Demand and Distance: Evidence on Cross-Border Shopping[♣]

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Abstract

An important issue for commodity taxation is the extent to which changes in foreign taxes affect the extent of cross-border shopping and thereby, domestic tax revenue. We use data from Swedish municipalities to estimate how responsive alcohol sales are to foreign prices, and relate the sensitivity to the distance of the location to the border. Typical results suggest that the elasticity with respect to the foreign price is around 0.3 in the border region; moving 150 (400) kilometers inland reduces the cross-price elasticity to 0.2 (0.1). Our estimates suggest that a recent Danish cut in the spirits tax reduced Swedish tax revenues from spirits sales by more than two percent, and that an attempt by Sweden to cut taxes in response would reduce tax revenues further.

Keywords: Law of one price, tax competition, tax harmonization, cross-border shopping, European integration.

JEL Codes: F15, H20, H77, R12

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1. Introduction

That prices of many goods differ considerably across countries is well documented.[1] What we know much less about, however, is to what extent consumers actually take advantage of these price differentials and engage in cross-border arbitrage. To provide evidence on this, we examine the responsiveness of alcohol sales in Swedish communities to foreign prices, and relate the price sensitivity to the distance of a location to the border.

With the deeper integration of the European Union (EU) and its expansion, the effects of cross-border trade have become an important policy issue, since the price differences are, in many cases, due to taxes set by individual member states. The resulting price differentials may be so great that consumers in high-tax countries make their purchases elsewhere, with important consequences for tax revenues. In fact, it is sometimes argued that countries "compete" by lowering taxes to attract foreign demand, leading to an equilibrium with taxes at a lower level than if countries had been able to coordinate; see, for instance, Kanbur and Keen (1993).[2] These issues figure prominently in the ongoing debate on tax harmonization within the EU and can be illustrated with the following quote from a press release regarding taxes on alcohol.[3]

> "The Commission concludes that more convergence of the rates of excise duty [on alcohol] in the different Member States is needed so as to reduce distortions of competition and fraud. However, given the widely differing views in the Member States about the appropriate levels of the minimum rates, and given that any change would require

[1] See, for instance, Engel and Rogers (1996), Goldberg and Knetter (1997), Haskel and Wolf (2001), Anderson and Van Wincoop (2004) and Goldberg and Verboven (2005).

[2] Theoretical work using a game theoretic framework was pioneered by Mintz and Tulkens (1986). Kanbur and Keen (1993) examine a tax setting game between two governments. In their model, consumers incur a transport cost to shop in the other country such that the closer to the border they live, the less costly it is to go shopping abroad. In their analysis, a less densely populated country will set the lower tax rate since it has relatively less to lose from reducing taxes. Wang (1999) shows that this result from Kanbur and Keen is further strengthened if the large country decides on its tax first. Nielsen (2001) lets countries differ in size rather than in population density, and similarly finds that the smaller country sets the lower tax rate; see Keen (2002) for a survey.

[3] Some recent cuts in alcohol taxation by Denmark and Finland were prompted by concerns about cross-border shopping from Germany and Estonia, respectively. This, in turn, caused Sweden to consider the effects of reducing its taxes to limit the price differential to neighboring Denmark and Finland (SOU, 2004). In October 2004, Britain was sued by the European Commission on claims that it tried to prevent high volume cross-border shoppers of alcohol in a way that is inconsistent with the common market.

> unanimous agreement, the Commission is not making a proposal at this time. Instead the Commission wishes to launch a broad debate in the Council, the European Parliament,…" (Press release May 26, 2004).

A key problem in this debate is that little is known about the magnitude of cross-border shopping, see Keen (2002) for a discussion. Interview studies indicate that the effects might be substantial. Frequently cited work by Fitzgerald (1992), for instance, reports that in 1986, about 25 percent of the spirits consumed in the Republic of Ireland were bought in Northern Ireland. Campbell and Lapham (2004) examine links between the number of firms along the Canada-US border and the real exchange rate. They find that when prices in the US fall relative to prices in Canada (a real exchange rate depreciation), there is a significant increase in the number of sellers and/or in the average employment on the US side of the border for the four sectors they study (food stores, gasoline service stations, drinking and eating places). Their findings are thus consistent with substantial changes in demand as a result of relative price changes and therefore, with substantial cross-border flows. However, based on an interview study by Ford (1992), they argue that for the industries in question, the effects of cross-border shopping are confined to border counties. Goldberg and Verboven (2005) report that, despite persistent price differences, cross-border shopping of automobiles in Europe is limited. There also exist some papers examining spillover effects of different sales taxes across US states (see e.g. Fox, 1986, and Walsh and Jones, 1988).[4] This literature suggests that low prices across the border are important for sales in the border counties, but it is an open question whether this also has an effect on the interior.

