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Driven to Drink
Sin Taxes Near a Border

Abstract:
This paper investigates household purchasing behavior in response to differing alcohol and tobacco taxes near an international border. Our study suggests that large tax differentials near borders induce economically important tax avoidance behavior that may limit a government's ability to raise revenue and potentially undermine the pursuit of important health and social policy goals. We match novel supermarket scanner and consumer expenditure data to measure the size and scope of the effect for households and stores. We find that stores near/far from the international border have statistically significantly lower/higher sales of beer and tobacco than comparable stores far/near the border. Moreover, we find that households near the border report higher consumption of these same goods. This is consistent with households facing lower prices. Finally, we find measures of externalities associated with the consumption of alcohol and tobacco are higher near the border.

Keywords: Alcohol Consumption, Tobacco Consumption, Border Trade, Taxation

JEL classification: C31, F14, I18.

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1. Introduction

Large differences in taxation on alcohol and tobacco exist within countries (United States), between countries (Scandinavia) and within economic federations (E.U., NAFTA). These differences can lead to lower tax revenues for the state and have distributional implications within states or regions. Perhaps most importantly for alcohol and tobacco consumption, large differences in tax levels in a small geographic area may undermine health and social policy goals. This paper uses detailed sales and consumption data from Norway to measure the magnitude and scope of cross-border purchasing behavior.

Alcohol and tobacco are considerably less expensive in Sweden than in Norway. The difference in prices is directly attributable to high levels of taxation levied on these goods by the Norwegian government. Anecdotal evidence, and evidence from survey data, suggests that Norwegian consumers have responded to price differences by engaging in extensive cross-border shopping. That is to say, purchasing goods highly taxed in Norway (notably alcohol and tobacco), in neighboring countries. We ask the following series of related questions. First, how extensive is cross-border shopping between Norway and Sweden? Using a matched sample of supermarkets located near and far from the border we can accurately measure differences in sales between regions. Second, do these differences in sales translate into differences in consumption? Using a matched sample of households, located near and far from the border, we can assess the extent to which differences in sales are reflected in differences in consumption. Third, do we observe higher levels of externalities associated with alcohol and beer consumption near the border relative to far from the border? Finally, we investigate the geographic scope of tax avoidance behavior. How far, in terms of driving time, does the effect of lower prices on the other side of the border extend? The answers to all of these questions will be of interest to policy makers who view taxation of alcohol and tobacco as a quintessentially Pigouvian tax.

There is a small empirical literature that investigates the role of differential taxation schemes on cross-border shopping and smuggling. Crawford et al. (1999) test whether the creation of the European single market in 1993 affected demand for alcoholic beverages in Britain. They examine household survey data before and after the change and found little difference. While Crawford et al. (1999) use variation over time to identify cross-border trade, the present work focuses on

Gruber et al. (2003) examine cross-border smuggling of tobacco between Canada and the United States in the early 1990s. They estimate the price elasticity of demand for cigarettes using provinciallevel sales data and extend their analysis using household level expenditure data. A key difference with the current paper is the focus on estimating the price elasticity of demand for cigarettes conditional on the existence of smuggling, which is assumed to exist in, and be limited to, certain provinces during certain periods. The current paper differs in that the goal here is to detect the presence, and quantify the magnitude, of cross-border commerce. This is close to Stehr (2005), who considers differences in state taxes on tobacco products. He examines both the sale of tobacco and consumption of tobacco at the state level and uses differences between these to infer tax avoidance when there are changes in state-level taxes. Stehr finds, over the period 1986-2001, tax avoidance accounted for almost 10% of sales over the period 1986-2001.

Our paper is perhaps closest in spirit to recent work by Asplund et al. (2007) who consider cross-border shopping for of alcohol between Sweden and Denmark. They estimate a demand model for alcoholic beverages in Sweden that incorporates both domestic and foreign prices. They find that consumers in Sweden are responsive to price changes in neighboring Denmark. Moreover, they find that the effect of the border extends a great distance into Sweden. Our analysis echoes Asplund et al. (2007) but differs with respect to methodology, focus, and scope. First, rather than explicitly estimating a demand relationship, we use a more intuitive matching regression approach, comparing stores near the border and stores far from the border. More importantly, we analyze data from both sides of the market. We consider foregone sales, but we also examine differences in household consumption. Further, we focus attention on the trade of both alcohol and tobacco. Finally, we also briefly examine the correlation between high incidence of cross-border shopping and health outcomes.

We begin by describing the differences in taxation schemes on alcohol and tobacco and institutional structures that make tax avoidance through cross-border shopping attractive. Our analysis begins by considering the supply side of the market using sales data from a representative group of Norwegian supermarkets. We compare a group of supermarkets near the border to a group of supermarkets far from the border and using a matching estimator and compare expenditure on beer and tobacco between the two groups. We then turn to the demand side of the market and compare reported expenditure on these commodities by households in the Norwegian consumer expenditure survey. In short, we find that stores report selling less near the border whereas consumers report consuming more near the border, suggesting the presence of large scale cross-border trade in beer and tobacco.Consistent with higher consumption we find statistically significantly higher levels of lung cancer and drunk driving arrests in counties near the border than far from the border. Finally we find that sales of beer and tobacco are an increasing function of distance to the border.

2. Institutional Background

High levels of taxation on alcoholic beverages and tobacco in Norway are meant to be part of an externality-correcting Pigouvian, externality-targeting taxes. In a universal health care coverage system, consumption of these goods can place a burden on public health resources, which individual agents do not consider when they plan their consumption. Since consumers do not face the full financial burden of their actions, the private price of consumption is smaller than the social cost of consumption. In Norway, the taxation scheme belongs to a wider set of policy instruments designed to limit alcohol and tobacco intake, which include, but are not limited to, additional sales taxes on purchases of alcohol and tobacco, personal import quotas on travel and trips abroad, prohibition of sales of alcohol after 6 p.m. before holidays and on election day, prohibition of sales of alcohol after 8 p.m. before working-days, a complete ban of tobacco and alcohol advertising, prohibition of sales of beverages with substantial alcoholic content (strong beer, wine, liquor) in stores (they can only be sold at governmentally owned and operated stores, Vinmonopolet), and the prohibition of the sales of liquor to persons below 20 years of age.

In addition, high taxes are levied on alcohol and tobacco. These taxes are consistent with the general notion in the Norwegian tax system that consumption taxes are to be preferred to taxes on wage income. For example, the revenue from indirect taxes as share of total tax revenue in Norway is 31.3 percent, which is above the EU (15) average of 28.7 percent and considerably higher than the share in Sweden, which is 20.8 percent NOU (2003).

As a result of these taxes, the price of alcohol and tobacco is substantially lower in Sweden than in Norway as Tables 1 and 2 demonstrate.

Table 1. Special Purpose Taxes on Beverages with Alcoholic Content in Norway and Sweden, per January 1st 2003. In NOK (1 NOK=0.165 USD)

Type of Beverage	Norway	Sweden
Liquor, 70 cl, 40 percent alcohol per volume	152.32	120.00
Wine, 75 cl, 12 percent alcohol per volume	31.95	14.15
Beer, 50 cl, 4.7 percent alcohol per volume	7.95	2.95

Source: NOU (2003).

