowledge, we are also the first study to extend the formula for optimal Pigouvian corrective taxation to incorporate excise tax avoidance. Taking into account tax avoidance implies the optimal tax is substantially below the simple Pigouvian tax that internalizes external costs. In illustrative calculations for 2003, we find that in 20 states the optimal tax that accounts for tax avoidance is at least 20 percent smaller than the simple Pigouvian tax.

Philip DeCicca
Department of Economics
422 Kenneth Taylor Hall
McMaster University
Hamilton, ON L8S, 4M4
CANADA
and NBER
decicca@mcmaster.ca

Donald S. Kenkel
Department of Policy Analysis and Management
College of Human Ecology
Cornell University
Martha Van Rensselaer Hall
Ithaca, NY 14853-4401
and NBER
dsk10@cornell.edu

Feng Liu
School of Economics
and Institute for Advanced Research
Shanghai University of Finance and Economics
777 Guoding Road
Shanghai 200433, China
fliu22@gmail.com

1. Introduction

Many countries impose excise taxes on alcohol, cigarettes, gasoline, and environmentally-related goods (Cnossen, 2005). Excise taxes are relatively small but non-trivial sources of revenue. On average across the OECD, they account for almost 12 percent of government revenues(OECD 2005). However, it is widely agreed that the revenues are not the main reason for excise taxes. As Hines (2007, p. 50) argues: "Instead, excise taxes are intended to discourage consumption of the specific taxed goods, thereby preventing some potential consumers from contributing to pollution, traffic congestion, injury, and poor health." In neoclassical welfare economics substantial excise taxes on certain goods can be justified as efficient Pigouvian taxes that internalize external costs.[1] Recent work in behavioral economics suggests that much higher excise taxes may sometimes be justified to correct the "internalities" consumers impose on their future selves by unhealthy time-inconsistent decisions (O'Donoghue and Rabin 2003, 2006, Gruber and Koszegi 2004).

In the U.S. excise taxes are imposed at the federal, state, and local level. In recent years states have been particularly active increasing the excise taxes on cigarettes. Since 2000, 47 states and the District of Columbia have enacted 100 cigarette tax hikes (Federation of Tax Administrators 2010). According to a major tobacco company, 16 states are considering new cigarette tax hikes in 2010 (R.J. Reynolds Tobacco Company 2010). Cigarette tax rates currently range from a low of $0.07 per pack in South Carolina to a high of $3.46 per pack in

[1]The seminal study by Manning *et al.* (1989) concluded that the external costs of drinking justified higher alcohol taxes, but cigarette taxes were already high enough. Smith (2005, pp. 67 - 73), Cnosssen and Smart (2005, pp. 36 - 37), and Sloan *et al.* (2004) review more recent empirical evidence on the external costs of alcohol and cigarettes. Parry, Walls, and Harrington (2007) review empirical evidence on externalities related to automobile use.

Rhode Island. Some localities also tax cigarettes, the most notable being New York City's $1.50 per pack tax since 2002, and Chicago and Cook County's combined $2.68 per pack tax since 2006. Alcohol and gasoline excise taxes also vary widely across states, although not as widely as cigarette taxes (Federation of Tax Administrators 2010). In the contiguous U.S., beer tax rates currently range from $0.02 per gallon in Wyoming to $0.77 per gallon in South Carolina. Perhaps not coincidentally, some of the very highest beer taxes are in the geographically isolated states of Alaska ($1.07 per gallon) and Hawaii ($0.93 per gallon). Gasoline tax rates in the contiguous U.S. range from $0.14 per gallon in Wyoming to $0.375 per gallon in Washington.

Consumers can legally avoid national, state, and local excise taxes by making purchases from nearby tax jurisdictions with lower tax rates. Excise tax avoidance is a potential problem in both Europe and the U.S. Twelve percent of the E.U. population lives near the border with another member nation (Cnossen 2005, p. 45). About 40 percent of the U.S. population lives in counties that border another state or nation (Vedder 1997). Following Oliver Wendell Holmes in Bullen v. Wisconsin (1916), it is standard to distinguish legal tax avoidance from illegal tax evasion. In most U.S. states, cross-border purchases are legal if intended for personal consumption. For cigarettes, this is usually implemented through limits on the quantity purchased, typically 20 to 30 packs (two to three cartons of 10 packs each).

Although policy makers in high-tax jurisdictions understandably worry about the potential lost tax revenues, economic research on excise tax avoidance is limited. The extensive body of theoretical and empirical research on tax evasion and compliance focuses almost entirely on income taxes, not excise taxes (Andreoni, Erard, and Feinstein 1998, Sandmo 2005, Slemrod 2007, Chetty 2009a). Some health economics studies attempt to control for legal consumer tax avoidance and illegal smuggling of cigarettes and alcohol, but these studies lack actual measures of tax avoidance and their primary goal is to develop unbiased estimates of the price elasticities of demand.[2] As Merriman (2010) notes about many of these studies, "none of the widely used approaches is fully satisfactory because they require researchers to infer tax avoidance based on discrepancies in observed data (e.g. the difference between tax revenues collected and smoking observed in surveys of the smoking public)."

In this paper we contribute new empirical results about consumers' decisions to avoid cigarette excise taxes, and a new applied welfare economic analysis of optimal excise taxation with tax avoidance. In our empirical study, we examine direct measures of consumer excise tax avoidance in novel individual-level data from the 2003 and 2006 - 2007 cycles of the Tobacco Use Supplements to the U.S. Current Population Survey (TUS-CPS). In addition to standard questions about smoking, the TUS-CPS asked smokers directly about their actions to avoid cigarette taxes. We use geographic information on the respondents' location to merge data on excise taxes in their home states and bordering states, as well as their distance to the state border. Another special feature of these cycles of the TUS-CPS is that they asked consumers about the prices they actually paid for their cigarettes.

Section 2 describes the data in more detail and provides an overview of the extent of tax

---

[2]Chaloupka and Warner (2000) provide a comprehensive review of cigarette demand studies. Cigarette demand studies that emphasize the role of tax avoidance and smuggling include Coats (1995), Saba *et al.* (1995), Thursby and Thursby (2000), Yurekli and Zhang (2000), Gruber, Sen and Stabile (2003), Stehr (2005), Lovenheim (2008) and Chiou and Muehlegger (2008). Cook and Moore (2000) provide a comprehensive review of alcohol demand studies. Alcohol demand studies that address border-crossing include Baltagi and Goel (1990), Baltalgi and Griffin (1995), Beard, Gant and Saba (1997), and Stehr (2007). In a related study, Asplund, Friberg and Wilander (2007) estimate the responsiveness of Swedish alcohol sales to foreign prices.

avoidance. Cross-border purchases appear to be the most common form of cigarette tax avoidance. About five percent of the smokers in the TUS-CPS sample report that their last purchase of cigarettes was in a state other than their state of residence. As with excise tax rates, the rate of cross-border purchases varies widely across states, from under one percent of smokers in several low-tax states to about 20 percent in the District of Columbia. The prevalence of cross-border cigarette purchases as directly measured in the TUS-CPS is higher than most previous estimates based on indirect evidence from cigarette demand models.

In section 3 we report results from reduced-form models of the probability of cross-border cigarette purchases. The results show that this form of tax avoidance responds to economic incentives in predictable ways: the probability of border crossing depends on the consumer's distance to the border and on the home- and border-state cigarette taxes. Socioeconomic factors often play different roles in border crossing than is usually found in cigarette demand models. For example, although previous studies find that smoking is less likely among people with more schooling and higher incomes, we find that border-crossing is more likely among smokers with college degrees and higher incomes.

In section 4 we extend our empirical analysis to estimate a structural endogenous switching regression model of border-crossing and cigarette prices. Depending on whether the individual crosses the border, the price paid for cigarettes switches between two regimes: the home-state price and the border-state price. In the structural border-crossing equation, the decision to cross the border depends on the difference between the endogenous home- and border-state prices. We estimate that at the sample averages, the elasticity of border-crossing with respect to the home-state price is 3.1, suggesting that consumer tax avoidance strongly responds to price differentials created by state tax differences.

In section 5 we discuss the implications of tax avoidance for applied welfare economic analysis of excise taxes. To our knowledge, we are the first study to extend the standard formula for the optimal Pigouvian corrective tax to incorporate tax avoidance. In illustrative calculations, we find that for many states, after taking into account tax avoidance the optimal tax is at least 20 percent smaller than the simple Pigouvian tax that internalizes external costs. Our empirical estimate that tax avoidance strongly responds to the price differential is the main reason for this result. Regardless of how large smoking's externalities or internalities are, tax avoidance reduces the effectiveness of state excise taxes as a corrective policy tool. If tax avoidance and evasion directly generate external costs, such as traffic fatalities or illegality costs, the optimal state excise tax on cigarettes is even lower.

The concluding Section 6 includes a discussion of the relevance of the results for other common excise taxes.

2. Data

Beginning in 1992, the Tobacco Use Supplements (TUS) have been sponsored by the National Cancer Institute and administered as part of the Consumer Population Survey (CPS) (Hartman *et al.* 2002). Each cycle provides a large nationally representative sample and sub-samples that are representative at the state level. In addition to questions about smoking behaviors, respondents were asked other questions that varied somewhat over the TUS-CPS cycles. We use data from two TUS-CPS cycles: the cycle conducted in February, June, and November of 2003; and the cycle conducted in May and August 2006 and January 2007. In these cycles only, the TUS-CPS asked smokers whether their last purchase of cigarettes was in a state other than their state of residence, or over the internet or by other means. They were also asked how much they paid for their last pack (or carton) of cigarettes. In order to calculate distance to the state border for each respondent, we restrict the sample to residents of Metropolitan Statistical Areas (MSAs). Our sample of analysis consists of 29,377 smokers who lived in an MSA and provided valid responses to the questions about border-crossing and cigarette price paid. We used Google Maps to calculate each respondent's distance to the closest lower-tax border state. We match cigarette excise tax rates from Orzechoswski and Walker (2008) to respondents, based on their MSA, the closest border state, and their interview month. When MSAs span state lines, we match tax rates based on the respondents' state of residence. Respondents in the Chicago and New York City MSAs are also assigned the applicable local cigarette taxes.

Table 1 provides descriptive statistics from the TUS-CPS for the variables used in the empirical models below. About five percent of TUS-CPS smokers report that their last cigarette purchase was made across a state border, and less than one percent report that their last purchase was over the internet or other means.[3] Therefore, we focus on cross-border purchases in the empirical work below. Table 1 cross-tabulates the means for the other variables by border-crossing status. The average border crosser lives about 70 miles closer to a lower-tax state and pays about $0.60 less for a pack of cigarettes. The difference between the median distance to the border by border-crossing status is also about 70 miles (20 miles versus 93 miles).

[3]The low prevalence of internet purchases might seem surprising, and could reflect TUS-CPS respondents' reluctance to report actions of questionable legality. As Goolsbee, Lovenheim, and Slemrod (2010) point out, there is very little systematic evidence about the volume of internet cigarette sales.

As shown in Table 2, the rate of cross-border purchases varies widely across states. For example, in Kentucky and South Carolina, where the cigarette excise taxes are very low, one percent or fewer smokers report a cross-border purchase. These cross-border purchases might be incidental, for example regular commuters might sometimes buy cigarettes across the border even without a tax advantage. Some of the highest rates of cross-border purchases are in the District of Columbia (18 - 22 percent) and Maryland (14 - 18 percent). Not only are cigarette taxes relatively high at $1.00 per pack in these two jurisdictions, but they both border Virginia, where the tax rate was only $0.03 per pack in 2003 and still relatively low at $0.30 per pack in 2006 - 2007.

To the best of our knowledge, the TUS-CPS provides the first national estimates based on direct measures of consumer cigarette tax avoidance.[4] There are a few previous state- or locality-specific estimates. Emery *et al.* (2002) find that 3.1 percent of California smokers report making cross-border purchases after the 1999 cigarette tax hike, compared to our estimate of 2.4 percent in the 2003 TUS-CPS. Merriman (2010) and Chernick and Merriman (2009) measure tax avoidance in Chicago and New York City by examining littered cigarette packs. This novel method yields evidence of high levels of avoidance in both cities: in 2007 26 percent of the littered packs in Chicago and Cook County had Indiana tax stamps; and in 2008 14 percent of littered packs in New York City had out-of-state tax stamps. By comparison, the 2006 - 2007

[4]In a national sample from the 2003 TUS-CPS, Chiou and Muehlegger (2008) find that about four percent of smokers make cross-border purchases. Chiou and Muehlegger limit their sample to the 9,745 smokers with identified county of residence. Our 2003 TUS-CPS sample includes 16,745 smokers with identified MSA of residence, and includes virtually all of the respondents with identified county of residence. With the addition of the 2006 - 2007 TUS-CPS, our total sample of 29,377 is about three times larger than the sample Chiou and Muehlegger use.