An unusually ambitious interview study by the Centre for Social Research on Alcohol and Drugs provides an indication of the extent of cross-border shopping of alcohol. Since 2001, about 18000 randomly selected Swedes per year have been asked about their consumption of alcohol, and also about the sources. Figure 1, based on data in Table 6.1 in SORAD (2004), shows the consumption in 2003 from the three main sources of alcohol consumption (the Swedish government retail monopoly,

[4] A related literature examines the revenue impact at the state level of taxes in neighboring states. This literature shows that cross-border shopping acts as a constraint on the possibilities of raising the state revenue by sales taxes, gasoline taxes or state lotteries. See Garrett and Marsh (2002) for references. Similarly, Beard et al (1997) try to infer the amount of cross-border shopping from state-level data on alcohol sales. Another somewhat related paper is Goolsbee (2000), which documents more Internet sales in locations with high sales taxes.

legally imported, illegally imported), measured in liters of pure alcohol. The data is disaggregated by seven regions. As discussed below, the gateway to lower alcohol prices is in Sweden's south western corner and we measure each region's average distance to Malmö. Bearing in mind the problem with measurement errors[5] with this type of survey data, the general emerging picture is that the fraction of imported alcohol is negatively related to the distance to the border. This aggregate data suggests that the prevalence of cross-border shopping is related to the distance to the border and that it is roughly replacing domestic sales. However, even with this type of data, a more quantitative analysis is needed to disentangle the relationship between demand at the local level, domestic and foreign prices, and distance to the border.

[FIGURE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

In this paper, we use data from the Swedish government retail monopoly to estimate how the sensitivity of sales to foreign prices depends on the distance to the border. A number of features make this an unusually clean case. First, we have monthly data on sales of spirits, wine, and beer over a ten-year period for each store that sells alcohol in Sweden. Second, prices are the same across the country. This implies that prices in border areas are not endogenously lower, which in other cases could blur the picture. At the same time, relative prices between countries have varied considerably, both due to major tax changes and volatile exchange rates. Third, as seen in Figure 2, geography suggests that the distance to the relevant Danish border is easily measured. The shape of the country (it is a drive of about 2000 kilometers or 24 straight hours from north to south) also gives us substantial variation to exploit.

Our findings suggest that the distance to the border plays an important role for the extent of cross-border arbitrage. Using our estimates from spirits, the demand elasticity with respect to foreign price is about 0.35 in a border region, while if moving 200 kilometers inland, this elasticity is reduced to 0.16; at 400 kilometers, the elasticity is 0.06. We use the estimated demand functions to evaluate the

[5] The telephone interviews underestimate true consumption, primarily due to people's systematic underreporting of their own consumption (see www.sorad.su.se/alkrapp.pdf). SORAD has attempted to correct for this in the numbers we use for Figure 1.

consequences of a Danish tax cut on Swedish tax revenues, and also consider the effects of a matching tax cut by Sweden.

2. Data

The government-owned retail monopoly (Systembolaget) made available monthly volume data on sales of spirits, wine, and beer at all its approximately 400 outlets for the period January 1995 – July 2004.[6] We aggregate the data to the municipality level (in 2004, 286 municipalities out of 288 had at least one outlet). Importantly, variation across municipalities in per capita volume is not driven by differences in prices or selection across outlets, since Systembolaget maintains the same prices and assortment in all stores. Descriptive statistics of raw data and variables used in regressions are found in Table 1 and the Appendix, respectively.

[TABLE 1 ABOUT HERE]

To measure the development of domestic and foreign price levels, we use price indices from Eurostat for the different product categories. Foreign price indices are converted into Swedish kronor by the corresponding monthly average exchange rate and all prices are deflated by the Swedish Consumer Price Index. These price indices do not inform us about any differences in the level of prices between countries. However, Horverak and Österberg (2002) give us a snapshot, as of June 1999, of the prices of identical baskets in Denmark and Sweden. At that time, the basket with beer was 27 percent cheaper and the spirits basket was 10 percent cheaper in Denmark; the basket with wine was 1.5 percent more expensive. For ease of comparison, Figures 3a-3c illustrate how the price of the basket in Sweden and Denmark would have developed over our sample period given the Eurostat price index, where we have normalized indices to match the absolute price differences reported by Horverak and Österberg (2002). While the compositions of these baskets certainly differ from those

[6] In addition, in many remote locations without an outlet, it is possible to order from Systembolaget's entire range through a local agent (often a country store) at no extra cost for delivery from the nearest outlet the following day. For further information about Systembolaget, see http://www.systembolaget.se/Applikationer/Knappar/InEnglish/. Beer low alcohol content (less than 3.5 percent alcohol by volume) is available in grocery stores and supermarkets.

that form the basis of the price indices, this nevertheless suggests that spirits and beer are cheaper in Denmark over essentially the whole time period, and wines are at least as expensive as in Sweden. From the figures, it is evident that the Danish price indices (when expressed in Swedish kronor) display greater volatility, something that is partly due to the floating exchange rate between Swedish kronor and Danish kronor. The most striking price change is due to a cut in the Danish spirits tax in October 2003; in the next section, the regional responses to this are examined in some detail.