Table 2. Special Purpose Taxes on Tobacco in Norway and Sweden, per January 1st 2003.

Type of Beverage	Norway	Sweden
Pack of 40 gram tobacco (self-rolled)	48.00	21.54
Pack of 20 cigarettes	34.80	14.97

Source: NOU (2003).

Tables 1 and 2 show that, for example the taxes on a can of beer in Norway (50 cl) are substantially larger than in Sweden. In Norway, these taxes amount to NOK 8 as compared to NOK 3 in Sweden. A study controlling for purchasing power parity (NOU 2003, p. 28)) estimates the price level in Norway for beverages with alcoholic content to be 66 percent higher in Norway than in Sweden. For tobacco, the estimate is 86 percent (NOU 2003, p. 32).

Table 3. Cross-Country Comparison

Country	**Per Capital Liters of Alcohol (2003)**	**Per Capita Number of Cigarettes (2000)**
Denmark	9.84	1525.03
Finland	8.23 (2005)	919.59
France	9.95	1303.29
Germany	10.71	1553.15
Ireland	10.61(2005)	1815.21
Netherlands	7.79	2401.99
Norway	4.82	578.53
Spain	9.99	2464.44
Sweden	5.62	902.36
United Kingdom	9.29	1108

Source: WHO (2007).

As a social policy designed to reduce consumption, taxation seems to have been reasonably successful, although additional factors probably have contributed. Table 3 shows that per capita consumption of both alcohol and tobacco is among the lowest in Western Europe and the lowest amongst the Nordic countries.

Tables 1 and 2 show that for an individual household, there are strong financial incentives to avoid Norwegian taxes and purchase alcohol and tobacco abroad. Legally, however, there exists a strict regulation on how much may be imported per trip. On January 10 2003 the following regulation concerning quotas was implemented:

1. Travelers may bring 1 liter of beverage with alcoholic content between 22 and 60 percent of volume and 1 liter beverage with alcoholic content between 2.5 and 22 percent of volume -- or 2 liter beverage with alcoholic content between 2.5 and 22 percent of volume.
2. Travelers may bring 2 liters of beer with alcoholic content above 2.5 percent of volume -- or another beverage with alcoholic content between 2.5 and 4.75 percent of volume.

Travelers are allowed to use both quotas i) and ii). Since beer may fit both quota i) and ii), a traveler, complying with this regulation, may bring into the country in total 4 liters of beer with alcoholic content below 4.75 percent of volume, given that they do not bring other beverages with alcoholic content into the country. The legal allowance for importing cigarettes without having to pay duty is 200 cigarettes.

The price incentives to purchase alcoholic beverages and tobacco abroad, as evidenced by Tables 1 and 2, are strong and entice consumers to engage in tax avoidance behavior. The share of border crossings motivated by these price incentives is high. Table 4 shows the results of an intercept survey conducted at the major crossing points from Norway to Sweden. Results show that the motivation for the majority of border crossings is a single day shopping trip.

Table 4. Main Purpose of Border Crossing. 4 Main Routes between Norway and Sweden. Percentages of Consumers Using Automobile Transportation, Passing between 11am and 8 pm. 2000

Main Purpose of Travel	Svinesund	Ørje	Magnor	Teveldal
Shopping, Day Trip	74	66	69	44
Visit, Day Trip	13	18	18	23
Vacation, incl. overnight stay	9	10	10	26
Business	5	6	3	7
Total	101	100	100	100
Basis (n)	619	255	163	238

Source: Ericsson (2001, p. 10)

The effect of this tax avoidance behavior on the overall economy depends upon not only the existence of a price incentive and a consumer response to the price incentive, but also on the magnitude of the effect. The magnitude is a function of the share of population that has access to cross-border purchases without substantial travel time. In Table 5, we tabulate the population in the regions where most cross-border trade occurs. We observe that the region, Østfold, which encompasses the most frequently used border crossing, Svinesund, comprises a population of 260,389 citizens, i.e. 5.6 percent of the Norwegian population. Other areas such as Akershus and Hedmark, which consists of 10.80 percent and 4.06 percent, respectively, of the Norwegian population, are substantial in population size and close to the border geographically. Thus, households residing in these areas may frequently travel across the border to Sweden, without incurring substantial travel costs.

Table 5. Population Residing in Near, or Semi-Near, Proximity to Swedish Border. Norway. 2006

Region	Population	Share of Norway's Population
Østfold	260,389	5.61%
Akershus	501,125	10.80%
Hedmark	188,511	4.06%
Oppland	183,204	3.95%
Sør-Trøndelag	275,403	5.94%
Norway	4,640,219	100%

Source: Statistics Norway. As of January 1st 2006.

3. Sales of Beer and Tobacco

The central research question is to measure the scale, scope and effects of cross-border shopping. Our empirical strategy is first to compare revenue from beer and tobacco sales at stores near the border to stores far from the border. Subsequently we compare household expenditure on beer and tobacco in the same two areas. In this way we combine information on both sides of the market. The intuition here is straightforward, if we observe two otherwise identical stores or two otherwise identical households, one located near the border and one located far from the border, differences in expenditure and differences in reported consumption on alcohol and tobacco may be attributed to proximity to the border. The size of these differences provides evidence on the magnitude of tax avoidance behavior.

A very simple analytic model leads directly to our empirical specification. We assume that local markets (Near and Far) are in equilibrium; supply equals demand in each market:

$$
\begin{aligned}
S_N &= D_N\left(p_N\right) \\
S_F &= D_S\left(p_F\right).
\end{aligned}
\tag{1}
$$

We make the maintained and untestable assumption that households far from the border purchase these goods only locally, e.g. $S_F = s_F$. Supply near the border is satisfied through local purchases and purchases across the border, $S_N = s_N + CB$. This allows us to estimate the magnitude of cross-border shopping as the difference between the differences of quantities demanded and quantities supplied.

(2) $$CB = \left(D_N\left(p_N\right) - D_S\left(p_S\right)\right) - \left(s_N - s_F\right).$$

If we are willing to assume that preferences are the same between the two regions, we can write $D_N\left(p\right) = D_F\left(p\right) = D\left(p\right)$. In the absence of border trade, prices can be expected to be the same. As a result, differences in local supply provide an estimate of the increase in sales near the border that would result from the elimination of cross-border shopping, perhaps as the result of increasing border inspection or increasing penalties for non-compliance.

(3) $$CB = s_F - s_N.$$

The outcome variable of interest is revenue from the sale of beer and tobacco. Ideally, one would observe sales at identical supermarkets in identical communities, one located near the border and one located far from the border. However, in practice each supermarket is observed either near or far from the border. Because of this, the key challenge is constructing a counterfactual. Measuring the average treatment effect requires estimating the unobserved potential outcome for each supermarket in our sample. For each supermarket near or far from the border we find another supermarket far or near from the border that is, in a way that will be made precise shortly, "similar". The border effect can then be computed in a straightforward way. If we are only interested in the effect of proximity to the border for those near the border (average treatment effect on the treated), we need only compute the counterfactual for supermarkets near the border. In what follows we report both measures.