TUS-CPS data for these two cities yields lower estimates than the littered pack method: about 14 percent of Chicago smokers and 5 percent of New York City smokers report making cross-border purchases. In addition to the legal tax cross-border purchases measured in the TUS-CPS, the higher littered pack estimates might also reflect organized smuggling of low-taxed and untaxed cigarettes. It is also difficult to know if the population of smokers who litter is representative of all smokers, in terms of their tax avoidance behavior.

Several studies use cigarette demand models to develop indirect estimates of the extent of cross-border purchases and illegal smuggling. The indirect estimates of the prevalence of border crossing range from under one percent to as high as 25 percent. The first set of indirect estimates are from a series of academic studies and consulting reports that estimate models of state cigarette sales. Although the details of the specifications differ, the basic approach is to include variables related to border-crossing incentives in the cigarette demand models. The estimated model parameters are then used to predict the extent of cross-border purchases. Saba *et al.* (1995) estimate that from 1973 through 1986 almost all states experienced trivial losses (usually less than 1 percent of sales) to border crossing. A notable exception is their estimate that in 1986 the high-tax jurisdiction of D.C. lost 51 percent of sales to its lower-tax border states. Using updated data from 1970 through 1995, Yurekli and Zhang (2000) estimate that nationally in 1995 only 1.5 percent of state tax revenues were lost to border-crossing. The consulting reports also suggest that border-crossing is fairly uncommon (Fleenor 1999, Farrelly and Nimsch 2003, O'Connor 2008, LaFaive, Fleenor and Nesbit 2008).[5] Stehr (2005) compares

[5]Several other studies including Coats (1995), Thursby and Thursby (2000), and Gruber, Sen, and Stabile (2003) estimate the extent of illegal smuggling of cigarettes, but do not separately estimate the extent of legal border-crossing.

individual cigarette consumption data with state sales data. His regression model shows the association between changes in incentives to avoid taxes and changes in the difference between consumption and sales. He estimates that border-crossing effects are very small and account for less than 1 percent of total sales in 2001. In contrast, based on a demand model estimated with individual-level data from 1992 - 2002, Lovenheim (2008) estimates that between 13 and 25 percent of consumers make cross-border purchases. Our direct estimate from the TUS-CPS of about 5 percent suggests that border-crossing is neither as trivial as suggested by earlier studies nor as prevalent as suggested by Lovenheim.

3. Reduced-Form Model of Border Crossing

In this section we report alternative specifications of a reduced-form model of the probability of making a cross-border cigarette purchase. Border crossing is based on whether the consumer's most recent purchase of cigarettes was made in some state other than his or her state of residence. In the basic linear probability model, border crossing is a function of distance to the border, distance-squared, and a set of socioeconomic variables measuring age, gender, race/ethnicity, schooling, family income, household size, marital status, and employment status. In additional model specifications, we add the home-state and border-state cigarette tax rates the consumer faces, and then we add interactions of these variables with the distance measures. Finally, we explore whether the results are sensitive to the use of probit instead of the linear probability model, or to the inclusion of a measure of state anti-smoking sentiment. Individual respondents in the TUS-CPS are clustered within 234 MSAs, and our models include variables measured at both the individual- and MSA-level (e.g., cigarette taxes). We use Stata's *robust* and *cluster* commands to obtain robust standard errors that account for potential clustering within MSAs.

The results for the linear probability models of border-crossing are reported in the first three columns (A - C) of Table 3. The fourth column (D) of Table 3 reports results from a probit model of border-crossing that includes the full set of distance, tax, and interaction terms. To help compare the results across model specifications, Table 3 also reports the implied marginal effect of distance on the probability of border-crossing, evaluated at the sample averages of the relevant variables. Distance to the border statistically significantly deceases the probability of border crossing. The size of the marginal effect of distance falls at higher distances. The implied marginal effect of distance is fairly stable across specifications and suggests that at the mean distance each additional mile reduces the probability of border crossing by about 0.05 percentage points. Taking into account the quadratic distance term, the predicted probability of border crossing approaches zero at a distance to the border of about 300 miles. Comparing Model C to D, the substantive results are not very sensitive to the use of probit instead of the linear probability model.[6]

In the specifications reported in columns C through E of Table 3, a higher home-state tax increases the probability of border-crossing, while a higher border-state tax decreases the probability of border-crossing. As expected the estimated coefficients on the home- and border-state tax variables are virtually identical in size and opposite in sign: consumers apparently cross the border in response to a tax difference regardless of whether it is caused by a high home-state tax or a low border-state tax. A tax difference of $1.00, which is approximately the difference

[6]The models in columns A - C and E suffer from the well-known drawback of the linear probability model and predict negative probabilities at distances above 300 miles or so. However, these distances are outside the range of virtually all of the data.

in 2003 between Maryland and Virginia or D.C. and Virginia, is predicted to increase the probability of border crossing by about 5 to 6 percentage points. In the models reported in columns C, D and E, there are statistically significant interaction terms between the distance and tax variables. These results suggest that: when the home-state tax is higher, the effect of distance is larger in absolute value; and when the border-state tax is higher, the effect of distance is smaller. Put differently, when the tax differential is very small , consumers do not cross the border even at low distances.

Additional model specifications, which are not reported in Table 3 but are available upon request, explore more possible determinants of border crossing. In one set of models, we explore the hypothesis that recent tax hikes have greater salience for border-crossing decisions than longer-standing taxes.[7] We add to our model an indicator variable for consumers who face a recent tax hike, i.e. a tax hike within either 3, 6, or 12 months before the date they were surveyed. Farrelly, Nimsch, and James (2003) provide suggestive evidence that there may be a surge in cigarette tax avoidance immediately after a tax hike, which then quickly subsides within several months. Our results are consistent with this pattern. Our point estimate is that consumers who face a tax hike within the past 3 months are 2.6 percentage points (t=2.19) more likely to cross the border, which is a very large effect compared to the sample proportion of 5 percent border-crossing. The average effect of a tax hike within the past 6 months falls to 1.9 percentage points (t=2.11), and the average effect of a tax hike within the past 12 months falls to 1.0 percentage points (t=1.54).

In another set of additional specifications, we include state gasoline, beer, and sales taxes

[7]Chetty, Looney and Kroft (2009) find that excise taxes have greater salience than sales taxes as determinants of alcohol demand in both the short- and long-run.

in our models of cross-border cigarette purchases. High gasoline taxes increase the travel costs of border crossing. At the same time, some consumers may be able to jointly avoid several taxes when they make a cross-border cigarette purchase. We do not find evidence that cross-border purchases of cigarettes respond much to the level of the gasoline tax, or to gasoline- , beer-, or sales-tax differentials. The lack of evidence might reflect the fact that in general, gasoline, beer, and sales taxes vary much less across states than cigarette taxes.

Another specification issue concerns the role of unobserved state-level influences. In empirical studies of cigarette demand there is a concern that state cigarette taxes are endogenous because they are correlated with anti-smoking sentiment or some other hard-to-observe state-level influence (Keeler *et al*, 2001; DeCicca *et al*, 2008). Although the decision to purchase cigarettes across the border is much different than the decision to smoke, the state tax variables might also be endogenous in our models. To address this concern, we include a direct measure of state anti-smoking sentiment (DeCicca *et al.* 2008). [8] The measure is based on responses about attitudes towards smoking reported in earlier TUS-CPS cycles and is similar to the measures used by Gilpin, Lee and Pierce (2004) and Alamar and Glantz (2006). The measure of state anti-smoking sentiment has been merged with several different data sets to estimate cigarette demand models (Carpenter and Cook 2008, DeCicca *et al.*, 2008, DeCicca,

---

[8]Another common specification to address this concern is to use repeated cross-sectional data and include location fixed effects. However, a location fixed effects specification is problematic in a study of a mainly time-invariant characteristic like distance to the border. Lovenheim (2008) includes MSA fixed effects in his study of the effect of distance to the border on cigarette demand. Even though distance to a specific state border is time invariant, home- or border-state price changes create within-MSA variation in distance to the closest lower-price border. However, the within-MSA variation is limited in Lovenheim's study: between most survey years less than 20 percent of the MSAs experience a change in distance to a lower-price border.

Kenkel, and Mathios 2008, DeCicca and McLeod 2008, Liu 2009). In these studies, measured state anti-smoking sentiment is strongly associated with less smoking. The estimated effects of cigarette taxes or prices on smoking are also typically very sensitive to the inclusion of sentiment measure.

The model of border-crossing reported in column E of Table 3 includes the measure of state anti-smoking sentiment. We find that residents of states with higher anti-smoking sentiment are more likely to make a cross-border purchase. When we include measures of both home- and border-state anti-smoking sentiment, we find that a higher level of anti-smoking sentiment in the border state discourages border crossing (results not reported but available upon request). Home- and border-state anti-smoking sentiment seem to play roles similar to taxes in smokers' decisions about border purchases. This might reflect social influences that increase the full cost of a cigarette purchase in a state with high anti-smoking sentiment, or it might reflect other unobserved extra costs of purchases. Comparing the models in columns C and E, the estimated coefficients on the tax variables are not sensitive to the inclusion of the sentiment measure.

It is impossible to rule out all possible sources of state-level heterogeneity that might create bias in our estimates of the impact of state cigarette taxes on border crossing. However, we find no evidence of the most likely source – policy endogeneity bias related to state anti-smoking sentiment. We also note that many sources of heterogeneity should lead to different biases in our estimates of the effects of home-state taxes versus border-state taxes.[9] Therefore,

[9]For example, suppose that there is still some remaining unmeasured anti-smoking sentiment that is positively correlated with state tax rates. Based on the economics of consumer price search (Baye, Morgan, and Scholten 2006), heavier smokers will search more intensively for lower-price cigarettes, so they may be more likely to cross the border. To the extent

the fact that the home-state and border-state tax coefficients are virtually identical provides additional suggestive evidence that these estimates are not biased by endogeneity.

Finally, we note that the different model specifications show consistent patterns between border-crossing and the socioeconomic variables. In cigarette demand studies, people with more schooling are much less likely to smoke, and the association with income is typically negative (Wasserman *et al.* 1991, Colman and Remler 2008). In contrast, in the results in Table 3 smokers who are college graduates are about one percentage point more likely to cross a state border to purchase their cigarettes. And instead of a negative income gradient, the probability of border crossing increases with income. Respondents with family incomes in the two higher categories (roughly the upper half of the income distribution) are 1 to 1.5 percentage points more likely to cross the border. The probability of border crossing also increases with age: middle-aged and older smokers are two to four percentage points more likely to cross the border than young adults under age 30. Compared to the average prevalence of about 5 percent border-crossing, the estimated differences for college graduates, higher income households, and older age groups are sizeable.

The patterns for many of the socioeconomic variables might reflect two often conflicting influences: the opportunity cost of time and the amount of automobile travel. For example, because higher-income consumers will generally have a higher opportunity cost of time, the

---

unmeasured anti-smoking sentiment reduces heavier smoking, it will also tend to reduce border crossing. If unmeasured sentiment is positively correlated with the home state tax rate, the coefficient on the home-state tax in the border-crossing equation is biased towards zero and thus away from the coefficient on the border-state tax. More generally, it is unlikely that unobservable heterogeneity will lead to the same bias in the estimates of the effects of home- and border-state taxes. Of course, the biases in the coefficients could be equal by accident, so the equality of the coefficients is consistent with, but not definitive proof of, the tax exogeniety assumptions.

positive relationship between income and time- intensive border crossing might seem surprising. However, research suggests that higher-income consumers have higher demands for automobiles, gasoline, and traffic volume (Johnson 1978, Kayser 2000, Goodwin, Dargay and Hanly 2004). Their higher automobile travel probably explains why higher-income consumers are also more likely to purchase cigarettes across state borders. The probability of border crossing also decreases with household size and is lower for Blacks and Hispanics; again, similar patterns are found in studies of the demand for automobiles and gasoline (Kayser 2000). Although we do not find strong patterns for consumers who are unemployed or out of the labor force, border-crossing among retirees is estimated to be about one percentage point more likely, consistent with a lower opportunity cost of time.