[FIGURES 3a-3c ABOUT HERE]

Another way of comparing price levels comes from the Purchasing Power Parity indices of alcoholic beverages that Eurostat calculate on a yearly basis (series A010201). For each year, the average price for the EU-15 is 100. The average of this index over 1995-2003 was 235 for Norway, 188 for Finland, 162 for Sweden, 129 for Denmark and 83 for Germany. Thus, on average, the basket was some 25 percent more expensive in Sweden than in Denmark, and almost twice as expensive as in Germany. The levels obviously differ over the years, but the ranking is consistent. Since prices in neighboring Finland and especially Norway tend to be higher, some people from these countries cross the Swedish border to make their purchases. (The municipalities with the highest sales per capita spirits volumes are almost exclusively municipalities bordering Norway.)

The main gateway to lower alcohol prices is in Sweden's south-west corner (see Figure 2). There are quick ferries from Helsingborg to Denmark, and in 2000, a toll bridge was opened linking Malmö to Copenhagen, Denmark (before this, there were quick ferries linking the two cities). To Germany, there are a number of ferry lines from Trelleborg.[7] Our measure of distance to the border is in kilometers by car (by the fastest route) to Malmö; Malmö, Helsingborg, and Trelleborg are very closely situated and the correlation between distance measures to these locations is very close

[7] For the different alternatives, the distance in hours (one way) and prices per car with same day return in 2004 were in Swedish kronor (kr) (9kr~1Euro): Malmö-Denmark (bridge) 15minutes, 500kr; Helsingborg-Denmark 20min, 580kr; Trelleborg-Germany 4hours, 650kr. There are also infrequent ferries to Denmark further north: Varberg-Denmark 4 hours, 1195kr and Göteborg-Denmark 3 hours, 745kr. When Poland and the Baltic States joined the European Union in May 1 2004, additional low price locations became accessible. However, Poland is 8 hours from Ystad (south of Malmö) and Estonia is 15 hours from Stockholm and we have not tried to measure the impact of these improved opportunities to buy cheap alcohol.

to one. (Using the travel time to Malmö as a distance measure gives qualitatively the same results as those reported below.) To examine the effects of a large tax cut in Finland, we also measure the distance by car from municipalities in the northern part of the country to the nearest Finnish border crossing.

There are restrictions on how much alcohol that can be brought into the country. After July 2000, there has been a gradual ease of the quotas[8] and one might conjecture that this has added to the price sensitivity with respect to foreign prices. There is insufficient time variation in the data to provide a definite test of this. However, there are reasons to believe that the increased allowances had a less pronounced effect than suggested by the numbers. When Sweden joined the European Union in January 1995 (the first month of our data), the possibility for the Swedish Customs of checking individual travelers was severely curtailed.[9] Our reading of the available evidence is that, in practice, the change of the quotas at the end of our sample period had a relatively minor effect on individual travelers' decisions to purchase abroad.[10]

In estimating the demand functions, we control for some factors other than prices that may drive regional- and time variation in sales. Income differences are measured with the average municipal income for the population (+16 years). The density of stores varies across municipalities and our measure is the number of stores per capita. Two other factors that vary over time (but not across regions) are the number of public holidays and the number of Fridays (until 2003, outlets were closed on Saturdays and Sundays). In the regressions, all municipalities bordering Norway (21) or Finland (4) are excluded, as sales are here influenced by cross-border shoppers from the two neighboring countries.

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[8] The quota in Jan.1995 was 1l. spirits, 15l. beer, and 5l. wine and it was effective until July 2000, when the allowance for beer and wine was increased to 24l. and 20l., respectively. Further adjustments came in Jan.2001 (b:32; w:26), Jan.2002 (s:2), Jan. 2003 (s:5; b:64; w:52), and Jan.2004 (s:10; b:110; w:90).