Measures of the border effect will capture the total effect of proximity to or distance from the border. For example, a national supermarket chain may decide to build stores differently depending on where they are located, giving less space to beer close to the border. Households may then find these stores more or less attractive and decide to spend their money differently. Our estimates will pick this up, but we will not be able to disentangle this indirect effect from the direct effect of cross-border shopping. Finally, an obvious limitation of this approach is that if there is a latent low level of cross-border shopping that does not vary spatially, say as a result of air or ferry travel, this empirical strategy will not detect it. As a consequence, our results should be interpreted as a lower bound on the magnitude of cross-border purchases of highly taxed goods. Moreover, notice that it is fathomable that stores far from the border sell more alcohol than do stores near the border, while consumers far from the border actually consume less, not more, than consumers close to the border. However, this would be detected in two ways. First, our estimates on household consumption would show such an effect. Second, our estimates on sales of control commodities would pick up supply side size effects.

3.1 Method

We compute both the average treatment effect and the average treatment effect on those near the border. To construct our counterfactual, we use the bias corrected matching approach proposed by Abadie and Imbens (2002). Given a counterfactual, the two measures of tax avoidance behavior are:

(4) $$\tau = \frac{1}{N}\sum_{i=1}^{N}\left\{Y_i\left(Near\right) - Y_i\left(Far\right)\right\}, \text{ and}$$

(5) $$\tau^t = \frac{1}{N_{Near}}\sum_{i|Near}\left\{Y_i\left(Near\right) - Y_i\left(Far\right)\right\},$$

where, $Y_i\left(\bullet\right)$ is the revenue from the sale of beer or tobacco for store *i*.

Identification and consistency of our matching estimator of the border effect requires several assumptions that are easily interpretable in the program evaluation literature but may be slightly nonstandard in the current context. The first is the conditional independence assumption, also known as the unconfoundedness or selection on observables assumption. This requires that assignment to treatment is independent of outcomes, that is $Y(Near), Y\left(Far\right) \perp \left\{Near, Far\right\} \mid X$. This requires that that the distribution of characteristics be orthogonal to the border in the absence of tax differences. This rules out the possibility that heavy drinkers or smokers will choose to locate near the border because they are heavy drinkers and smokers. The second is known as the overlap assumption that requires that the probability of assignment be bounded away from zero and one. $0 < \Pr\left(Near \mid X = x\right) < 1$. This simply requires that stores of a certain type are present both near and far from the border. Finally this approach excludes the possibility of general equilibrium effects in which the choices of households and stores near the border affect the households far from the border and vice-versa.

To construct our counterfactual, we use the bias corrected matching approach proposed by Abadie and Imbens (2002)[1]. The Abadie and Imbens (2002) matching estimator defines the distance between the two vectors of covariates as the norm of the differences in the covariates, weighted by the inverse of the variance matrix to control for scale differences. Following the simulation results presented in

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[1] We use the nnmatch package developed by and described in Abadie et al. (2004).

Abadie and Imbens (2002) we match each supermarket to the 4 closest supermarkets in the other group.

Matching is facilitated by the fact that there are only four major supermarket chains in Norway (Coop, NG, ICA, REMA). Each of these chains is national in scope. We only match supermarkets from the same chain with another supermarket from the same chain, in the same month, in the same year. In addition, because within a chain/week/year stores may also vary in size, we use sales of goods that do not vary widely in price between countries as an indicator of overall store size to match stores to others of the same size. Specifically we use revenues from sales of dairy products, eggs, spices and bread as our matching variables. Prices within a given chain/week/year are comparable between regions, thus differences in expenditure are indicative of differences in quantities sold.

Finally, there may be some concern that matching on sales of other foods might be endogenous. From an economic standpoint, this would be the case if sales of alcohol and tobacco were joint in productions with sales of dairy products, eggs, spices and bread. Note that at present we are considering the supply side of the market, where an exogenous increase in the sales beer and tobacco will cause an increase in the sales of dairy products, eggs, spices and bread, given that these items were being purchased locally in the first place. In sum, each supermarket is matched to other supermarkets in the same chain/week/year whose sales of a set of control commodities are closest.

3.2 Data

Our data consists of per store price and quantity sales information by EAN/UPC code for a representative sample of 287 supermarkets, evenly distributed across Norway, over the period 2004-2006. These data are colleted as an input to the construction of the Norwegian CPI. On a monthly basis, stores provide price and quantity information for the week which contains the 15th of the month[2]. Thus, each observation consists of a week's worth of sales data from a given supermarket. The four major grocery chains in Norway participate in the program. These stores constitute approximately 70% of grocery sales by volume for Norway.

For the purposes of this analysis, postal regions sharing a border with Sweden were classified as "near", and postal regions in the western part of the country were classified as "far". We omit stores in the regions in between. Figure 1 shows these areas on a map. This implies that we omit stores in Oslo (Norway's capital and largest city) from the analysis. As a result, our sample consists of 31

[2] If the 15th falls on a Sunday, the following week is used instead.

supermarkets classified as being near the border and 80 supermarkets are classified as being far from the border. Table 6 summarizes the driving time to the nearest border crossing from the supermarkets in each group.

Figure 1. Near and Far Regions

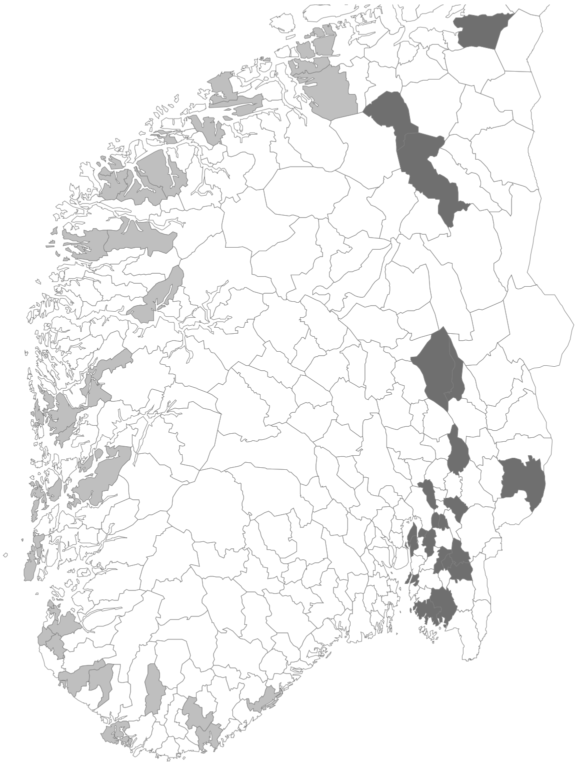


Table 6. Driving Time to Nearest Border Crossing

	Mean Travel Time in Minutes	Std. Dev.	5th Percentile	95th Percentile
NEAR	38.34	15.89	24	73
FAR	227.30	159.04	89	478

We aggregate individual EAN codes into 6 broad expenditure categories: two outcome categories: expenditure on beer and tobacco and four control categories expenditure on dairy products, eggs, bread and spices. Note that not all supermarkets are observed in all periods as some are rotated in and out of the sample as needed for purposes of index construction. Table 7 presents summarizes the data for each group.