4. Endogenous Switching Regression Model

An Empirical Model of Border-Crossing and Cigarette Prices

In this section we estimate a structural endogenous switching regression model of border- crossing and cigarette prices in two regimes: the home price (P^H)and the border price (P^B). Depending on whether individual i crosses the border (B_i = 0 or 1), the price paid by individual i switches between the two regimes:

(1a) $P_i^H = \beta_1 + \beta_2 X_i + \epsilon_i^H$ if $B_i = 0$

(1b) $P_i^B = \gamma_1 + \gamma_2 X_i + \epsilon_i^B$ if $B_i = 1$

The individual is assumed to make cross-border purchases of cigarettes if doing so increases his or her utility. Assume the individual receives utility from a composite consumption good g, disutility from miles of distance traveled m, and utility from cigarette consumption c. The latent utility difference behind the observed border-crossing decision is given by:

(2) $\Delta u = u(g^*, m^*, c^*) - u(g^{**}, m^{**}, c^{**})$

where g*, m*, and c* are the optimal choices given border crossing and g**, m**, and c** are the optimal choices given no border crossing.

To develop an empirical version of equation (2), consider a first-order Taylor series approximation of the utility function:

(3) $u(g^* + \Delta g, m^* + \Delta m, c^* + \Delta c) = u(g^*, m^*, c^*) + u_g \; \Delta g + u_m \; \Delta m + r$

where u_g and u_m are partial derivatives of the utility function and r is the remainder term for the Taylor series approximation (including the terms related to Δc). Because g is the composite consumption good, the difference between the optimal choice of g with and without border-crossing is simply the potential savings from purchasing less expensive cigarettes across the border: $\Delta g = g^* - g^{**} = c\,(P^B - P^H)$. The difference between the optimal choice of m with and without border crossing is the distance to the border: $\Delta m = m^* - m^{**}$ = miles to the border. Making these substitutions and plugging equation (3) into (2) thus yields:

(4) $\Delta u = u_g\, c\,(P^B - P^H) + u_m$ (miles to the border) $+ r$

Equation (4) motivates the structural equation for the latent utility difference behind observed border-crossing:

(5) $\Delta u = \delta_0 + \delta_1 (P_i^B - P_i^H) + \delta_2 (\text{miles to the border})_i + \delta_3 W_i + \zeta_i$

The Taylor series remainder term r in equation (4) is captured in equation (5) by the constant term, the vector of exogenous variables W, and the error term ζ. The empirical model reported below includes quadratic terms and interaction terms corresponding to a second-order Taylor series approximation; the higher order terms are suppressed in equation (5) for expositional ease. The use of a Taylor series approximation is justified on the grounds that border crossing to purchase lower-price cigarettes results in small changes relative to the typical consumer's total purchases of all goods and total travel for all purposes.

Comparing equation (5) to (4) reveals that the ratio of the estimated coefficients δ_2 / δ_1 is proportional to the ratio of the marginal utility of distance over the marginal utility of the composite consumption good. As a result, the ratio δ_2 / δ_1 provides an estimate of the shadow price of distance, i.e. the dollar value of a marginal change in distance.[10] In essence, the price savings required to induce consumers at different distances to cross the border reveals consumer preferences for the non-market good "distance traveled."[11]

To estimate the model, we use the standard assumption that the error terms ϵ_i^H, ϵ_i^B, and ζ_i have a trivariate normal distribution with non-zero covariances. The model is estimated by maximum likelihood using Stata's command *movestay*. Stata's *movestay* command yields estimates of the price equations (1a) and (1b) and a reduced-form version of the border-crossing equation that does not include the endogenous price variables on the right hand side. We use the estimated price equations to predict P^H and P^B for each smoker in the sample. We then estimate the structural border-crossing equation as a function of the predicted price differential $P^B - P^H$ and the other explanatory variables.[12]

---

[10]The parameters in discrete choice models based on random utility maximization have analogous interpretations (Train 2003, Small, Winston and Yan 2005).

[11]In environmental economics the travel cost method is used to estimate consumers' willingness to pay for public goods such as recreation sites (Freeman 1979). Studies that use this method typically begin with an assumption about the cost of travel to the recreation site. The studies then use consumers' revealed preferences to incur the assumed travel costs to estimate the value of the recreation site. In contrast, instead of making an assumption about travel costs, we examine revealed preferences to infer consumers' values for distance traveled.

[12]Our estimation method follows Maddala (1983, pp. 236 - 239). Lee (1978) and Willis and Rosen (1979) are seminal examples that use this method to estimate structural endogenous switching models.

The structural endogenous switching model is identified by differences in the vectors of explanatory variables in equations (5), (1a) and (1b). Specifically, the exclusion restrictions are that: distance and distance-squared only enter the border-crossing equation (5); and the home- and border-state tax variables only enter the home- and border-state price equations (1a) and (1b), respectively.[13]

The exclusion restrictions are supported by the argument that there is enough competition in retail cigarette markets so that within each state the price is driven down to approximately the retailers' marginal cost plus the state tax rate. This implies that the consumer's distance to the border does not directly enter the price equations (1a) and (1b). It also implies that retailers in the home state can not change their prices in response to border-state taxes, and *vice versa*. Anecdotal evidence suggests that retail cigarette markets are instead equilibrated by changes in the volume of cigarette sales and the entry and exit of cigarette retailers. For example, Fleenor (1998, p. 5) relates that after the 1995 Michigan cigarette tax increase: "One Michigan convenience store located approximately four miles from the Indiana border lost 98 percent of its cigarette carton sales...." Efrati (2007) relates more recent anecdotes along these lines, including a fivefold increase in cigarette sales in Sunland Park, New Mexico after a cigarette tax hike across the border in El Paso, Texas. These large swings in the volume of sales are consistent with price-taking behavior within a state where retailers near borders can not change their prices in response to border-state taxes. To further explore the issue empirically in the TUS-CPS data, we examine the geographic patterns of cigarette prices paid by consumers who purchased their cigarettes in their home state. Prices do not vary systematically with distance to

[13]These exclusion restrictions meet the identification conditions described by Maddala (1983, p. 239).

the border of states with either lower or higher cigarette taxes.[14]

Regarding the strength of our identification strategy, in ordinary least squares models of reduced-form versions of equations (5), (1a), and (1b), the F-statistics on the identifying variables are 25.8, 388.5, and 9.2 respectively. We are unaware of specific tests of weak identification in the endogenous switching model. The values for the F-statistics in two of the reduced-forms exceed the common rule of thumb for linear instrumental variables models that the F-statistic on the excluded IVs should be greater than 10 (Staiger and Stock 1997, Stock, Wright, and Yogo 2002). The F-statistic for the border-state tax variable suggests that this might be marginally weak, perhaps due to the much smaller sample size of border crossers whom we can observe paying the border price.

Results

Table 4 reports estimates of the structural endogenous switching model. The probability of border crossing is estimated to decrease with distance from the border and to increase with the differential between home- and border-state cigarette prices. The marginal effect of distance is around -0.07, somewhat larger (in absolute value) than the reduced-form results.

We use the estimated marginal effect of the price differential to calculate that the cross-price elasticity $\eta^B = 3.1$. This is a "cross" price elasticity in two senses. First, η^B shows the

[14]Doyle and Samphantharak (2008) find mixed evidence about whether the effects of gasoline taxes on prices depend on the distance from the border. Although they conclude that their results are "generally consistent wit the effect of the tax extending across state borders" (p. 880), there are important differences between the retail market for gasoline they study, and the retail market for cigarettes. In particular, because convenience stores and other cigarette retailers sell a variety of products, entry and exit is relatively easy and large swings in sales volume are feasible. In contrast, the fixed costs of gasoline storage tanks and pumps create more frictions in the retail market for gasoline.

elasticity of the probability of border crossing with respect to the home-state price of cigarettes.[15] Recall that the baseline level of cross-border purchases is five percent. Our elasticity estimate implies that a 10 percent increase in the home-state price, holding the border-state price constant, increases the probability of border crossing by 1.55 percentage points (31 percent of 5 percent).

Second, η^B is also a cross-price elasticity in the sense that it shows the elasticity of border-state purchases with respect to the home-state price. To see this interpretation, note that border-state purchases are the product of the probability of border-crossing times the quantity purchased conditional on having crossed the border. We assume that conditional upon having crossed the border, the quantity purchased across the border does not depend on the home-state price. As a result, the elasticity of border-state purchases equals the elasticity of the probability of border-crossing. In an exercise described more completely in the Appendix, we combine our estimate that $\eta^B = 3.1$ with a benchmark estimate that the price-elasticity of home-state purchases is -0.8 (Coats 1995). Our exercise shows that if a 10 percent price increase causes home-state purchases to fall by 8 percent, after taking into account the increase in border-state

[15] We define $\eta^B = [\partial \Pr\{B = 1\} / \partial P^H] [P^H / \Pr\{B=1\}]$ and calculate it at the sample average P^H and $\Pr\{B=1\}$. Because we model the border-crossing decision as a function of the price differential ($P^H - P^B$), it might seem more natural to use the results to calculate the price elasticity of the probability of border crossing with respect to the price differential, instead of with respect to the home-state price (P^H). We define η^B with respect to P^H to facilitate comparisons with previous research and to use in the formula for the optimal Pigouvian tax rate we develop in section 5. The comparison of η^B with respect to P^H and the elasticity of border-crossing with respect to the price differential is straight-forward. The partial derivative terms are the same, because holding P^B constant, $[\partial \Pr\{B = 1\} / \partial P^H] = [\partial \Pr\{B = 1\} / \partial (P^H - P^B)]$. The next term is adjusted to express the marginal change as a percentage of the price differential rather than the home-price level. So the elasticity of border-crossing with respect to the price differential = $\eta^B (P^H - P^B) / (P^H) = (3.1)(0.63/3.54) = 0.55$.

purchases, home-state cigarette consumption only falls by 6.1 percent. Put differently, border-crossing accounts for almost one quarter of the response of home-state purchases to changes in the home-state price. This is smaller than several previous estimates, but those estimates mainly reflect illegal smuggling instead of legal tax avoidance (Gruber, Sen, and Stabile 2003, Stehr 2005, and Lovenheim 2008).

Turning to other results in Table 4, the ratio of the marginal effect of distance to the marginal effect of the price differential provides an estimate of the shadow price of distance traveled. The shadow price calculation also requires an estimate of the quantity of cigarettes purchased (c in equation 4) . If we assume the average border crosser purchases a carton of 10 packs of cigarettes per trip, and that distance traveled on a round trip is twice the distance to the border, the implied shadow price of distance is $0.08 per mile. For sensitivity analysis: if the average purchase is 3 cartons (the legal maximum in a number of states), the implied shadow price is $0.24 per mile.

Our estimates of the shadow price of distance traveled are lower than standard estimates of travel costs, but this is reasonable if consumer travel jointly produces cross-border cigarette purchases and other activities. Piecing together several sources, a standard estimate of travel costs might be around $0.70 per mile.[16] Suppose the consumer makes travel decisions by comparing the total travel cost per mile to the total benefits, where the value of the total benefits

[16] In 2003 the Internal Revenue Service allowed taxpayers to deduct business mileage at $0.36 per mile, while the American Automobile Association estimated the average operating and ownership costs of driving a new car at $0.52 per mile (AAA 2003). Adding the value of time increases travel costs by at least $0.10 to $0.20 per mile (Victoria Transport Policy Institute 2008), leading to an estimate that the total travel costs might be as high as $0.70 per mile. This might over-state the marginal costs of travel, for example some of the costs of owning and operating a car are sunk costs.

equals the sum of the values placed on the various services that jointly flow from the travel. Our approach isolates one component of the total value. Many consumers jointly produce cross-border cigarette purchases with activities like shopping for other goods, commuting, or recreation. If the value of the total benefits is \$0.70 per mile, our estimate that the value component due to cross-border cigarette purchases is only \$0.08 per mile out suggests that consumers derive \$0.62 per mile of benefits from these other activities.

Table 4 also shows estimates of the determinants of the prices consumers pay for cigarettes in the home- and border-state regimes. We estimate that the home-state tax is passed through to the home-state price at a rate of about 0.87. Most previous studies find that cigarette taxes are passed through at a rate of slightly above 1.0 (Barzel 1976, Johnson 1978, Sumner and Ward 1981, Keeler *et al.* 1996, and Delipalla and O'Donnell 2001). In sharper contrast to previous estimates, we estimate that the border-state cigarette tax is passed through to the border-state price at a rate of about 0.40. One explanation is that border crossers are more likely to obtain volume discounts by purchasing cigarettes by the carton instead of the pack. DeCicca, Kenkel and Liu (2010) find that taxes are passed through at lower rates to the prices paid by carton-buyers.