[9] From this point, the Swedish Customs had to have well-founded suspicions to perform a search of an individual traveler (i.e. random checks were no longer permitted). In effect, this meant that its resources were redirected from checks of individuals toward targeting organized smuggling. A manifestation of this is that in 1994, the year before entry into the EU, 7 261 seizures with an average of 24.5 liters of spirits were made. In 1996, when the quota for spirits was still 1 liter, the number was down to 3 887, but the average volume had increased to 123.5 liters (data from Swedish Customs).

[10] For instance, SORAD (2004) estimates, based on surveys, that the volumes (in liters of pure alcohol) of cross-border shopping terms were .8 liters per person in 1995, 1.1 in 1996, 1.6 in 1998 and 2000, 1.8 in 2001, 1.9 in 2002 and 2.3 in 2003. Thus, most of the increase occurred during 1995-2000 when there was no change in the quotas (the large increase in 2003 is likely to be explained by the tax cut for Danish spirits).

3. Demand and distance – a first look at the data

Before turning to a direct estimation of demand functions, it is useful to take a preliminary look at the raw data to establish that distance to the border is really of importance for price sensitivity.

As a first piece of evidence to support this, we examine the raw correlations between growth in per capita volumes and growth in the Danish price, stratifying the sample according to distance to the border. As evidenced in Table 2, where the municipalities are split into three categories, the highest correlations are, as expected, for those closest to the border. Correlations tend to be lower further away from the border, but only for spirits are the correlations significant more than 250 kilometers inland.

[TABLE 2 ABOUT HERE]

Another indication of a relation between the response to foreign price changes and distance to the border is the sales development around the two large changes in the foreign prices of spirits we have in the sample. In October 2003, Denmark reduced the taxes on spirits (resulting in 27 percent lower prices), and in March 2004, Finland cut its spirits tax (32 percent lower prices). If the distance to the border plays a role for price sensitivity, then we expect sales to be visibly more affected close to the border around these events. Indeed, this pattern is clearly discernible in Figure 4a, which shows the percentage change in monthly volume between October 2002 and October 2003 for Swedish municipalities, related to the distance to the Danish border. Volumes decreased substantially in the municipalities near the border and as one moves further away, the effect tapers off. This suggests that some consumers with easy access switched from buying in Sweden to making their purchases abroad.

A similar picture emerges in Figure 4b for the generally sparsely populated northernmost 34 municipalities which are closest to Finland, with dramatic declines by 35-70 percent in the municipalities on or near the border. The pattern is not due to some unobservable factor (e.g. local festivals, weather) correlated with the distance to the Finnish border – no relation is found for wine for the same period in Figure 4c. A fall of this magnitude in spirits sales may be less surprising when considering the

price difference and the ease of purchasing abroad. For example, the effect of the tax cut was to reduce the price of a liter of Absolut Vodka in Finland from the equivalent of 329 kronor (36 Euro) to 219 kronor, as compared to the Swedish price of 310 kronor. Moreover, there are no direct costs of crossing the Finnish border and, for instance, it is only a ten-minute drive from the single Systembolaget store in the border municipality of Haparanda to the Finnish counterpart in Tornio.

Finally, if quotas were binding and important, we would expect to see that the gradual lifting of these at the end of our sample period had a different effect on local demand, depending on the distance to the border. Any such pattern is most likely to be visible around January 2003, with great increases in allowances. No pattern stands out though, as exemplified by Figure 4d, which shows the growth in spirits volumes around the increased allowance from 2 to 5 liters. This is consistent with the claim made above that the quotas had little bite for Swedish alcohol sales after the country's EU entry.

[FIGURE 4 ABOUT HERE]

4. Econometric analysis

4.1 Econometric model

That distance to the border strongly influenced the development of a region's alcohol sales was shown above. In this section, we estimate how sensitive regional sales are to the price across the border, P^F, and the domestic price, P^D.[11]

The starting point is that the demand per capita for alcohol of type j={spirits,wine,beer} in region i at time t is assumed to be given by

$$\ln[q_{j,i,t}] = b_{j,0} + b_{j,1}\ln[P^D_{j,t}] + g(\boldsymbol{d}_j, D_i)\ln[P^F_{j,t}] + \boldsymbol{\beta X}_{\boldsymbol{j,i,t}} + u_{j,i} + e_{j,i,t} \qquad (1),$$

where D_i is distance to the border, $\boldsymbol{X_{j,i,t}}$ is a vector of control variables, $u_{j,i}$ is unobserved heterogeneity, and $e_{j,i,t}$ is a standard error term. The specification is

[11] Demand can, in principle, be modeled as dependent on prices in several neighboring countries. In our application, however, the fact the e.g. Danish and German prices are highly correlated, together with the distance measure being identical, give rise to a severe multicollinearity problem that we are not able to address with the relatively short time dimension in the data.