Table 7. Summary Statistics: Store-level Data

Near	**N=744**		**Far**	**N=1763**
Outcome Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
BEER	44819.47	29076.74	46966.50	39113.45
TOBACCO	53050.84	84396.59	91289.26	261169.00
Control Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
BREAD	17324.35	15491.42	18464.29	13870.40
DAIRY PRODUCTS	72625.88	96638.13	66451.62	116125.70
EGG PRODUCTS	11167.74	62432.10	11746.60	88574.41
SPICES	4862.92	11804.48	4003.45	9494.61

***All values are in Norwegian Kroner (NOK).

Table 7 shows that near the border, revenue from sales of Beer and Tobacco is lower than revenue from these items far from the border. The difference is statistically significant at the 10% for beer and at the 1% level for tobacco. Sales of our control goods (Bread, Dairy, Egg, Spices) are comparable between regions and are not statistically significantly different from one another at all conventional levels. If household consumption is assumed uniform across the country, this provides some weak evidence in favor of the hypothesis that households in Norway are purchasing beer and tobacco outside of our sample, and presumably in Sweden.

3.3 Results

We now report the results of estimating the difference in revenue from beer and tobacco sales estimated using the matching approach described above on our sample of Norwegian supermarkets. We report both the average treatment effect (ATE) and the average treatment effect on the treated (ATET), e.g. those supermarkets located close to the border.

Table 8. Results: Store-Level Data

Average Treatment Effect	Estimate	Std. Err.	z	P>|z|	(95% Confidence Interval)
BEER	-7070.30	1813.58	-3.90	0.00	(-10624.86…-3515.75)
TOBACCO	-38694.27	10722.34	-3.61	0.00	(-59709.68…-17678.86)

Average Treatment Effect on the Treated	Estimate	Std. Err.	z	P>|z|	(95% Confidence Interval)
BEER	-9078.57	2117.59	-4.29	0.00	(-13228.98…-4928.163)
TOBACCO	-34180.95	7835.53	-4.36	0.00	(-49538.31…-18823.59)

The estimated ATE and ATET for both revenue from sales of beer and sales of tobacco are negative and statistically significant. In other words, supermarkets near the border report lower sales of beer and tobacco and supermarkets far from the border report higher sales of beer and tobacco. The difference is economically important and statistically significant at all conventional levels. Expenditure on beer is lower (higher) near (far) from the border. The estimate effect for beer is roughly 16% lower near the border than far from the border. In percentage terms, the effect on tobacco even larger, sales near the border are roughly 42% lower near the border than far from the border.

In short, we find that stores near/far from the border have statistically significantly lower/higher sales of beer and tobacco than stores from the same chain, in the same month in the same year, whose sales of other goods are similar. The estimated effects are comparable between the ATE and ATET with the ATET yielding a slightly larger (in magnitude) estimate of the border effect for beer and a slightly smaller effect for tobacco.

4. Consumption of Alcohol and Tobacco

An assumption thus far has been that the observed variations in store revenues are not simply the result of variation in local demand, but rather reflect the presence of tax avoidance behavior. Economic theory would predict that households near the border, facing lower prices for beer and tobacco, will consume these goods in larger quantities. However, an alternative explanation, entirely consistent with the previous results, is that households close to the Swedish border simply consume less beer and tobacco than households far from the border due to differences in preferences or that stores far from the border sell more alcohol and tobacco because they serve more people. While the latter can be rejected due to the non-existing difference of sales revenue on the control commodities, the former may be ruled out by turning our attention to the demand side of the market using data from the Norwegian Consumer Expenditure Survey. We replicate the analysis conducted in the previous section using households both near and far from the border rather than stores. In this way, we have evidence from both sides of the market. Once again we use the previously described bias corrected matching approach to test whether quantities consumed are different between the two groups.

4.1 Method

We consider the impact of proximity to the border on three different outcome variables: quantity purchased and expenditure on beer and on tobacco expenditure (information on the physical quantity of tobacco purchased is not collected). To see whether being located near or far from the border impacts expenditure behavior, we use the bias adjusted matching estimator previously described. To match households in the near and far regions we use a small number of demographic variables: household size, number of children under seven and total household income[3]. In addition, each household is been classified into one of fifteen different structures and we only match households to other households with identical structures.

4.2 Data

The Norwegian Consumer Expenditure Surveys contain detailed observations of household expenditures; see e.g. Statistics Norway (1990) for a detailed description of account books, interviews, and classification. The surveys are conducted continuously every year by Statistics Norway, with 1/26 of the sample reporting each 14-day period of the year. The samples contain expenditures and other information on more than one thousand households each year, and the samples include information on many socio-economic variables of each household. Physical quantity information is collected for a subset of goods, notably foodstuffs. Importantly for our study is the fact that information on quantity of beer is collected, but, unfortunately, quantity information on tobacco is not. Finally, in contrast to other household expenditure surveys, such as the British Family Expenditure survey, information on expenditures abroad are collected.

The sampling scheme is a two-stage stratified, random sample with a small sub-sample of a two-year panel. The response rate is typically around 60 percent. The 2003 sample, contained 1193 observations out of a population of about 1.8 million Norwegian households. Data consists of annualized expenditures on beer and tobacco as well as physical quantities of beer. The sample used in this analysis consists of 225 households near the border and 380 households far from the border.

[3] Note that we do not use total expenditure as this might be influence by proximity to the border.

Table 9. Summary Statistics: Household Survey Data

Near	N=225		Far	N=380
Outcome Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
BEER QUANTITY (ml)	77051.29	124735.80	51193.72	88770.74
BEER EXPENDITURE (ore)	317083.60	511034.20	234607.60	400746.80
TOBACCO EXPENDITURE (ore)	262345.70	636851.40	312904.40	645238.10
Control Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Number of Persons	3.08	1.34	3.28	1.50
Number of Children under 7	0.39	0.69	0.42	0.76
Income	488416.80	368200.70	458781.00	209161.20

Table 9 shows that for beer, quantities and expenditure are higher near the border than far from the border. The difference is statistically significant at the one and five percent levels, respectively. While mean tobacco expenditure is higher far from the border, the difference is not statistically significant at any conventional level. As concerns our matching variables, we cannot reject the null of equality of means for the number of children under 7 or household income. However mean household size near the border is statistically significantly smaller than mean household size far from the border at the 10% level.

One possible complication is that households may underreport their alcohol and tobacco expenditure. However, because we are interested in the difference between our groups rather than the level, as long as the underreporting is consistent between the two groups, our measure of cross-border commerce should not be affected. If underreporting is increasing in quantities, which seems more likely than the alternative, our estimates will understate the difference between the two regions.

4.3 Results

Table 10 presents the results of estimating the matching model for households on expenditures and quantity of beer and expenditure on tobacco.