The results in Table 4 suggest that some socioeconomic factors have similar effects on the probability of border crossing and on the price paid for cigarettes in either regime. For example, smokers with higher incomes are more likely to cross the border, and they pay higher prices for their cigarettes either at home or in the border state. It should be kept in mind that the TUS-CPS did not ask respondents about which brand of cigarettes they purchased. Previous research suggests that younger smokers, smokers with higher incomes, and smokers with more schooling are more likely to purchase the higher-priced premium brand cigarettes (Cummings *et* *al.* 1997, Hyland *et al.* 2005, Office of Applied Studies Substance Abuse and Mental Health Services Administration 2007). The patterns across socioeconomic groups for the prices paid for cigarettes reflect these differences in brand or quality preference.

5. Implications of Excise Tax Avoidance for State Tax Policy

Tax Avoidance and Optimal Taxation

In this section, we discuss the implications of tax avoidance for applied welfare economic analysis of state cigarette taxes. In state policy debates, the most common concern is that tax avoidance reduces tax revenues. Of course, taking a somewhat broader perspective, some of the higher-tax states' revenue losses are revenue gains for neighboring lower-tax states. Applied welfare economics takes a still broader perspective and focuses on the impact of taxes on the welfare of all members of society, not state budgets. Typically from this perspective when tax revenues fall it is simply a transfer: the losses to state budgets are gains for the taxpayers.[17] From the broad social welfare perspective, cigarette excise taxes are justified as a Pigouvian solution to the negative externalites from secondhand smoke, third-party medical costs for smoking-related illnesses, and so on (Sloan *et al.* 2004).[18] Consequently, we next consider the implications of tax avoidance for the optimal corrective Pigouvian tax rate.

In the Appendix we sketch a simple general equilibrium model that provides an

---

[17]State budgets are not precisely "members of society." The implicit assumption is that when tax revenues fall, either other taxes are raised or government programs are cut. To re-state the transfer more precisely: the losses to other taxpayers, or the losses to the beneficiaries of state government spending, are gains for cigarette taxpayers.

[18]As we noted in the introduction, a common justification for excise taxes is that they reduce socially undesirable consumption. In some cases this justification relies on merit good arguments (Besley 1988, Schroyen 2005). For cigarettes, the externality argument seems more relevant than the merit good argument.

expression for social welfare as a function of the home state cigarette tax. We follow the approach of Chetty (2009b), who provides a useful exposition of Harberger's (1964) measure of the welfare cost of an excise tax. We extend the Harberger/Chetty model in two ways: we assume that the taxed good, cigarettes, imposes external costs of $\$E^C$ per pack; and we assume that the smoker can consume home-state cigarettes (c^H) or border-state cigarettes (c^B). We consider the case of a home state that borders a state where the cigarette tax is too low to correct for the external costs of smoking: $T^B < E^C$. Following Harberger and Chetty, the thought experiment is to raise the home-state tax T^H while returning home-state tax revenues to the taxpayer and adjusting for border-state tax revenues via lump sum transfers. Appendix equation (A4) provides the expression for social welfare (W) as a function of the home-state tax T^H. Applying the envelope theorem when we differentiate our expression for social welfare yields the marginal social welfare gain from a marginal change in home-state tax:

$$(6) \qquad dW/dT^H = \underset{(-)}{T^H [dc^H/dT^H]} - \underset{(+)}{E^C [dc^H/dT^H]} + \underset{(-)}{(T^B - E^C)[dc^B/dT^H]}$$

Equation (6) is an example of what Chetty (2009b) calls the "sufficient statistic" approach to applied welfare economics: it shows the welfare consequences of the excise tax as a function of high-level elasticities rather than deep structural parameters. The first two terms of equation (6) reflect the standard tradeoff in Pigouvian taxation. Integrated over a change in tax, the first term is the Harberger triangle of excess tax burden for cigarette consumers. The second term is the social gain from reducing the negative externalities. The third term in equation (6) is the social welfare loss that stems from interactions between the home-state and border-state cigarette markets. Because the border-state cigarette tax is below the external cost of smoking, there is a welfare loss when an increase in the home-state tax increases border-state cigarette purchases. Chetty (2009b) and Goulder and Williams (2003) stress a point also made in Harberger's (1964) original work: in an n-th best world with many distorted markets, the excess burden of a new tax reflects general equilibrium interactions with the other distorted markets. Goulder and Williams show that the interactions will be important for excess burden calculations for goods that are strong complements to or substitutes for the newly taxed good. Our case is an extreme version: except for the need to travel across the border, cigarettes purchased in the home-state and border-state are perfect substitutes. The border-state cigarette market is distorted not by the presence of a tax, but by the fact that the tax is not high enough to correct for the externality. (Below, we discuss further extending our analysis to include the additional distortion created if tax avoidance directly generates an externality, such as traffic fatalities or illegality costs).

It is interesting that equation (6) does not include an explicit term for the travel costs of tax avoidance. These costs are internal to consumers and fully accounted for in their optimizing decisions. Feldstein (1999) and Chetty (2009a, 2009b) discuss an analogous result for measuring the social welfare cost of income tax avoidance.

We show in the Appendix that setting $dW/dT^H = 0$ and solving for the social welfare maximizing Pigouvian tax yields:

$$(7) \qquad T^{H}* = E^C - (E^C - T^B) \cdot (\eta^B / \eta^H) \cdot (C^B / C^H)$$

If there are no opportunities for tax avoidance and $\eta^B = 0$, the second term of equation (7) drops out and the expression simplifies to the simple Pigouvian tax: $T^{H}* = E$. This applies to the important example of a federal excise tax, unless there is cross-country tax avoidance. If the border-state tax is high enough to internalize the external costs of smoking ($T^B = E^C$), the second term again disappears and the expression again simplifies to the simple Pigouvian tax.

Equation (7) shows that the home state's optimal tax rate depends on border crossing only in the second-best world where its neighbor set its cigarette tax too low. In this second-best world, as long as there is some tax avoidance, the optimal tax rate that takes into account tax avoidance is always smaller than the standard Pigouvian tax rate that simply internalizes the externality. In the second-best world, the optimal tax is lower: when the border-state tax (T^B) is lower; when the price-elasticity of border-crossing (η^B) is higher; and when the ratio of cross-border sales to home-state sales (C^B/C^H) is higher.

Illustrative Calculations of the Optimal Tax with Tax Avoidance

To develop illustrative calculations of the optimal cigarette tax $T^{H}*$ given by equation (7), we combine standard estimates of E^C and η^H with our estimates of η^B and C^B / C^H.

Based on standard estimates, during our study period most states had neighbors that set their cigarette taxes below the external costs of smoking. Sloan *et al.* (2004, p. 255) estimate that smoking generates $2.20 of external costs per pack. However, some of these external costs have been addressed by the current (2003 - 2007) federal excise tax of $0.39 per pack, and the national legal settlement with the tobacco industry, which is equivalent to a tax of about $0.45 per pack (Bulow and Klemperer 1998). So we estimate that for all U.S. states, E^C is $1.36 per pack, which is an estimate of the remaining external costs of smoking that are relevant for the optimal tax at the state level ($2.20 - $0.39 - $0.45 = $1.36). We then compare this estimate to the current (2003 or 2006 - 2007) tax rates for each state's border-state tax T^B. In 2003, 42 states and D.C. faced a border-state tax below the estimated external cost per pack of $1.36. By 2006 - 2007, only 36 states and D.C. were in this situation.

To complete our illustrative calculations of the optimal tax rates, we use a benchmark estimate that η^H, the elasticity of home purchases with respect to the home price, is 0.8 in all states. We evaluate the marginal effect of the price differential on the probability of border-crossing at each state's averages, to develop state-specific estimates of η^B, the cross-price elasticity of border purchases with respect to the home-state price. We also use state-specific estimates from our data for the ratio of cigarettes purchased from a border state over cigarettes purchased at home, C^B / C^H.

Using these parameter estimates in equation (7) provides illustrative calculations of the optimal tax in each state that faced a border-state tax below the external costs of smoking. (The complete results are not reported but are available upon request.) In 2003, in 20 states the optimal tax that accounts for tax avoidance is at least 20 percent smaller than the simple Pigouvian rate of $1.36. The lowest optimal taxes are $0.66 in D.C. and $0.87 in Maryland, which make sense because of their proximity to the low-state tax of Virginia. The results for 2006 -2007 are broadly similar. Because Virginia increased its tax to $0.30 in 2005, the optimal taxes in D.C. and Maryland in 2006 - 2007 rise slightly to $0.81 and $0.95, respectively. To take an example of a state that does not border Virginia or any other very low-tax state, we calculate that the optimal tax in Massachusetts is $1.09 in 2003 and $1.14 in 2006 - 2007.

Our illustrative calculations show the "optimal" tax in a second-best world: given that they border states with low cigarette taxes, it is optimal for many states to set their taxes below the simple Pigouvian rate. One possible policy prescription based on these calculations is that currently high-tax states might need to re-consider their cigarette excise tax rates. An alternative policy prescription is to focus on the possible gains from moving closer to a first-best world. For example, when low-tax states like Virginia increase taxes, the optimal corrective tax in the bordering states also increases.

Another possible policy prescription is to replace avoidable state excise taxes with a harder-to-avoid federal excise tax on cigarettes. We consider this exercise in the Appendix, for a home state with a currently high tax and a low-tax border state. Under a simple assumption, replacing the home-state tax with the same-sized federal tax leaves home-state cigarette consumption unchanged. The external costs of home-state smoking are also unchanged, while not surprisingly the new federal tax revenues exceed the sum of home-state and border-state tax revenues previously collected from home-state residents. More importantly, social welfare in the home-state increases because smokers no longer incur travel costs to avoid the home-state tax. With the incentives created by differences in state excise taxes, consumer tax avoidance uses resources – the travel costs – that are deadweight losses, compared to an equal-sized federal tax. Using our estimated shadow price per mile, we calculate that replacing state taxes with a federal tax saves the median border crosser in our sample about \$0.32 per pack in travel costs that were deadweight losses to home-state social welfare.

Sensitivity Analyses

We next explore the sensitivity of our illustrative calculations of the optimal tax to different assumed parameters. First, we consider the implications of a much higher estimate of E^C. Using a higher estimate of E^C is a simple way to incorporate the argument from behavioral public economics that higher cigarette taxes might be justified based on internalities that consumers impose on their future selves (O'Donoghue Rabin 2003, 2006, Gruber and Koszegi 2001, 2004). Gruber and Koszegi (2004, p. 1980) and Sloan *et al.* (2004, p. 252) estimate that the private costs smokers impose on themselves are around \$35 per pack. However, Gruber and

Koszegi (2001) show that unlike Pigouvian externalities, because the sophisticated time-inconsistent consumer helps the government by limiting her consumption, the optimal internality tax is smaller than the internality costs. Using various parameter estimates they estimate the optimal internality tax is in the range of $1 to $3 per pack. If we increase our estimate of E^C by $3, from $1.36 per pack to $4.36 per pack, from equation (7) the optimal tax in D.C. increases to $2.22. Not surprisingly, the policy prescription – whether the current cigarette tax in D.C. is too low or too high – is sensitive to using a much higher estimate of E^C to capture the idea of internalities. But the qualitative result, that taking into account tax avoidance sharply reduces the optimal tax on cigarettes, still holds.

In another extension, we consider the possibility that tax avoidance itself directly generates external costs, E^A . These costs might take several forms. First, automobile travel to purchase cigarettes out-of-state creates externalities related to pollution, congestion, and traffic safety. As relevant examples, empirical evidence suggests that traffic fatalities increase due to consumer avoidance of local bans of smoking in bars (Adams and Cotti 2008) and teen avoidance of state minimum drinking age laws (Lovenheim and Slemrod 2010). However, gasoline taxes already correct for at least some of the external costs of travel (Parry and Small 2005). Second, and probably more significantly, illegal smuggling of cigarettes might generate significant externalties. Cigarette smuggling has been linked to organized crime and even terrorism.[19] Shelley *et al.* (2007) report ethnographic research about attitudes towards "the $5

[19]As discussed by the Advisory Commission on Intergovernmental Relations (1977) and Fleenor (2008), the links between cigarette smuggling and organized crime have been long-standing. The president of Americans for Tax Reform, Grover Norquist, recently repeated this concern: "By raising cigarette taxes you help fund the mob." (Sarlin 2008). In 2002 a cigarette smuggler was convicted of funneling profits from a multi-million smuggling operation to Hezbollah (Horwitz, 2004).