parsimonious but easily interpreted. The elasticity with respect to the domestic price is $b_{j,1}$, and the elasticity with respect to the foreign price is $g(\boldsymbol{d}_j, D_i)$ and thus, depends on the distance to the border.[12] We specify, analogously to a parametric version of the model of Pinkse et al (2002), the function $g(.,.)$ as a flexible third-order polynomial

$$g(\boldsymbol{d}_j, D_i) = d_{j,0} + d_{j,1} \times D_i + d_{j,2} \times D_i^2 + d_{j,3} \times D_i^3 .$$

The prior is that the influence of the foreign price is decreasing in the distance to the border, such that $g'(\boldsymbol{d}_j, D_i)<0$ and $g''(\boldsymbol{d}_j, D_i)>0$; at the border, the elasticity is $d_{j,0}$.

Regions differ in alcohol consumption levels, due e.g. demographics. Moreover, Figures 3a-3c reveal strong seasonality in the aggregate data (high volumes in the summer and December) but there may also be regional differences in the seasonal purchasing patterns. The first type of heterogeneity is captured by $u_{j,i}$ in (1), while the second could be captured in $\boldsymbol{X}_{j,i,t}$ by region-specific dummy variables for each calendar month.[13] We use 12-month differences, Δ_{12}, to take out these region-specific effects and estimate

$$\begin{aligned}\Delta_{12} \ln[q_{j,i,t}] = {} & b_{j,0}\Delta_{12} \ln[P_{j,t}^D] + (d_{j,0} + d_{j,1}D_i + d_{j,2}D_i^2 + d_{j,3}D_i^3)\Delta_{12} \ln[P_{j,t}^F] + \\ & \boldsymbol{\beta}\Delta_{12}\boldsymbol{X}_{j,i,t} + \varepsilon_{j,i,t}\end{aligned} \quad (2)$$

The variables included in $\boldsymbol{X}_{j,i,t}$ are a time trend, the log of average per capita income, the log of the number of stores per capita, the log of the number of Fridays in the month (four or five), and the number of public holidays in the month (zero to three). The two latter variables in $\boldsymbol{X}_{j,i,t}$ are intended to capture that traditionally most of the sales take place on Fridays (until 2003, outlets were closed on Saturdays and Sundays) and that sales are affected by in which calendar month some of the public holidays fall.

[12] It is plausible that elasticity with respect to domestic price is also dependent on distance to the border. In particular, consumers close to the border may be more price sensitive than those further inland. However, the limited time variation in the domestic price makes it infeasible to estimate this effect.

[13] A specification with only monthly dummy variables, where the absolute effect of a given calendar month is the same for all municipalities, is inappropriate, given the fact that municipalities clearly differ in consumption levels.

We estimate (2) as a system of seemingly unrelated equations (SUR) to account for the fact that error terms may be correlated across equations, but treating $\Delta_{12}\ln[P^D_{j,t}]$ and $\Delta_{12}\ln[P^F_{j,t}]$ as uncorrelated with the error terms. The institutional fact that prices do not vary across Swedish locations (i.e. do not vary with local demand conditions) and that changing taxes is a very drawn out process, are two reasons why endogeneity of $\Delta_{12}\ln[P^D_{j,t}]$ is not an issue here.[14] The reason for assuming that $\Delta_{12}\ln[P^F_{j,t}]$ is predetermined is that the national Danish price indices are unlikely to be influenced by local Swedish demand shocks.[15] Much of the variation in $\Delta_{12}\ln[P^F_{j,t}]$ is also due to exchange rate movements, something that further reduces endogeneity bias concerns.

4.2. Econometric results

The results for spirits, beer, and wine volumes are shown in Table 3. Overall, coefficients are significant with the expected signs and are plausible in magnitude.

For municipal-specific control variables, increases in average per capita income and store density have a positive impact on volumes for all types of alcohol. The implied income elasticity ranges from 0.6 (wine) to 1.4 (spirits).[16] Likewise, for the monthly control variables, months with more Fridays and public holidays tend to generate higher volumes.

[14] For instance, a government commission was initiated in January 2004 in response to concerns about cross-border arbitrage following the Danish tax cut in October 2003. When the findings of this commission were presented in March 2005, they recommended a cut in Swedish spirits taxes. As of March 2006, the minority government has not found any support for a tax cut in parliament. To exemplify the limited scope of changes in demand to have a rapid feedback into prices, note that for a medium priced bottle of spirits, taxes account for about 80 percent of the price and there have been no changes in the spirits tax during the period of study. In addition, Systembolaget uses fixed markup rules that are changed infrequently (they were changed in May 2004 and the last time before that was in January 2000). Systembolaget applies a fixed percentage markup to all products (currently 23 percent) in addition to a low fixed markup per container (currently 2.7 kronor per bottle of spirits, or around .25 euro).