Table 10. Results: Household Survey Data

Average Treatment Effect	**Estimate**	**Std. Err.**	**z**	**P>|z|**	**(95% Confidence Interval)**
BEER	26799.76	9434.60	2.84	0.01	(8308.28… 45291.24)
BEER EXPENDITURE	82764.66	38975.57	2.12	0.03	(6373.95…159155.40)
TOBACCO EXPENDITURE	-38071.11	54779.76	-0.69	0.49	(-145437.50…69295.26)

Average Treatment Effect on the Treated	**Estimate**	**Std. Err.**	**z**	**P>|z|**	**(95% Confidence Interval)**
BEER	28005.19	9777.87	2.86	0.00	(8840.91…47169.46)
BEER EXPENDITURE	95392.87	41377.98	2.31	0.02	(14293.53…176492.2)
TOBACCO EXPENDITURE	-47618.45	55309.02	-0.86	0.39	(-156022.1…60785.24)

The results are straightforward and intuitively pleasing. Households near the border, with access to lower prices, report purchasing more beer than households far from the border. The effect is statistically significant at the 95% level. In practice this means that a household near the border consumes 30% more beer than a household far from the border and spends 20% more on beer. Indeed, the results are consistent with the fact that beer is a normal good and facing lower prices both the income and substitution effects push in the same direction

For tobacco expenditure, the difference between the two regions is not statistically significantly different at any conventional level. The point estimate is that household expenditures are 12% lower near the border. However, given that supermarket sales near the border are 42% lower, this is consistent with households consuming larger quantities. Moreover, even if reported purchase expenditures are somewhat lower, the purchase quantity may still be clearly higher since prices are lower when the purchase took place across the border. Thus, if this is true, the picture that emerges is the same as for alcohol. Recall from Table 1 the price of cigarettes is roughly 130% higher in Norway than in Sweden. At a minimum the results presented in Table 9 suggest that the store level results are not driven by lower demand for these goods near the border.

In the context of the simple analytical model, these results show that $D_N > D_F$ for beer, which then establishes $CB > s_F - s_N$. The difference in store revenues from beer provides a lower bound on the size of the tax avoidance behavior. Thus, near the border 16% of the beer consumed is purchased abroad. Given the large difference in reported consumption, this estimate is probably extremely conservative. For the case of tobacco, we cannot reject the hypothesis that $D_N = D_F$, even if access to lower prices makes it likely that $D_N > D_F$ here as well. The more conservative hypothesis, i.e.

$D_N = D_F$, still suggests that roughly 40% of the tobacco consumed near the border is purchased to avoid taxation.

5. Scope of the Border Effect

In the preceding sections we have found evidence that supermarkets near the border report significantly lower sales of beer and tobacco than comparable stores far from the border. We have also found that households near the border report spending more on beer and no less on tobacco than similar households far from the border. Assuming that markets are in equilibrium it seems plausible that the “missing” sales of alcohol and tobacco in the near group are being purchased abroad.

As an additional means of ascertaining whether the border is indeed the cause of this discrepancy is to examine the continuous response of the border’s effect on revenues from alcohol and tobacco as we move further from it. As travel time and resulting travel cost increase, the returns to cross-border shopping decrease. A priori, if distance is the causal mechanism, one would expect cross-border shopping to decrease and sales to increase gradually with distance from the border. To investigate this possibility further, we estimate model of alcohol and tobacco revenue as a function of travel time to the border.

5.1 Method

To quantify the relationship between distance from the border and alcohol and tobacco sales we estimate a simple semi-parametric model of the form:

(4) $$Y = f\left(TT\right) + Z\beta + e,$$

where log expenditure on beer or tobacco at a given supermarket *Y* is a nonparametric function of travel time *TT*, a linear function of other covariates *Z* and a well behaved error term e. This approach allows the effect of travel time on expenditure to vary over the range of travel times observed in our sample. To model the nonparametric component, we use the penalized spline approach described by Ruppert et al. (2003). The technical details of this approach are outlined in Appendix A.

5.2 Data

Driving distances and travel times were calculated from a given stores' postal code to the closest town in Norway on the Swedish border[4]. As previously noted, the vast majority of border crossings occur at

[4] To compute these distances the website MSN Maps was used.

three points (Svinesund, Ørje and Magnor)[5] with Svinesund accounting for over half or all border crossings. The sample is slightly larger than in the previous section as we include supermarkets that fell in between our “near” and “far” regions. However as before, we omit Oslo from our analysis as it differs both with respect to demographic composition and with respect to rates of car ownership from the rest of Norway. Lower rates of car ownership increase the costs of travel to the border and presumably increase sales at stores in Oslo. In addition, we exclude stores in the northern area of the country. Finally, we use the same set of covariates as in the section 3 to control for supermarket characteristics. Again we use sales of goods less likely to be imported (bread, eggs, dairy products and spices) as controls. In addition, we include dummies to control for the effects of year, month and supermarket chain. Table 11 reports the means and standard deviations for the variables of interest.

Table 11: Summary Statistics: Scope of Border Effect

	N=3279	
Variable	**Mean**	**Std.Dev**
Log Expenditure Beer	10.56188	0.7159355
Log Travel Time	5.162119	0.8119703
Log Expenditure Tobacco	10.91791	0.6190003
Log Expenditure Bread	8.455918	1.870401
Log Expenditure Dairy	10.81102	0.6977486
Log Expenditure Eggs	8.611579	1.0191
Log Expenditure Spices	7.800847	1.05497
Log Travel Time	5.162119	0.8119703

Note that in several instances multiple supermarkets are located at the same distance to the border. This occurs when two supermarkets are in the same postal region. As a result, in our sample we observe 83 distinct distances to the border.

5.3 Results

Figures 2 and 3 summarize the main results of interest from (4). We plot the estimate of the effect of log travel time against the log of expenditure on beer and tobacco as well as a pointwise two standard deviation confidence interval. The results are fairly clear, log revenues from alcohol and tobacco, controlling for other factors, are an increasing function of travel time, but only up to a point.

[5] Teveldal is the most common crossing point in northern Norway but is excluded from our sample.