Man," that is, the typical cigarette bootlegger in Central Harlem in New York City. They report that "Bootleggers were uniformly viewed as a justifiable and appreciated response to the high price of cigarettes," caused by the combined New York City and State excise taxes (p. 1486).

In the Appendix, we show that considering the external costs of tax avoidance adds a term involving E^A to the optimal tax formula (see Appendix equation A8). Even though our empirical study captures tax avoidance and not smuggling, it is interesting to speculate on the implications of the costs of illegal smuggling for optimal taxation. However, developing a reasonable estimate of the external costs due to illegal smuggling would require quantifying the social costs of funding organized crime and terrorism and of contributing to community norms favoring illegal behavior. Instead, we ask a related question: How high would E^A have to be to drive the optimal tax to zero? Using our other baseline parameters in equation (7), if the external cost of tax avoidance exceeds $1.40 per pack of cigarettes, the optimal tax in D.C. drops from a baseline of $0.69 to zero. In Massachusetts, the optimal tax drops from a baseline of $1.08 to zero if the external cost of tax avoidance exceeds $2.50 per pack. These results hinge in part on our baseline estimate that the external costs of smoking amount to $1.36 per pack. But at least from a neoclassical welfare economic perspective that focuses on externalities, it seems plausible that tax avoidance costs related to illegal smuggling might be high enough to drive the optimal tax close to zero in some jurisdictions.

6. Discussion

Our empirical models of cigarette tax avoidance show that consumers respond to the incentives created by excise tax differentials across states. It is not clear that there is anything particularly special about cigarettes that drives this consumer behavior. The other most commonly taxed goods in the U.S. – alcoholic beverages and gasoline – share some key similarities with cigarettes. All three goods are frequently purchased, which should lead to similar levels of consumer price search (Baye, Morgan, and Scholten 2006). In quantities intended for personal consumption beer and gasoline are about as easily transported as cigarettes and involve roughly similar expenditures. In fact, in certain localities convenience stores offer "one-stop" tax avoidance. For example, in 2007 a consumer in Ohio who crossed the border into northern Kentucky could avoid $5.20 of taxes on a carton on cigarettes, $0.23 of taxes on a case of beer, and $0.83 of taxes on 10 gallons of gasoline.

Of course, one key difference between the commonly taxed goods is that cigarettes are addictive to virtually all consumers. Based on insights from behavioral economic models of addiction, Khwaja, Silverman, and Sloan (2007) suggest that smokers might purchase their cigarettes by the pack instead of the carton as a commitment device to limit their smoking. In exploratory regressions (available upon request), we find that smokers who report that they intend to quit within the next six months are less likely to make cross-border purchases and are less likely to purchase their cigarettes by the carton. Although not the only explanation, one interpretation is that some smokers refrain from purchasing less expensive cigarettes (across the border or by the carton) as a commitment device. To the extent fewer consumers of beer and gasoline see the need for a commitment device, consumers may be even more likely to cross the border in response to beer and gasoline tax differentials than in response to cigarette tax differentials. A more complete examination of cigarette purchase practices as commitment devices is an interesting direction for future work.

Taking into account tax avoidance reduces the optimal Pigouvian tax rate on goods that generate negative externalities or internalities. Combining an existing estimate that the external cost of smoking is $1.36 per pack with our empirical parameter estimates, our illustrative calculations suggest that many states may already impose cigarette excise taxes that are higher than optimal, and there is a strong policy trend towards even more cigarette tax hikes. At current levels of beer- and gasoline-tax differentials there is probably relatively little tax avoidance, so it might not seem to matter as much for beer- and gasoline-tax policy. However, previous research estimates that current levels of both beer and gasoline taxes in the U.S. might be far below the simple Pigouvian rate (as calculated without taking into account tax avoidance).[20] If one state unilaterally hiked its beer or gasoline tax to be closer to these estimates of the simple Pigouvian rate, it could stimulate substantial tax avoidance. The higher level of tax avoidance, in turn, would have important implications for the optimal tax rate in that state.

While we adopt the Pigouvian framework, we recognize that different criteria used in public economics to judge the desirability of taxes can lead to different conclusions. However, regardless of which of several common criteria are used, taking into account tax avoidance makes state cigarette taxes less desirable. The Ramsey inverse elasticity rule favors taxing inelastically demanded goods like cigarettes as a relatively efficient way to raise revenues at low deadweight loss. But tax avoidance makes state cigarette sales more elastic and hence makes cigarette taxes a less attractive way to raise revenue. In terms of tax fairness, cigarette taxes are regressive because the poor are more likely to smoke (Colman and Remler 2008). Our empirical results suggest that tax avoidance increases with income. Because richer smokers avoid more taxes, state cigarette taxes may be even more regressive than commonly estimated.

---

[20]Studies that suggest current beer taxes are far below the optimal Pigouvian rate include Manning *et al.* (1989), Pogue and Sgontz (1989), Kenkel (1996) and Parry *et al.* (2006). Similarly, Parry and Small (2005) and Harrington, Parry, and Walls (2007) suggest that current gasoline taxes fall far short of the Pigouvian rate. Both lines of research also suggest that other policy tools, such as penalizing drunk driving or imposing a vehicle-miles-traveled tax, have advantages over excise taxes on beer or gasoline.

Political economy models introduce another set of criteria to judge the desirability of excise taxes (Seiglie 1990). Several empirical studies of states' tax-setting policies suggest that tax avoidance makes the cigarette tax less politically desirable (Benjamin and Dougan 1997, Nelson 2002, Goel and Nelson 2007). This leaves something of a puzzle. Compared to state and local taxes, consumers have fewer opportunities to legally avoid the U.S. federal cigarette tax. Because of less tax avoidance, the federal cigarette tax seems to be more efficient, more equitable, and is predicted to even be more politically popular than state excise taxes. However, U.S. federal cigarette tax hikes have been less frequent and smaller than state tax hikes. Perhaps some idiosyncratic effect at work in U.S. federal politics helps explain the reluctance to tax cigarettes, compared either to U.S. state politics or to European politics that also have led to much higher national excise taxes on cigarettes (Cnossen 2005).

Appendix

Elasticities of border-crossing and cigarette demand

As noted in the text, because η^{B} can be interpreted as the elasticity of border-state purchases, we can compare it to results from cigarette demand studies. Using capital letters for aggregate consumption, home-state residents' total cigarette consumption is the sum of their consumption of cigarettes purchased at home and their consumption of cigarettes purchased in the border state: $C^{TOTAL} = C^{H} + C^{B}$. The elasticity of total consumption with respect to P^{H} is the weighted difference of the elasticities of home-state and border-state purchases:

(A1) $$\eta^{TOTAL} = [C^{H} /(C^{H} + C^{B})]\ \eta^{H} - [C^{B}/ (C^{H} + C^{B})]\ \eta^{B}$$

where η^{H} is the absolute value of the elasticity of home-state purchases with respect to P^{H}. The weights are the fractions of total purchases accounted for by home-state and border-state purchases, which in our data are 0.95 and 0.05 respectively.

Equation (A1) allows us to compare our results about the price elasticity of border crossing to estimates from cigarette demand studies. Our estimate contributes to a growing body of evidence that while a state cigarette tax hike reduces home-state purchases and thus sales, it is not as effective in reducing the total consumption of home-state smokers. As a benchmark, we assume that the absolute value of the elasticity of home-state purchases η^{H} is around 0.8 (Coats 1995). Combining this with our estimate of η^{B} implies that the absolute value of the elasticity of total consumption is 0.605.[21] Put differently, border-crossing accounts for about 25 percent of the response of home-state purchases to changes in the home-state price. By comparison, Gruber, Sen, and Stabile's (2003) estimates suggest that tax avoidance accounts about one-third of the response of tax paid sales in Canada. Stehr (2005) estimates that tax avoidance accounts for up to 85 percent of the response of tax paid sales in the U.S. However, in both of these studies, the predominant form of tax avoidance is long-distance cigarette smuggling, not legal cross-border purchases. Although our results are similar in that they suggest a strong cigarette tax avoidance response, we find a much different channel for the response. Like our study, Lovenheim (2008) also focuses on legal cross-border purchases, but he finds an even stronger

[21]We use Coats' estimate because it specifically applies to the elasticity of home-state purchases or sales. Chaloupka and Warner's (2000) review identifies price-elasticity estimates ranging from -0.14 to -1.23; Gallet and List's (2003) meta-analysis finds an even wider range from -3.12 to +1.41. Chaloupka and Warner (2000, p. 1547) describe a "consensus range" from -0.3 to -0.5. Because the consensus range is based on a variety of empirical approaches, it is ambiguous whether it refers to the price elasticity of home-state purchases or the price-elasticity of total consumption, although it is often interpreted as referring to the latter. It is interesting to note that combining our estimate of η^{B} with a benchmark estimate that $\eta^{H} = 0.8$ implies a value of η^{TOTAL} about in the consensus range.

response and estimates that approximately all of the response in home-state sales is due to tax avoidance.

Optimal tax

Our extension of the formula for the Pigovian tax on cigarettes follows the approach of Chetty (2009b), who provides a useful exposition of Harberger's (1964) measure of the welfare cost of an excise tax. It is also related to the approach used in several studies of the optimal tax on alcohol (Pogue and Sgontz 1989, Kenkel 1996). In this Appendix we provide more detail about the background and steps in this approach.

For our applied welfare economic analysis, we adopt the perspective of a home-state policy maker setting a cigarette excise tax, T^H. We assume the home-state tax T^H is fully passed through to prices, so the price consumers pay in the home state increases from P to $P^H = P + T^H$. The price consumers pay in the border state is given by $P^B = P + T^B$, where the border-state tax T^B is exogenous to the home-state policy maker.

As a preliminary, it is useful to consider the consumer's optimal choices of cigarettes purchased in the home state, c^H, and cigarettes purchased in the border state, c^B. In the text we assume that the consumer receives utility from a composite good g, disutility from miles of distance traveled m, and utility from cigarette consumption c: u = u(g,m,c). Following Chetty (2009b), we now assume utility is quasi-linear in the composite good g, and the price of g is normalized to 1. We also assume that cigarettes purchased in the home state and cigarettes purchased in the border state are perfect substitutes in consumption. However, purchases of c^B require travel, so the miles of distance traveled, m, is a function of c^B, where m' > 0. The consumer has an income of Z, and is assumed to solve the following maximization problem:

$$\max\ g + u\,(m,\ c^H + c^B)$$

subject to

$$(P + T^H)\,c^H + (P + T^B)\,c^B + g = Z$$

$$m = m(c^B)$$

Substituting in the constraints the problem becomes to choose c^H and c^B to solve the maximization problem:

(A2) $$\max\ \mathbf{[}u\ \mathbf{(}\ m(c^B)\mathbf{,}\ c^H + c^B\mathbf{)} + Z - (P + T^H)\,c^H - (P + T^B)\,c^B\ \mathbf{]}$$

The first order conditions for the utility maximizing choices of c^{H*} and c^{B*} are:

(A3) $$\partial[\quad]/\partial c^H = u_c\ \mathbf{(}m(c^{B*}),\ c^{H*} + c^{B*}\mathbf{)} - (P + T^H) = 0$$

$$\Leftrightarrow \quad u_c\,\mathbf{(}m(c^{B}*),\; c^{H}* + c^{B}*\,\mathbf{)} = (P + T^{H})$$

and $\qquad \partial[\quad]/\partial c^{B} = u_m\,\mathbf{(}m(c^{B}*),\; c^{H}* + c^{B}*\,\mathbf{)}\, m' + \; u_c\,\mathbf{(}m(c^{B}*),\; c^{H}* + c^{B}*\,\mathbf{)} - (P + T^{B}) = 0$

$$\Leftrightarrow \quad u_c\,\mathbf{(}m(c^{B}*),\; c^{H}* + c^{B}*\,\mathbf{)} \; = - u_m\,\mathbf{(}m(c^{B}*),\; c^{H}* + c^{B}*\,\mathbf{)}\, m' + \; (P + T^{B})$$

The FOCs have the standard interpretations. The consumer sets the marginal utility per dollar spent on cigarettes equal to the "full price" of cigarettes. Recall that $u_m < 0$ and $m' > 0$, so the first term on the LHS of the second FOC is positive ($- u_m\, m' > 0$): the travel costs required to purchase cigarettes in the border state increase the "full price" of c^B.

To guarantee an interior solution, we assume that the home-state tax is higher than the border-state tax: $T^H > T^B$. Because of the travel costs, when the border-state tax is equal to or less than the home-state tax, the consumer (with positive miles of distance to the border) would choose a corner solution and only purchase home-state cigarettes.