[15] Given the population in Denmark (5.4m), it is unlikely that national prices are influenced by demand from Swedish cross-border shoppers. The fact that P^F is a national average does not in itself rule out the possibility that prices just across the border are influenced by local Swedish demand shocks. However, since Copenhagen with a population of 1.7 million is the border town, this suggests that changes in its prices are driven by changes in Danish rather than Swedish conditions. As a robustness check, we have instrumented the foreign prices with the Danish consumer price index (excluding alcohol) and the results from 3SLS (available upon request) are very similar to those from SUR.

[16] Our estimates point at income elasticities in Sweden being at the high end relative to other countries – typically, they are found to be below unity (see, for instance, Baltagi and Griffin, 1995, for one example).

Price elasticities with respect to domestic price are highest for spirits, close to unity for beer, but only 0.25 for wine. While these numbers are in line with previous estimates[17], it must be recognized that the variation in domestic prices is limited (see Appendix Table). Furthermore, as noted before, the elasticities should be interpreted as averages across the country and they might well be higher near the border where there is a close substitute – purchasing alcohol abroad.

For the question of primary interest here, the Danish price indices display more variation. At the border, the elasticity with respect to the Danish price ranges between 0.17 for wine to 0.47 for beer. To show how the elasticity varies with the distance to the border, Figures 5a-5c illustrate the effect of a hypothetical 10 percent reduction in the price of Danish spirits, wine and beer, respectively. For spirits, such a reduction in the spirits price causes a fall in per capita sales of roughly 3.2 percent at the border (Malmö), but the effect gradually diminishes as one moves further from the border. The point estimate is that the fall in sales is estimated to drop below 2 and 1 percent only at 150 and 400 kilometers from the border, respectively. The 95 percent confidence intervals are tight and suggest that Danish prices have an impact on municipalities almost 700 kilometers from the border.

For beer and wine, there is a similar pattern with price sensitivity being negatively related to the distance to the border. For wine, the effect tapers off much more rapidly than for spirits and beer, reaching zero at some 200 kilometers from the border. A likely explanation for this difference is that prices of the former types are significantly lower across the border, while prices of most medium to high quality wines are about the same. However, in Denmark, there exist low-quality wines that are cheaper than any that can be found in Sweden. This could give rise to modest amounts of cross-border shopping. For beer, the effect of the Danish price tapers out at around 400-500 kilometers from the border. The effect does not converge to zero over the range of distances considered here, which suggests that even far from the border, some fraction of consumers travel to take advantage of Danish beer prices that are 25-35 percent lower.

For all types of alcohol, it might be unexpected that the effects may stretch many hundreds of kilometers from the border. Note, though, that these products are

[17] Estimates of price elasticities for alcoholic beverages are typically within a range of -0.2 to -1.5 (see e.g. Baltagi and Griffin, 1995 and Cook and Moore, 2000). As in our data, spirits demand is typically more elastic than the demand for beer.

easily transported and storable – by driving down to Denmark, the price conscious consumer could keep her bar stocked with just one or two yearly trips. Calculations of the cost savings associated with going to Denmark to buy alcohol were particularly common in the Swedish press around the time of the Danish tax cut in 2003. One example (from the tabloid *Expressen*, October 20, 2003) indicated that two people sharing a car from Stockholm (around 650 kilometers from Malmö) and each buying the full quota at the time would save 3200 kronor (around 350 euros) net of travel costs.

In Asplund et al (2005) we also examined price elasticities with respect to German prices and found that the results were very similar to those reported in Table 3. For beer and wine, this is likely to be due to the high correlation between the German and Danish price indices (0.82 and 0.97).[18] More surprising, in the light of the higher cost to travel to Germany in terms of time and outlays, was the similarity for spirits, given that the correlation between the indices was a modest 0.47. Here, a counteracting factor, however, is that German prices are substantially lower than Danish prices. For some consumers intending to buy large quantities, traveling to Germany might instead be a worthwhile exercise.

[TABLE 3 ABOUT HERE]

[FIGURES 5a-5c ABOUT HERE]

5. Consequences for tax revenues

The total tax revenues from alcohol sales are important in many countries: in 2004, the Swedish excise taxes on alcohol amounted to 10.2 billion kronor (1.1 billion euros). We can use our estimated demand functions to provide some calculations of the direct consequences of foreign and domestic tax changes.