Figure 2. Scope of the Border Effect: Beer

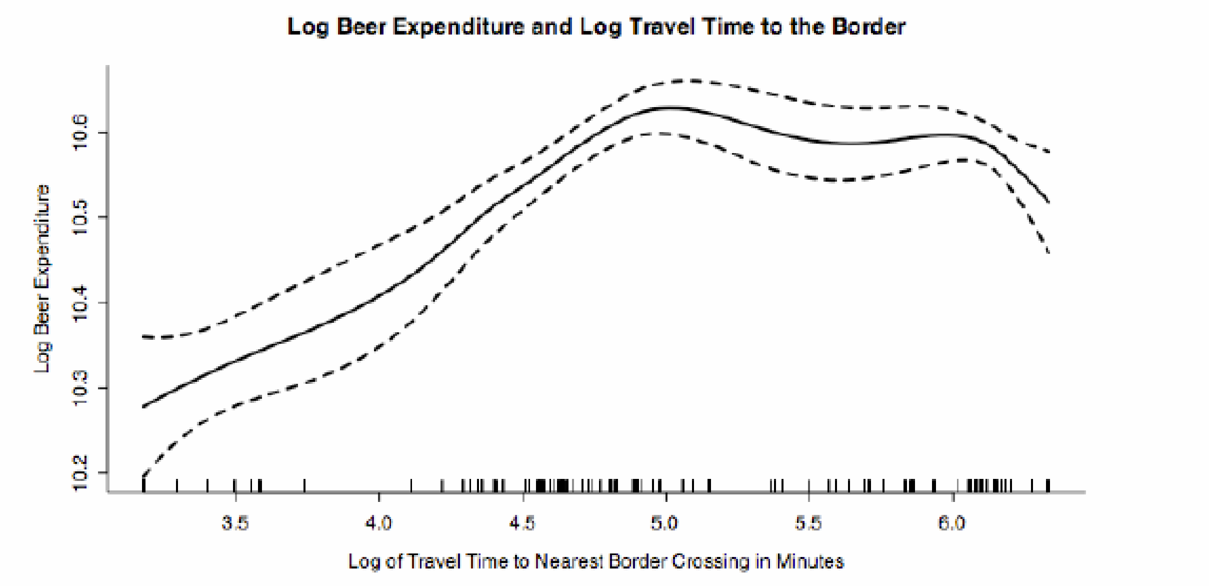
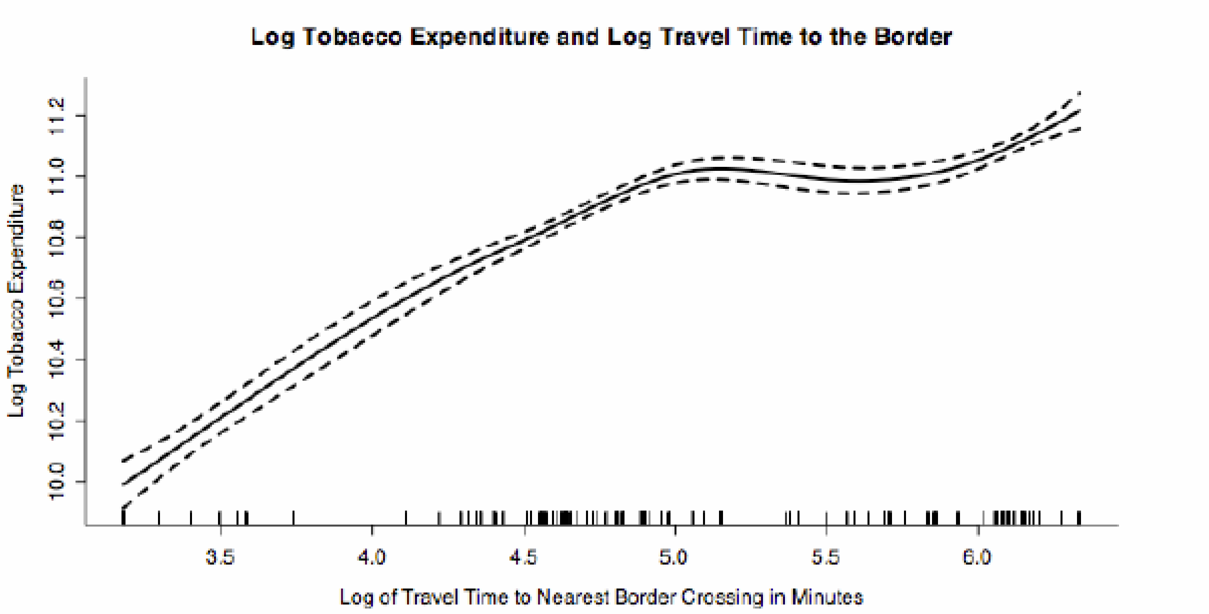


Figure 3. Scope of the Border Effect: Tobacco



The effect of travel time on the sales of beer and sales of tobacco is reasonably similar. For both goods, the effect of the border on store sales seems to dissipate at about 2 ½ hours of travel time.

6. Externalities & Cross-border shopping

We now examine several aspects of the costs associated with cross-border shopping. First, we consider recoverable tax revenues. Rather than computing the value of taxes evaded, we consider a policy relevant alternative, the tax revenue the Norwegian government could expect to generate as a result of increased border inspections and policing combined with the counterfactual that no imports were allowed. We then examine two health externalities associated with the consumption of beer and tobacco: lung cancer and drunk driving. For these behaviors, we compare incidence rates near and far from the border. While a host of confounding factors precludes a definitive link between these externalities and cross-border trade, our findings are consistent with existence of such a link and previous findings.

6.1 Recoverable Tax Revenue

We now turn to a simple back of the envelope computation to quantify recoverable tax revenues. Again, this is an underestimate of taxes currently not being paid, but rather represents the most the Norwegian government could hope to recover through, for example, increased border enforcement activity combined with no import allowance.

We can estimate foregone sales of beer and tobacco by multiplying the number of stores in the region near the border times the lower sales per store times 52 weeks per year. The proportion of the value of sales that are made up of taxes will be our best guess as to the value of foregone revenues. Our sample of supermarkets was constructed to be representative of Norway as a whole. To compute the number of supermarkets in our region, we assume that the proportion of stores in the sample in the near region is the same as the proportion of stores in the population. If 10.8% (31/287) of supermarkets in our sample are located in the near group, then 332 (0.108*3078[6]) supermarkets in the population are located in this region.

We use the estimated average treatment effect on the treated as our measure of foregone revenue per store. The results are shown in Table 12.

[6] Source: Statistics Norway, Internal Communication.

Table 12. Foregone Tax Revenues per year, relative to a closed border

	Number of Stores	Taxes as a share of price*	Estimated forgone sales per store	Weeks	Foregone Tax Revenues per Year
Beer	332.47	0.40	-9078.57	52.00	-62,781,139.51
Tobacco	332.47	0.59	-34180.95	52.00	-348,648,576.52

* Source: NOU (2003)