Still following Chetty (2009b), specify a complete general equilibrium model, with price- taking firms who face a cost function k ( ). Following Chetty, who is following Harberger (1964), the thought experiment is to measure the net loss in welfare from raising the tax and returning the tax revenue to the taxpayer through lump-sum rebates. As Chetty explains: "With quasi-linear utility, the consumer will always choose to allocate the lump-sum rebate to consumption of the numeraire good..... Social welfare can therefore be written by the sum of the [representative] consumer's utility, producer profits, and tax revenue.....[and then re-written to] effectively recast the decentralized equilibrium as a planner's allocation problem." (This re-writing replaces the prices in the consumer's budget constraint with the costs from the firm's problem.) We also extend Chetty's equation to include external costs E^C per pack of cigarettes, to obtain our expression for social welfare as a function of the home-state tax on cigarettes:

(A4) $\quad W(T^{H}) = \mathbf{\{}\max u\,\mathbf{(}\,m(c^{B}*),\, c^{B}* + c^{H}*\mathbf{)} + Z - T^{H} c^{H}* - \; T^{B}c^{B}* - k\,(c^{H}*+ c^{H}*)\,\mathbf{\}}$

$$+\, T^{H} c^{H}* + T^{B} c^{B}* - E^{C}\,[c^{H}*+ c^{B}*]$$

We are assuming that the home-state policy maker chooses the tax rate to maximize social welfare. The policy maker takes the border-state tax rate as given, but adopts a "national" perspective and counts the border state's revenues from taxing c^B as a social welfare gain. Although not very realistic, this assumption is in the same spirit as Harberger's original thought experiment: we want to focus on the efficiency aspects of taxation, not the distributional implications (even across state borders).

Chetty points out that the individual treats tax revenue as fixed when making choices, failing to internalize the effects of his behavior on the lump-sum transfer he ultimately receives. Similarly, in our extension, we assume that the individual also fails to internalize the external costs generated by his smoking. Both assumptions are justified by the intuitive argument that the economy has a large number of consumers, so each individual has a negligible impact on tax revenues and external costs.

With these assumptions, the term in { } measures private surplus, while the following terms measure tax revenues and external costs.

The quick derivation of dW/dT^H uses the envelope theorem: the behavioral responses $[dc^H/ dT^H]$ and $[dc^B/ dT^H]$ in the { } can be ignored. The long derivation is to take the derivative and plug in the FOCs. When terms are collected, the behavioral response terms in the { } are multiplied by the FOCs, which = 0, so they drop out. This yields text equation (6):

(A5) $$dW/dT^H = - c^H + c^H + T^H [dc^H /dT^H] + T^B [dc^B /dT^H] - E^C [dc^H/d T^H] - E^C [dc^B/ d T^H])$$

$$= \underset{(-)}{T^H [dc^H /dT^H]} \underset{(+)}{- E^C [dc^H/d T^H]} + \underset{(-)}{(T^B - E^C) [dc^B/ d T^H]})$$

Expression (A5) is an example of what Chetty (2009b) calls the "sufficient statistic" approach to applied welfare economics: it shows the welfare consequences of the tax policy as a function of high-level elasticities rather than deep structural parameters. Chetty also extends his analysis to consider multiple consumers with heterogenous preferences, and shows that the effect of a tax increase on aggregate behavior is a sufficient statistic for welfare analysis.

To find the optimal home-state tax, set $dW/d T^H = 0$ and solve to find the optimal T^{H*} :

$$dW/dT^H = T^{H*} [dc^H /dT^H] + T^B [dc^B /dT^H] - E^C [dc^H/d T^H] - E^C [dc^B/ d T^H]) = 0$$

$$T^{H*}[dc^H /dT^H] = - T^B [dc^B /dT^H] + E^C [dc^H/d T^H] + E^C [dc^B/ d T^H])$$

$$- T^H * \eta^H C^H = - T^B \eta^B C^B - E^C \eta^H C^H + E^C \eta^B C^B$$

$$T^H * = (T^B \eta^B C^B) / (\eta^H C^H) + E^C - E^C (\eta^B C^B)/ (\eta^H C^H)$$

Re-arranging yields text equation (7):

(A6) $$T^H * = E^C - (E^C - T^B) \bullet (\eta^B / \eta^H) \bullet (C^B /C^H)$$

Replacing state taxes with a federal tax

Another exercise is to consider replacing the avoidable state excise taxes with a harder-to-avoid federal excise tax on cigarettes. The exercise is for a home state with a currently high tax that faces a low-tax border state: $T^H > T^B$. Consider setting the federal tax equal to the home-state tax: $T^F = T^H$. Because the federal tax also applies to purchases from the border state, the consumer no longer has any incentive to make cross-border purchases so also has no incentive to incur travel costs: $c^{B**} = 0$ and $m^{**}=0$. This assumes the federal tax can not be avoided at all, for example by making purchases from other countries. The first order condition (equation A3) for the utility maximizing choice of cigarettes purchased c** becomes:

(A7) $\partial[\ \ ]/\partial c = u_c\,(0,\ c^{**}) - (P + T^F) = 0$

$\Leftrightarrow u_c\,(0, c^{**}) = (P + T^F)$

With the new federal tax set at the old home-state tax so $T^F = T^H$, inspection of the FOCs (A3) and (A7) reveals that at the consumer's optimum the marginal utility of cigarette consumption must be the same under either tax regime. Under the simple assumption that the mileage driven does not change the marginal utility of cigarette consumption ($u_{cm} = 0$), this implies that home-state cigarette consumption is unchanged after the new federal tax replaces the old home-state tax: $c^{**} = c^{H*} + c^{B*}$.

Examining the terms of equation (A4) shows the welfare implications in the home state of replacing the state taxes with a federal cigarette tax. The federal tax revenues collected exceed the sum of home-state and border-state tax revenues previously collected: $T^F c^* > T^H\ c^{H*} + T^B c^{B*}$. But because these are re-distributed back to the taxpayer via lump-sum rebates, this increase cancels out in equation (A4). Because cigarette consumption is unchanged, the private costs of producing cigarettes k( ) and the external costs of cigarette consumption are also unchanged. On net, home-state social welfare is higher because the home-state consumer's utility is higher with the new federal tax:

$$u\,(0, c^*) > u\,(m(c^{B*}), c^* = c^{H*} + c^{B*})$$

Recalling that mileage of travel (m) is a source of dis-utility, the key to the welfare gain is that the home-state consumer no longer incurs travel costs to avoid state taxes. With the incentives created by differences in state excise taxes, consumer tax avoidance uses resources – the travel costs – that are deadweight losses, compared to an equivalent federal tax.

Extending the formula to include external costs of tax avoidance

We consider a further extension to include the external costs of tax avoidance E^A per pack of cigarettes purchased without paying the home-state tax. These costs add a term to the expression for social welfare:

$$W(T^H) = \{\max u\,(m(c^B), c^B + c^H) + Z - T^H\ c^H - T^B\ c^B - k\,(c^H + c^H)\} + T^H c^H + T^B c^B$$
$$- E^C\,[c^H + c^B] - E^A\,[c^B]$$

As above, setting the derivative $dW/dT^H = 0$ and solving for the optimal tax rate yields:

(A8) $T^{H*} = E + (T^B - E^C)\,(\eta^B/\eta^H)\,(C^B/C^H) - E^A\,(\eta^B/\eta^H)\,(C^B/C^H)$

References

Adams, Scott and Chad Cotti (2008). "Drunk Driving After the Passage of Smoking Bans in Bars." *Journal of Public Economics* 92: 1288 - 1305.

Advisory Commission on Intergovernmental Relations (1977). *Cigarette Bootlegging: A State and Federal Responsibility*. Washington, DC: U.S. Government Printing Office.

Alamar B, and SA Glantz (2006). Effect of increased social unacceptability of cigarette smoking on reduction in cigarette consumption. *American Journal of Public Health* 96 (8): 1359-1363.

Andreoni, James, Brian Erard, and Jonathan Feinstein (1998). "Tax Compliance." *Journal of Economic Literature* 36 (2): 818 - 860.

American Automobile Association (2003). "AAA Says Average Driving Costs Up 1.5 Cents Per Mile for 2003." American Automobile Association, Orlando Florida, April 7, 2003. Available from www.aaanewsroom.net, accessed April 18, 2008.

Asplund, Marcus, Richard Friberg, and Fredrik Wilander (2007). "Demand and Distance: Evidence on Cross-Border Shopping." *Journal of Public Economics* 91 ( ): 141-157.

Baltagi BH and D Levin (1986). Estimating dynamic demand for cigarettes using panel data: The effects of bootlegging, taxation and advertising reconsidered. *Review of Economics and Statistics* 68 (1): 148-155.

Barzel, Y (1976). An alternative approach to the analysis of taxation. *Journal of Political Economy* 84 (6): 1177-1197.

Baye MR, J Morgan, and P Scholten (2006). Information, search, and price dispersion. Forthcoming, *Handbook on Economics and Information Systems*, T. Hendershott, et. (Elsevier)

Becker GS, M Grossman and K Murphy (1994). An empirical analysis of cigarette addiction. *American Economic Review* 84 (3): 396-418.

Benjamin, Daniel K. and William R. Dougan (1997). “Efficient Excise Taxation: The Evidence from Cigarettes.” *Journal of Law and Economics* XL: 113- 136.

Besley, Timothy (1988). “A Simple Model for Merit Good Arguments.” *Journal of Public Economics* 35: 371-383.

Bulow, Jeremy and Paul Klemperer (1998). “The Tobacco Deal.” *Brookings Papers on Economic Activity: Microeconomics*. 323-394.

Carpenter, Christopher and Cook, Philip J. (2008). “Cigarette taxes and youth smoking: New evidence from national, state and local Youth Risk Behavior Studies.” *Journal of Health Economics* 27 (2): 287-299.

Chaloupka, Frank J. and Kenneth E. Warner (2000). “The Economics of Smoking.” In Anthony Culyer and Joseph P. Newhouse, editors, *Handbook of Health Economics* (Volume 1B, pp. 1539 - 1627). Amsterdam: North Holland.

Chetty, Raj (2009a). “Is the Taxable Income Elasticity Sufficient to Calculate Deadweight Loss? The Implications of Evasion and Avoidance.” *American Economic Journal - Economic Policy* 1 (2): 31-52.

Chetty, Raj (2009b). “Sufficient Statistics for Welfare Analysis: A Bridge between Structural and Reduced-form Methods.” *Annual Review of Economics* 1: 451-488.

Chetty, Raj, Adam Looney, and Kory Kroft (2009). “Salience and Taxation: Theory and Evidence.” *American Economic Review* 99 (4): 1145 - 1177.

Chiou, Lesley and Erich Muehlegger (2008). “Crossing the Line: Direct Estimation of Cross-Border Cigarette Sales and the Effect on Tax Revenue.” *The B.E. Journal of Economic*

Analysis & Policy 8 (1): Article 48.

Cnossen, Sijbren (2005). "Economics and Politics of Excise Taxation." In Sijbren Cnossen, ed. *Theory and Practice of Excise Taxation: Smoking, Drinking, Gambling, Polluting, and Driving*. Oxford University Press. Pages 1 - 19.

Cnossen, Sijbren and Michael Smart (2005). "Taxation of Tobacco." In Sijbren Cnossen, ed. *Theory and Practice of Excise Taxation: Smoking, Drinking, Gambling, Polluting, and Driving*. Oxford University Press, pages 20 - 55.

Coats, R. Morris (1995). "A Note on Estimating Cross-Border Effects of State Cigarette Taxes." *National Tax Journal* 48 (4): 573-584.

Colman, Gregory J. and Dahlia K. Remler (2008). "Vertical Equity Consequences of Very High Cigarette Tax Increases: If the Poor Are the Ones Smoking, How Could Cigarette Tax Increases Be Progressive?" *Journal of Policy Analysis and Management* 27 (2): 376 - 400.

Cook, Philip J. and Michael J. Moore (2000). "Alcohol." In Anthony Culyer and Joseph P. Newhouse, editors, *Handbook of Health Economics* (Volume 1B, pp. 1629 - 1673). Amsterdam: North Holland.

Cummins, K. Michael, Andrew Hyland, Eugene Lewit, and Don Shopland (1997). "Use of Discount Cigarettes by Smokers in 20 Communities in the United States, 1988 - 1993." *Tobacco Control* 6 (Supplement 2): S25 - S30.

DeCicca, Philip, Donald S. Kenkel, and Feng Liu (2010). "Who Pays Cigarette Taxes? The Impact of Consumer Price Search." Working Paper, Department of Policy Analysis and Management, Cornell University.