Let us first consider the Danish cut of spirits taxes in October 2003 which reduced prices by 27 percent. The estimates of the demand elasticity with respect to

[18] Much of the variation in these price indices is from exchange rate movements versus the Swedish krona. The Danish krona has followed a fixed exchange rate vis-à-vis the Deutsch mark and, subsequently, against the euro within an even tighter band. Correlations between the exchange rates are thus very high (.976 between the Danish krona and the Deutsch mark exchange rates and .999 between the Danish krona and the euro exchange rates).

the Danish price (i.e. $g(\boldsymbol{d}_j, D_i)$ in equation (1)) give the percentage fall in Swedish spirits volumes. Taking the actual monthly volumes of 2002 as a benchmark, we infer what the annual 2002 tax revenues would have been, with a 27 percent lower Danish spirits price.[19] The effects are non-trivial: a direct loss of about 141 million kronor per year (15 million euro), or about 2.2 percent of the total tax revenue from spirits. The loss is not evenly distributed across country, but it depends on the geographical distribution of the population as the elasticity depends on the distance to the border. The municipalities near the Danish border, where elasticity is the highest, are relatively densely populated and those within a 100 km radius are the home of 1.1 million of Sweden's 9.0 million people. In this area, tax revenues are estimated to fall by 7.5 percent accounting for more than a quarter of the total tax revenue loss.[20] Municipalities within a radius of 300 km make up two thirds of the total revenue loss. Given that many European countries have far higher population densities than southern Sweden and that many people live close to one or more borders, it is not surprising that many countries within the European Union are concerned with the potential loss of revenues, when neighboring countries reduce the alcohol taxes.

Finally, let us now consider the consequences of a hypothetical Swedish tax reduction in response to lower Danish taxes. We base our calculations on a suggestion by a governmental report, SOU (2005), that spirits taxes be reduced by 40 percent, which would lead to approximately 30 percent lower prices. The experiment conducted here is based on the actual volumes over the ten-month period October 2003 – July 2004, during which 18.1m liters of spirits were sold. With our point estimate of the demand elasticity, -1.29, the volumes with the lower Swedish prices would have been 25.1m liters. The total effect on the tax revenue would be a loss of 646m kronor, 611m of which come from the alcohol tax and 15m from VAT. As a percentage of the pre-tax revenue, this is equivalent to a 13.3 percent reduction.[21, 22]

[19] The total tax on spirits depends on the alcohol content and VAT is a percentage of the retail price. Since we only have aggregate volume data, we use a typical bottle of spirits as our reference, which gives a tax of 201kr plus VAT of 66kr.

[20] For comparison, the even larger Finnish tax cut in March 2004 (discussed in Section 3) mostly hit the sparsely populated northernmost municipalities, where only 40 000 people live within a 100 km radius of the Finnish border. In Asplund et al. (2005), we estimated that the loss in aggregate tax revenues was only 0.3 percent.

[21] It is clear that with a strictly tax revenue maximizing objective, there is little to be said for cutting taxes. However, there are many other factors, both social and medical, to be considered in deciding on the optimal level of alcohol taxes (see e.g. Cook and More, 2000, and Pogue and Sgontz, 1989).

[22] For comparison, for the Finnish 44 percent cut in spirits taxes in March 2004, the Finnish Ministry of Finance estimated that tax revenues fell by 21.5 percent, as volumes only increased by 6.5 percent.

Note that while the Danish and Swedish price changes in the example were similar (27 and 30 percent), their consequences were not. The former reduced the Swedish tax revenue by only 2.2 percent, as it primarily influenced the southern regions. The latter, however, would affect the entire country and lead to an approximately six times larger fall in tax revenues.[23]

6. Conclusion

Many studies have documented deviations from the Law of One Price in international settings. Casual observation also suggests the existence of considerable cross-border shopping but up to now, hard evidence on the impact of foreign price changes on local demand has been remarkably absent. Our analysis of alcohol sales across Swedish regions offers an indication that the magnitude of cross-border arbitrage to which these deviations give rise can be substantial. By estimating demand functions, we have shown that the sensitivity of regional sales with respect to foreign prices depends on the distance to the border. The estimated elasticities are naturally highest at the communities near the border, but the effect lingers several hundred kilometers inland.