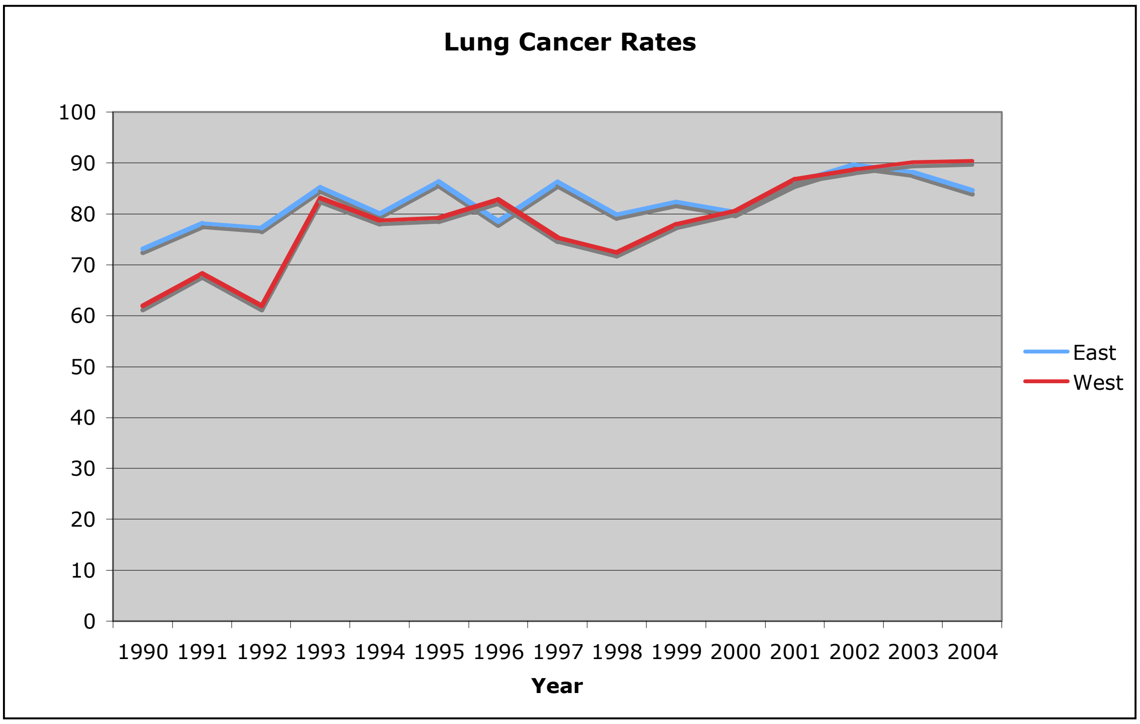
These numbers should be regarded as a cautious lower bound estimates. They assume that households near the border will consume comparable quantities of beer and tobacco when faced with the higher domestic prices. As guide to interpret these numbers, the foregone tax revenue from beer is approximately 1% of total alcohol taxes, including those from wine and spirits, and the foregone tax revenue from tobacco is approximately 6% of total tobacco revenues. Bear in mind that these are forgone revenues only in the "near" region, which accounts for a small share, approximately 18%, of the Norwegian population.

6.2 Externalities: Tobacco

Simply computing recoverable revenue ignores the fact that the official motivation for these unusually high taxes, at least by international standards, is to reduce the externalities associated with tobacco and alcohol taxation. A more complete assessment of the economic costs associated with tax avoiding cross-border shopping would address these issues. While a full costing is beyond the scope of the current paper, we provide a cursory look at lung cancer, one of the most common risks associated with tobacco consumption in our near and our far regions below.

Figure 4 reports lung cancer rates per 100,000 person in the three easternmost counties (consisting of the counties Østfold, Akershus, Hedmark) and the three westernmost counties (" consisting of the counties Rogaland, Hordaland, Sogn og Fjordane).

Figure 4. Lung Cancer Incidence per 100,000 persons



The available data makes it impossible to conclude that cross-border shopping is causally linked to lung cancer rates. However the evidence is suggestive. We see that for most years for which data is available (10 out of 14 years) regions near the border ("East) have higher incidence of lung cancer than regions far from the border ("West). Consumption is reported higher near the border but sales at stores near the border are lower than sales far from the border but expenditure is not significantly lower. The source of the discrepancy between consumption and sales is likely tobacco purchased in Sweden where prices are lower. Tougher enforcement combined with no import allowances would raise the price of tobacco faced by inhabitants of the near region. Whether this would lead to lower smoking rates and/or incidence of lung cancer is an open question. There is a large literature in public health (for example Hu et al. (1995)) and health economics (for an overview see Chaloupka and Warner (2000)) that links increases in prices to decreases in consumption. However recent work by Adda and Cornaglia (2006), suggests that smokers respond to increases in prices by smoking more intensively. This link is certainly worthy of further study.

6.3 Externalities: Alcohol

We now turn our attention to an activity that can be the result of excess alcohol consumption: Drunk Driving. We focus on drunk driving because it is socially undesirable behavior that is a direct result of alcohol consumption. Again some care should be taken in interpreting this figure; while alcohol consumption is a necessary condition for driving drunk it is not a sufficient one. A host of other environmental factors will also contribute to the level of drunk driving arrests in a region.

Figure 5 summarizes the drunk driving rates per 10,000 persons for the 3 easternmost counties (Østfold, Akershus, Hedmark) in our group and the 3 westernmost counties (Rogaland, Hordaland, Sogn og Fjordane) over the period 1986-2004. Again, note that these counties do not coincide exactly with the “near” and “far” regions previously described, but are broadly consistent with them. Unfortunately data is not available at a sufficiently disaggregated level to exactly match regions.

Figure 5. Drunken Driving Arrests per 10,000 persons

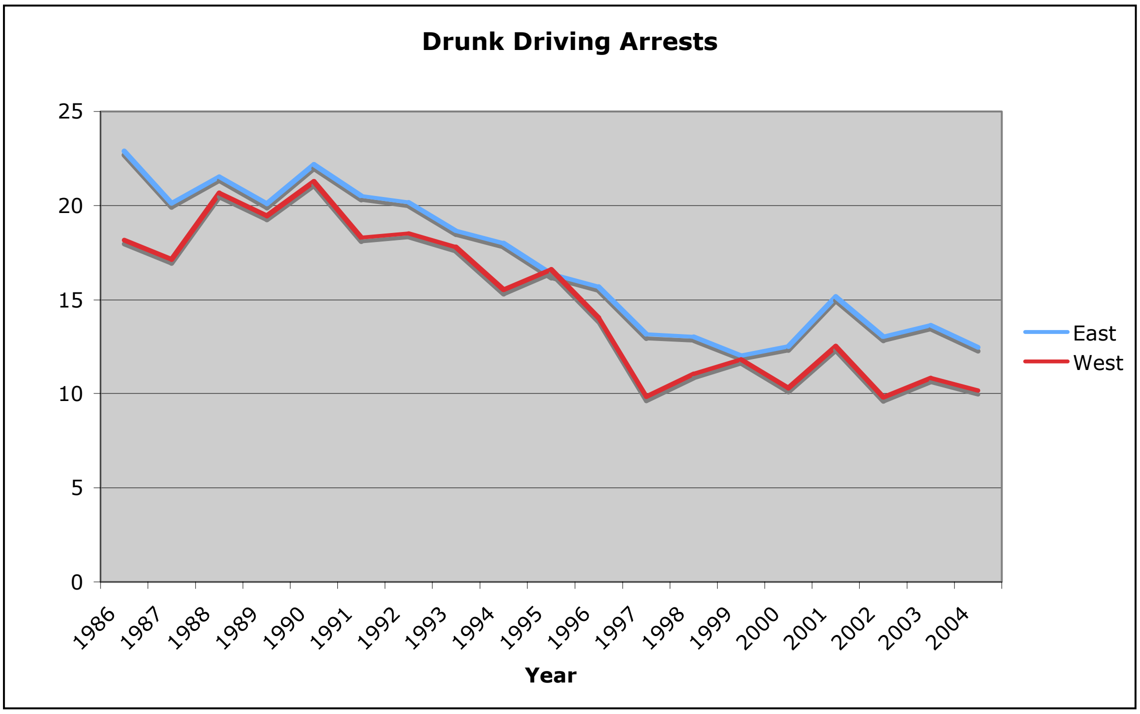


Figure 5 shows that drunk driving arrests are consistently higher in the easternmost counties than in the western most counties. The difference is statistically significantly larger in the easternmost counties at the 5% level. As was the case with tobacco, the evidence is consistent with a link between cross-border shopping activity (e.g. households near the border face a lower price for alcohol than households far from the border) and increased levels of driving under the influence of alcohol. Again, this does not constitute definitive proof of a link between cross border purchases of alcohol and drunk driving. However, our results are broadly consistent with a small body of empirical evidence which links higher levels alcohol taxation and higher prices to lower highway crash deaths in the United States (notably Phelps (1988) and Rhum (1996)). Again, direct research into this link is warranted.