DeCicca, Philip, Donald S. Kenkel, and Alan D. Mathios (2008). "Cigarette Taxes and the Transition from Youth to Adult Smoking: Smoking Initiation, Cessation, and Participation."

Journal of Health Economics 27 (4): 904-917.

DeCicca, Philip, Donald S. Kenkel, Alan D. Mathios, AD, Shin, Y-J, and Lim, J-Y (2008). "Youth smoking, taxes, and anti-smoking sentiment." *Health Economics* 17 (6): 739 - 749.

DeCicca, Philip and Logan McLeod (2008). "Cigarette taxes and older adult smoking: Evidence from recent large tax increases, *Journal of Health Economics.*

Delipalla S and O O'Donnell (2001). Estimating tax incidence, market power and market conduct: The European cigarette industry. *International Journal of Industrial Organization* 19: 885-908.

Doyle, Joseph J and Krislert Samphantharak (2008). "$2.00 Gas! Studying the Effects of a Gas Tax Moratorium." *Journal of Public Economics* 92: 869-884.

Efrati, Amir (2007). "Cigarette-Tax Disparities Are a Boon for Border Towns." *Wall Street Journal*, March 2, 2007, p. B1.

Emery, Sherry, M M White, E A Gilpin, John P. Pierce (2002). "Was There Significant Tax Evasion After the 1999 50 Cent per Pack Cigarette Tax Increase in California?" *Tobacco Control* 11: 130 - 134.

Farrelly, Matthew C. and Christian T. Nimsch (2003). *Impact of Cigarette Excise Tax Increases in Low-Tax Southern States on Cigarette Sales, Cigarette Excise Tax Revenue, Tax Evasion, and Economic Activity.* Final Report, RTI International, Research Triangle Park NC.

Farrelly, Matthew C., Christian T. Nimsch, and Joshua James (2003). *State Cigarette Excise Taxes: Implications for Revenue and Tax Evasion.* Final Report, RTI International, Research Triangle Park NC.

Federation of Tax Administrators (2010). Http://www.taxadmin.org.

Feldstein, Martin S. (1999). "Tax Avoidance and the Deadweight Loss of the Income

Tax." *Review of Economics and Statistics* 81 (4): 674-680.

Fleenor, Patrick (1998). "How Excise Tax Differentials Affect Interstate Smuggling and Cross-Border Sales of Cigarettes in the United States." Background Paper # 26. Tax Foundation, Washington, D.C.

Fleenor, Patrick (2008). "Cigarette Taxes are Fueling Organized Crime." Opinion, *The Wall Street Journal* May 7, 2008. P. A17.

Freeman, A. Myrick (1979). *The Benefits of Environmental Improvement: Theory and Practice*. Published for Resources for the Future Inc. by the Johns Hopkins University Press, Baltimore and London.

Gallet, Craig A., and John A. List (2003). "Cigarette Demand: A Meta-analysis of Elasticities." *Health Economics* 12 (10): 821 - 835.

Gilpin EA, L Lee and JP Pierce (2004). Changes in population attitudes about where smoking should not be allowed: California versus the rest of the USA. *Tobacco Control* 13: 38-44.

Goel, Rajeev K. and Michael A. Nelson (2007). "The Master Settlement Agreement and Cigarette Tax Policy." *Journal of Policy Modeling* 29: 431-438.

Goodwin, Phil, Joyce Dargay, and Mark Hanly (2004). "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review." *Transport Reviews* 24 (3): 275-292.

Goolsbee, Austin, Michael Lovenheim, and Joel Slemrod (2010). "Playing with Fire: Cigarettes, Taxes and Competition from the Internet." *American Economic Journal: Economic Policy* 2 (1):131 - 154.

Goulder, Lawrence H. and Roberton C. Williams (2003). "The Substantial Bias from

Ignoring General Equilibrium Effects in Estimating Excess Burden, and a Practical Solution." *Journal of Political Economy* 11 (4): 898 - 927.

Gruber, Jonathan and B Koszegi (2001). "Is Addiction 'Rational'? Theory and Evidence." *Quarterly Journal of Economics* 116 (4): 1261-1303.

Gruber, Jonathan and B Koszegi (2004). "Tax Incidence When Individuals are Time-Inconsistent: The Case of Cigarette Excise Taxes." *Journal of Public Economics* 88: 1959-1987,

Gruber, Jonathan, A Sen, M Stabile (2003). "Estimating Price Elasticities When There Is Smuggling." *Journal of Health Economics* 22 (5): 821 - 842.

Harberger, Arnold C. (1964). "The Measurement of Waste." *American Economic Review* 54 (3): 58-76.

Harrington, Winston, Ian Parry, and Margaret Walls (2007). "Automobile Externalities and Policies." *Journal of Economic Literature* XLV: pp. 374-400

Hartman A, Willis G, Lawrence D, Marcus S. (2002). *The 1998–1999 NCI Tobacco Use Supplement to the Current Population Survey (TUS-CPS): Representative Survey Findings*. National Cancer Institute, Available from: http://riskfactor.cancer.gov/studies/tus-cps/, Accessed February 2004.

Hines, James R. (2007). "Taxing Consumption and Other Sins." *Journal of Economic Perspectives* 21 (1): 49-68.

Horwitz, Sari (2004). "Cigarette Smuggling Linked to Terrorism." *Washington Post*, June 8, 2004, p. A01.

Hyland, A., J. E. Bauer, Q Li, et al. (2005). "Higher Cigarette Prices Influence Cigarette Purchase Patterns." *Tobacco Control* 14: 86 - 92.

Johnson, TR (1978). Additional evidence on the effects of alternative taxes on cigarette prices. *Journal of Political Economy* 86 (2): 325-328.

Johnson, Terry R. (1978). "A Cross-Section Analysis of the Demand for New and Used Automobiles in the United States." *Economic Inquiry* 16 (October): 531 - 548.

Kayser, Hilke A. (2000). "Gasoline Demand and Car Choice: Estimating Gasoline Demand Using Household Information." *Energy Economics* 22: 331-348.

Keeler, TE., T-W Hu, PB Barnett, WG Manning, and H-Y Sung. (1996). Do cigarette producers price-discriminate by State? An empirical analysis of local cigarette pricing and taxation. *Journal of Health Economics* 15 (4): 499-512.

Keeler, Theodore E., T eh - wei Hu, Willard G. Manning, and Hai-Yen Sung (2001). "State Tobacco Taxation, Education and Smoking: Controlling for the Effects of Omitted Variables." *National Tax Journal* 54 (1): 83 - 102.

Kenkel, Donald S. (1996). "New Estimates of the Optimal Tax on Alcohol." *Economic Inquiry* 34: 296-319.

Khwaja, Ahmed, Dan Silverman, and Frank Sloan (2007). "Time Preference, Time Discounting, and Smoking Decisions." *Journal of Health Economics* 26: 927-949.

LaFaive, Michael, Patrick Fleenor, and Todd Nesbit (2008). "Cigarette Taxes and Smuggling: A Statistical Analysis and Historical Review." Mackinac Center for Public Policy, Midland, Michigan.

Lee, L.F. (1978). "Unionism and Wage Rates: A Simultaneous Equation Model with Qualitative and Limited Dependent Variables." *International Economic Review* 19: 415-433.

Levy DE, and Ellen Meara (2006). "The Effect of the 1998 Master Settlement Agreement on Prenatal Smoking." *Journal of Health Economics* 25(2): 276-294.

Liu (2009). "Cutting through the Smoke: Separating the Effect of Price on Smoking

Initiation, Relapse, and Cessation." *Applied Economics* .

Lovenheim, Michael F. (2008). "How Far to the Border? The Extent and Impact of Cross-Border Casual Cigarette Smuggling." *National Tax Journal* 61 (1): 7 - 33.

Lovenheim, Michael and Joel Slemrod (2010). "The Fatal Toll of Driving to Drink: The Effect of Minimum Legal Drinking Age Evasion on Traffic Fatalities." *Journal of Health Economics* 29: 62 - 77.

Maddala, G.S. (1983). *Limited-dependent and Qualitative Variables in Econometrics.* Cambridge: Cambridge University Press.

Manning, Willard G, Emmet B. Keeler, Joseph P. Newshouse, et al. (1989). "The Taxes of Sin: Do Smokers and Drinkers Pay Their Way?" *Journal of the American Medical Association* 261: 1604-1609.

Merriman, David (2010). "The Micro-geography of Tax Avoidance: Evidence from Littered Cigarette Packs in Chicago." *American Economic Journal: Economic Policy* .

Nelson, Michael A. (2002). "Using Excise Taxes to Finance State Government: Do Neighboring State Taxation Policy and Cross-Border Markets Matter?" *Journal of Regional Science* 42 (4): 731-752.

O'Connor, Brian P. (2008). "An Update – Additional Cigarette Tax Revenue Sources for New York State." Prepared for the New York Association of Convenience Stores.

O'Donoghue, Ted and Matthew Rabin (2003). "Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes." *American Economic Review* May 93 (2): 186-191.

O'Donoghue, Ted and Matthew Rabin (2006). "Optimal Sin Taxes." *Journal of Public Economics* 90 (10 - 11): 1825-1849.

Organisation for Economic Cooperation and Development (2005). *Consumption Tax*

Trends, 2004 edition. Paris: OECD.

Orzechowski and Walker (2007). *The Tax Burden on Tobacco: Historical Compilation*. Orzechowski and Walker, Arlington Virginia.

Office of Applied Studies Substance Abuse and Mental Health Services Administration (2007). "Cigarette Brand Preferences in 2005." *The NSDUH Report*, January 12, 2007.

Parry, Ian W.H., Ramanan Laxminarayan, and Sarah E. West (2006). "Fiscal and Externality Rationales for Alcohol Taxes." Discussion Paper, Resources for the Future, Washington D.C.

Parry, Ian W.H. and Kenneth Small (2005). "Does Britain or the United States Have the Right Gasoline Tax?" *American Economic Review* 95 (4): 1276 - 1289.

Parry, Ian W.H., Margaret Walls, and Winston Harrington (2007). "Automobile Externalities and Policies." *Journal of Economic Literature*. 45 (2): 373-400.

Pogue, Thomas F. and Larry G. Sgontz (1989). "Taxing to Control Social Costs: The Case of Alcohol." *American Economic Review* 79: 235-243.

R.J. Reynolds Tobacco Company (2010). NoCigTax.com. Accessed March 23, 2010.

Saba, Richard P., T. Randolph Beard, Robert B. Eklund, and Rand W. Ressler (1995). "The Demand for Cigarette Smuggling." *Economic Inquiry* 33: 189 - 202.

Sack, Kevin (2008). "States Look to Tobacco Tax for Budget Holes." *New York Times*, April 21, 2008.

Sandmo, Agnar (2005). "The Theory of Tax Evasion: A Retrospective View." *National Tas Journal* 58 (4): 643-663.

Sarlin, Benjaimin (2008). "Cigarette Tax Hike: 'Gold Mine" for Smugglers." *New York Sun*, April 1, 2008.

Schroyen, Fred (2005). "An Alternative Way to Model Merit Good Arguments." *Journal of Public Economics* 89: 957-966.

Seiglie, Carlos (1990). "A Theory of the Politically Optimal Commodity Tax." *Economic Inquiry* 28: 586-603.

Shelley, Donna, M. Jennifer Cantrell, Joyce Moon-Howard, Destiny Q. Ramjohn, and Nancy VanDevanter (2007). "The $5 Man: The Underground Economic Response to a Large Cigarette Tax Increase in New York City." *American Journal of Public Health* 97 (8): 1483 - 1488.

Slemrod, Joel (2007). "Cheating Ourselves: The Economics of Tax Evasion." *Journal of Economic Perspectives* 21 (1): 25 - 48.

Sloan, Frank A., Jan Osterman, Gabriel Picone, Chistopher Conover, and Donald H. Taylor (2004). *The Price of Smoking*. Cambridge, Massachusetts: The MIT Press.

Small, Kenneth A., Clifford Winston, and Jia Yan (2005). "Uncovering the Distribution of Motorists' Preferences for Travel Time and Reliability." *Econometrica* 73 (4): 1367 - 1382.

Smith, Stephen (2005). "Economic Issues in Alcohol Taxation." In Sijbren Cnossen, ed. *Theory and Practice of Excise Taxation: Smoking, Drinking, Gambling, Polluting, and Driving*. Oxford University Press. Pages 56 - 83.

Staiger D and JH Stock (1997). "Instrumental variables regressions with weak instruments." *Econometrica* 65 (3): 557-586.

Stehr, Mark (2005). "Cigarette Tax Avoidance and Evasion." *Journal of Health Economics* 24 ( ): 277 - 297.

Stehr, Mark (2007). "The Effect of Sunday Sales Bans and Excise Taxes on Drinking and Cross-Border Shopping for Alcoholic Beverages." *National Tax Journal* 60 (1): 85 - 105.

Stern N (1987). The effects of taxation, price control and government contracts in oligopoly and monopolistic competition. *Journal of Public Economics* 32: 133-158.

Stock JH, JH Wright, and M Yogo (2002). A survey of weak instruments and weak identification in generalized method of moments." *Journal of Business & Economic Statistics* 20 (4): 518-529.

Sumner MT, and R Ward (1981). Tax changes and cigarette prices. *Journal of Political Economy* 89 (6): 1261-1265.

Tauras, John (2006). "Smoke-free Air Laws, Cigarette Prices, and Adult Cigarette Demand." *Economic Inquiry* 44(2): 333-342.

Thursby, Jerry G., and Marie C. Thursby (2000). “Interstate Cigarette Bootlegging: Extent, Revenue Losses, and Effects of Federal Intervention.” *National Tax Journal* 53 (1): 59 - 77.

Train, Kenneth E. (2003). *Discrete Choice Models with Simulation*. Cambridge University Press, Cambridge, England.

Vedder, Richard K. (1997). “Bordering on Chaos: Fiscal Federalism and Excise Taxes.” In William F. Shughart, editor. *Taxing Choice: The Predatory Politics of Fiscal Discrimination*. The Independent Institute, Transaction Publishers, New Brunswick and London.

Victoria Transport Policy Institute (2008). *Transportation Cost and Benefit Analysis – Travel Time Costs.* Victoria Transport Policy Institute, www.vtpi.org.

Wasserman, Jeffery, Willard G. Manning, Joseph P. Newhouse, J.D. Winkler (1991). “The Effects of Excise Taxes and Regulations on Cigarette Smoking.” *Journal of Health Economics* 10: 43-64.

Willis, Robert and Sherwin Rosen (1979). “Education and Self-Selection.” *Journal of*

Political Economy 87 (5, Part 2): 507 - 536.

Yurekli, Ayda A. and Ping Zhang (2000). "The Impact of Clean Indoor-Air Laws and Cigarette Smuggling on Demand for Cigarettes: An Empirical Model." *Health Economics* 9 (2): 159-170.

Table 1：Descriptive Statistics

Variable	Mean for non-crossers	Mean for border-crossers
Price paid	3.54	2.91
Home state tax	0.95	1.23
Distance to low-tax state border (100 miles)	1.20	0.52
State anti-smoking sentiment	0.20	0.20
Age 15-29 (omitted category)	0.22	0.12
Age 30-39	0.22	0.17
Age 40-49	0.25	0.28
Age 50-59	0.18	0.22
Age 60+	0.13	0.21
Female	0.51	0.51
White (omitted category)	0.76	0.82
Black	0.11	0.10
Hispanic	0.09	0.04
Other races	0.04	0.04
Less than high school	0.17	0.13
High school (omitted category)	0.38	0.37
Some college	0.30	0.29
College or higher	0.15	0.20
Family income < 25k (omitted category)	0.32	0.26
Family income 25k-40k	0.22	0.20

Family income 40k-75k	0.29	0.32
Family income 75k+	0.18	0.22
Household size	2.66	2.35
Married	0.42	0.44
Employed (omitted category)	0.68	0.66
Unemployed	0.07	0.05
Retired	0.08	0.14
Not in the labor force	0.17	0.15
Northeast (omitted category)	0.20	0.32
Midwest	0.28	0.33
South	0.30	0.25
West	0.22	0.10
Feb. 2003 (omitted category)	0.17	0.17
June 2003	0.21	0.20
Nov. 2003	0.19	0.20
May 2006	0.16	0.15
Aug. 2006	0.12	0.13
Jan. 2007	0.16	0.14
N	27,878	1,499

Table 2: Cross Border Cigarette Purchases by State

State	Tax in 2003	Border-crossing in 2003	Tax in 2006 /2007	Border-crossing in 2006/2007
Alabama	0.17	2.94	0.43	1.37
Alaska	1.00	2.99	1.73	2.61
Arizona	1.18	2.13	1.73	3.54
Arkansas	0.51	6.24	0.59	11.13
California	0.87	2.36	0.87	1.15
Colorado	0.20	0.75	0.84	1.17
Connecticut	1.38	6.73	1.51	3.06
Delaware	0.34	0.67	0.55	1.9
District of Columbia	1.00	22.42	1.00	18.45
Florida	0.34	1.47	0.34	0.68
Georgia	0.20	1.16	0.37	1.6
Hawaii	1.23	2.38	1.53	0.87
Idaho	0.47	1.65	0.57	2.63
Illinois	0.98	10.74	0.98	9.99
Indiana	0.56	5.92	0.56	4.31
Iowa	0.36	2.67	0.36	1.9
Kansas	0.79	9.57	0.79	6.9

Kentucky	0.03	0.6	0.30	0.53
Louisiana	0.36	1.53	0.36	1.29
Maine	1.00	6.94	2.00	8.51
Maryland	1.00	18.3	1.00	13.73
Massachusetts	1.51	15.24	1.51	9.6
Michigan	1.25	6.16	2.00	7.23
Minnesota	0.48	2.24	0.82	8.19
Mississippi	0.18	1.69	0.18	0.95
Missouri	0.17	1.59	0.17	0.43
Montana	0.53	1.81	1.70	3.18
Nebraska	0.64	9.16	0.64	8.92
Nevada	0.50	1.48	0.80	0.19
New Hampshire	0.52	1.02	0.80	1.03
New Jersey	1.68	13.47	2.52	8.62
New Mexico	0.44	3.52	0.91	2.52
New York	1.50	5.87	1.50	4.17
North Carolina	0.05	0.13	0.33	2.33
North Dakota	0.44	0.98	0.44	0.2
Ohio	0.55	4.94	1.25	7.9
Oklahoma	0.23	0.99	1.03	1.32
Oregon	1.28	1.59	1.18	1.08
Pennsylvania	1.00	4.67	1.35	6.58

Rhode Island	1.45	8.88	2.46	13.2
South Carolina	0.07	1	0.07	0.81
South Dakota	0.46	1.79	0.86	6.5
Tennessee	0.20	6.25	0.20	2.12
Texas	0.41	1.44	0.74	1.59
Utah	0.70	5.54	0.70	1.61
Vermont	1.02	18.37	1.59	18.66
Virginia	0.03	2.71	0.30	2.18
Washington	1.43	9.41	2.03	9.09
West Virginia	0.42	12.23	0.55	9.72
Wisconsin	0.77	2.51	0.77	1.1
Wyoming	0.28	1.47	0.60	1.99

Table 3: Reduced-Form Models of Border-Crossing

VARIABLES	A	B	C	D	E
Distance to border	-0.093***	-0.084***	-0.049***	-0.056***	-0.051***
	(0.014)	(0.011)	(0.012)	(0.007)	(0.011)
$Distance^2$	0.016***	0.015***	0.007**	0.008***	0.007***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Home-state tax		0.052***	0.118***	0.048***	0.115***
		(0.011)	(0.023)	(0.009)	(0.023)
Border-state tax		-0.063***	-0.138***	-0.060***	-0.136***
		(0.013)	(0.027)	(0.011)	(0.027)
Home-state tax * distance			-0.134***	-0.046***	-0.127***
			(0.030)	(0.013)	(0.030)
Border-state tax * distance			0.147***	0.063***	0.141***
			(0.038)	(0.020)	(0.038)
Home-state tax * $distance^2$			0.033***	0.013***	0.031***
			(0.008)	(0.003)	(0.008)
Border-state tax * $distance^2$			-0.031***	-0.015**	-0.030***
			(0.010)	(0.006)	(0.010)
State anti-smoking sentiment					0.048*
					(0.026)
Age 30-39	0.008*	0.008*	0.009**	0.009**	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Age 40-49	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
Age 50-59	0.022***	0.022***	0.023***	0.021***	0.023***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
Age 60+	0.038***	0.038***	0.038***	0.037***	0.038***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)
Female	-0.002	-0.002	-0.001	-0.002	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Black	-0.015**	-0.017***	-0.018***	-0.013***	-0.018***
	(0.007)	(0.006)	(0.006)	(0.004)	(0.006)
Hispanic	-0.009	-0.009*	-0.009*	-0.012***	-0.010**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Other races	0.003	0.004	0.004	0.006	0.003
	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)
Less than high school	-0.003	-0.003	-0.003	-0.003	-0.003
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Some college	0.002	0.003	0.002	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
College or higher	0.011**	0.010**	0.009*	0.006*	0.009*

	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)
Family income 25k-40k	0.006	0.006	0.005	0.005	0.005
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Family income 40k-75k	0.012***	0.012***	0.011***	0.011***	0.011***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Family income 75k+	0.015***	0.015***	0.014***	0.014***	0.014***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Household size	-0.005***	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Married	0.001	0.001	0.002	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Unemployed	-0.006	-0.006	-0.006	-0.005	-0.006
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
Retired	0.013*	0.012*	0.012*	0.009*	0.012*
	(0.007)	(0.007)	(0.007)	(0.005)	(0.007)
Not in labor force	0.004	0.003	0.003	0.004	0.003
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Marginal effect of distance(a)	-0.055	-0.049	-0.049	-0.037	-0.050
R-squared	0.045	0.052	0.057		0.057

Robust standard errors (clustered at MSA level) in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Models A, B, C, and E are OLS linear probability models. Model D is maximum likelihood Probit (marginal effects reported). All models also include a constant term and a set of dummies for MSA size, region, and survey month. Sample size for all models is 29,377.

(a) Marginal effect of distance is calculated at the mean distance for the sample.

Table 4: Structural Endogenous Switching Regression Model

VARIABLES	Probability of Border Crossing	Home-state price paid	Border-state price paid
Distance to border	-0.044***		
	(0.012)		
Distance^2	0.007***		
	(0.002)		
Price difference	0.095***		
	(0.017)		
Price difference * distance	-0.078***		
	(0.018)		
Price difference * distance^2	0.017***		
	(0.004)		
Home-state tax		0.866***	
		(0.043)	
Border-state tax			0.399***
			(0.136)
Age 30-39	0.009*	-0.146***	-0.134
	(0.004)	(0.020)	(0.107)
Age 40-49	0.014***	-0.323***	-0.445***
	(0.004)	(0.018)	(0.095)
Age 50-59	0.012**	-0.409***	-0.633***
	(0.005)	(0.024)	(0.113)
Age 60+	0.027***	-0.497***	-0.741***
	(0.008)	(0.032)	(0.134)
Female	0.001	-0.003	0.065
	(0.003)	(0.013)	(0.060)
Black	-0.005	0.272***	0.516***
	(0.008)	(0.027)	(0.077)
Hispanic	-0.004	0.230***	0.421**
	(0.006)	(0.027)	(0.177)
Other races	0.004	0.057	0.105
	(0.008)	(0.038)	(0.167)
Less than high school	-0.005	-0.011	-0.036
	(0.004)	(0.014)	(0.097)
Some college	0.005	0.034***	0.097
	(0.003)	(0.012)	(0.068)
College or higher	0.015**	0.192***	0.281***
	(0.006)	(0.020)	(0.082)
Family income 25k-40k	0.006*	0.063***	0.081
	(0.004)	(0.017)	(0.085)

Family income 40k-75k	0.012***	0.116***	0.137*
	(0.004)	(0.017)	(0.081)
Family income 75k+	0.020***	0.228***	0.392***
	(0.005)	(0.024)	(0.084)
Household size	-0.007***	-0.004	-0.067***
	(0.001)	(0.005)	(0.024)
Married	0.003	-0.075***	-0.039
	(0.003)	(0.015)	(0.080)
Unemployed	-0.000	-0.043**	0.079
	(0.005)	(0.019)	(0.120)
Retired	0.016**	-0.117***	-0.040
	(0.007)	(0.028)	(0.108)
Not in labor force	0.002	-0.113***	-0.138**
	(0.004)	(0.017)	(0.069)
Marginal effect of distance (a)	-0.072		
Marginal effect of price difference (a)	0.044		

Robust standard errors (clustered at MSA level) in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All models also include a constant term and a set of dummies for MSA size, region, and survey month. Sample size for all models is 29,377.

(a) Marginal effect is calculated at the mean for the sample.