7. Discussion and Conclusions

We have found that stores near the border report lower revenues on sales of goods that are highly taxed. In addition, we have found that consumers near the border report no lower expenditure on these goods for tobacco and significantly higher quantities and expenditure for beer. Finally we have seen that revenues from highly taxed goods increase as distance from the border increases, reaching zero after about 2 ½ hours travel time. Taken together these results suggest a pattern of tax avoidance behavior through cross-border shopping on the part of an important number of Norwegian households resulting in significant loss of revenue on the part of the Norwegian government and possible increased health risk due to higher consumption of beer and tobacco products. Finally, we find cautious evidence that household near the border exhibit higher levels of the kinds of externalities these taxes were designed to prevent.

Generalizing beyond our case study, our results suggest that the geography of a jurisdiction (state, country, region) will influence the effectiveness of consumption, or sin taxes. Within a given jurisdiction, uniform consumption taxes may create reasonably large regional differences. Specifically, we find that far from the border, households will pay more tax on a per unit basis than households near the border. This creates the scope for international agreements, such as a minimum tax on alcohol and tobacco, to mitigate this problem.

Taxation has become a key tool in alcohol and tobacco control policies. Thus, if the goal of policymakers is to tax negative externalities associated with the consumption of alcohol and tobacco, the results suggest that the high taxes will be a far less effective policy instrument near a border with a jurisdiction with much lower tax rates. Future work aims to test the link between proximity to the border, consumption and indicators of health.

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Appendix A

There are a number of ways to estimate semiparametric models as described by (1). We employ a parsimonious approach known as penalized regression splines (p-splines) that is relatively common in the statistical literature, but is somewhat less well known in econometrics. In its present form, this approach was first proposed by Eilers and Marx (1996) and Ruppert and Carroll (1997)[7]. In the interests of exposition, I describe a simplified version of (2) with only single variable being modeled semiparametrically. The extension to two semiparametric variables is straightforward.

The smooth functions $f(\cdot)$ or $g(\cdot)$ can be written using a cubic radial basis spline. The cubic degree radial basis spline model (sometimes called a thin plate spline) for the logarithm of travel time, from store *i* can be written

(5) $$f(\ln X_i) = \gamma_0 + \gamma_1 \ln X_i + \sum_{k=1}^{K} \mu_k \left|\ln X_i - \kappa_k\right|_+^3 ,$$

where, $\kappa_1 < \kappa_2 < \ldots < \kappa_K$, denote the knot points and the functions $\left|\ln X_i - \kappa_k\right|_+^3$ are the cube of the absolute value of the difference between a value of the log of travel time and a given knot point. Following the recommendation of Ruppert et al. (2003) the number of knots is chosen according to $K = \min\left(0.25\times \text{ number of unique } X_i, 35\right)$ and are evenly spaced over the range of $\ln X$.

Recasting the estimation problem in matrix form, write the vector of unit values $\mathbf{v} = \left[V_1 \ldots V_N\right]^{\mathrm{T}}$, define the design matrices

(6) $$\begin{aligned} \mathbf{X} &= \left[1, \ln X\right]_{1\le i\le N} \\ \mathbf{Z} &= \left[\left|\ln X_i - \kappa_1\right|^3, \ldots, \left|\ln X_i - \kappa_K\right|^3\right]_{1\le i\le N} , \end{aligned}$$

coefficient vectors $\mathbf{g} = [\gamma_0, \ldots, \gamma_p]^{\mathrm{T}}$, $\mathbf{m} = [\mu_1, \ldots, \mu_K]^{\mathrm{T}}$ and error term $\mathbf{e} = \left[\varepsilon_1 \ldots \varepsilon_N\right]^{\mathrm{T}}$. The estimation problem can be concisely written as

(7) $$\mathbf{v} = \mathbf{Xg} + \mathbf{Zm} + \mathbf{e} .$$

Note that if one wanted, equation (7) can be fit using ordinary least squares. However, this can result in overfitting the component being modeled nonparametrically. In order to avoid this, the influence of

[7] For a textbook length treatment of this approach see Ruppert et al. (2003).

the extended basis function $\mathbf{Z}$ needs to be constrained in some way. Following Ruppert et al. (2003), based on earlier work by Robinson (1991) and Brumback et al. (1999), this is accomplished by writing $\mu_k \sim N\left(0, \sigma_\mu^2\right)\ \forall k$. In other words, by modeling the parameters on the extended basis function as random with mean zero and finite variance. The result is a fit where the degree of smoothness is a function of σ_μ^2. Note that ordinary least squares is the special case where the variance term, σ_μ^2, is infinite.

More formally, given (7) assuming

(8) $$\mathrm{E}\begin{pmatrix} \mathbf{m} \\ \mathbf{e} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix},$$

and

(9) $$\mathrm{Cov}\begin{pmatrix} \mathbf{m} \\ \mathbf{e} \end{pmatrix} = \begin{pmatrix} \sigma_\mu^2 \mathbf{I} & 0 \\ 0 & \sigma_\varepsilon^2 \mathbf{I} \end{pmatrix},$$

the log likelihood function can be written

(10) $$\ell(\mathbf{g}, \boldsymbol{\Omega}) = -\frac{1}{2}\Big(n \log(2\pi) + \log\left|\boldsymbol{\Omega}\right| + (\mathbf{v} - \mathbf{Xg})^{\mathrm{T}}\, \boldsymbol{\Omega}^{-1} (\mathbf{v} - \mathbf{Xg})\Big),$$

where $\boldsymbol{\Omega} = \mathrm{Cov}(\mathbf{v}) = \sigma_\mu^2 \mathbf{Z}\mathbf{Z}^{\mathrm{T}} + \sigma_\varepsilon^2 \mathbf{I}$.

Incorporating additional parametric covariates is simply a matter of appending additional columns to the $\mathbf{X}$ matrix and adding the corresponding parameters to the vector **g**. E.g. $\tilde{\mathbf{X}} = [\mathbf{X} \,|\, \mathbf{S}]$ and $\tilde{\mathbf{g}} = [\mathbf{g} \,|\, \theta_1 \ldots \theta_J]$, where **S** is a matrix of control variables index by parameters θ_j.