This is related to an ongoing policy discussion where calls for tax harmonization within the European Union have often been accompanied by references to domino effects ("race to the bottom") of differential alcohol taxation. For instance, Denmark and Finland reduced their taxes with reference to cross-border shopping in neighboring countries with low prices (Germany and Estonia, respectively). Despite some theoretical work on tax competition and cross-border shopping (Kanbur and Keen, 1993, Wang, 1999 and Nielsen, 2001) there have, to the best of our knowledge, been no detailed studies of the effects of foreign tax changes on domestic demand and tax revenue. One contribution of this paper is therefore to show that the consequences for tax revenues of foreign price changes can be substantial. For instance, we estimate that the Danish spirits tax cut in October 2003 reduced the Swedish tax revenues from spirits by 2.2 percent, more than a quarter of which was concentrated to areas within a 100km radius from the border. However, a Swedish tax cut in response would reduce

[23] For the tax cut to have a positive effect on tax revenues, the elasticity would need to be above 2.1. As noted in footnote 13, our econometric specification assumes that the elasticity with respect to the domestic price is independent of the distance to the border and should be viewed as an average for the country. Thus, only if the elasticity were greater than 2.1 near the border would tax revenues in that region increase.

the tax revenues still further. A tax cut that would roughly match the Danish one, as proposed by a governmental report, would cause a 13.3 percent drop in tax revenues. Naturally, it is difficult to generalize these numbers to other countries and goods but, given the relatively high cost associated with cross-border shopping and limited monetary gains in our setting, there may well be cases where the tax consequences are even greater.

Table 1. Descriptive statistics for raw data.

	Mean	St.Dev.	Min	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	Max	Obs.[a]
P^D SPIRITS	1.011	0.017	0.975	0.985	0.998	1.012	1.024	1.032	1.043	25641
P^D BEER	0.952	0.025	0.887	0.924	0.936	0.953	0.968	0.987	1.009	25641
P^D WINE	0.996	0.034	0.937	0.946	0.959	1.005	1.023	1.039	1.054	25641
P^F SPIRITS	0.882	0.086	0.634	0.648	0.878	0.906	0.926	0.946	0.983	25641
P^F BEER	0.967	0.035	0.908	0.925	0.939	0.961	0.988	1.014	1.054	25641
P^F WINE	0.962	0.037	0.887	0.912	0.934	0.962	0.986	1.012	1.051	25641
q SPIRITS	0.234	0.106	0.030	0.139	0.170	0.211	0.272	0.348	1.812	25641
q WINE	0.910	0.637	0.057	0.460	0.574	0.762	1.035	1.467	11.429	25641
q BEER	1.361	0.827	0.057	0.581	0.843	1.205	1.678	2.247	13.103	25641
DISTANCE	0.488	0.328	0.000	0.090	0.271	0.455	0.628	0.951	1.563	25641
INCOME/CAP	1.578	0.210	1.151	1.371	1.446	1.544	1.651	1.810	3.195	25641
STORE/CAP	0.074	0.055	0.014	0.026	0.034	0.061	0.095	0.146	0.388	25641
FRIDAYS	4.350	0.477	4.000	4.000	4.000	4.000	5.000	5.000	5.000	25641
HOLIDAYS	0.670	0.937	0.000	0.000	0.000	0.000	2.000	2.000	3.000	25641

a) Sample excludes municipalities that bordering Norway and Finland.

Quantity data and number of outlets from Systembolaget. Population and income at the municipality level from Statistics Sweden. Distance is defined as kilometers/1000 by fastest road from Sveriges Nationalatlas. Price data are the Harmonized Consumer Price Indices (spirits: cp0211; wine: cp0212; beer: cp0213) from the Eurostat database. Foreign price indices are converted into Swedish ones, with mean monthly exchange rates from Sveriges Riksbank. All price series are deflated with CPI from the Eurostat database. Average per capita income is from Statistics Sweden.

Table 2. Raw correlation between the twelve-month growth rate in the Danish price and the growth rate in average sales volume per capita.[a]

	Dist.<250km	250km<Dist.<500km	500km<Dist.
Spirits	0.47	0.28	0.20
Wine	0.20	0.00	-0.01
Beer	0.17	0.01	0.05

a) January 1996-July 2004 (103 monthly observations). Sales volumes for municipalities bordering Norway or Finland are excluded.

Table 3. Change in regional sales volume. Dependent variable is twelve-month difference in log of sales volume, $\Delta_{12}\ln[q_{j,i,t}]$. Foreign price, P^F, is for Denmark. SUR estimation.

	Spirits (1)	Beer (2)	Wine (3)
$\Delta_{12}\ln[P^D]$	-1.291***	-0.917***	-0.239***
	[0.028]	[0.024]	[0.015]
$\Delta_{12}\ln[P^F]$	0.321***	0.467***	0.172***
	[0.009]	[0.030]	[0.020]
$Dist\times\Delta_{12}\ln[P^F]$	-0.898***	-0.989***	-0.948***
	[0.060]	[0.201]	[0.134]
$Dist^2\times\Delta_{12}\ln[P^F]$	0.828***	1.185***	1.380***
	[0.111]	[0.369]	[0.245]
$Dist^3\times\Delta_{12}\ln[P^F]$	-0.215***	-0.448**	-0.591***
	[0.054]	[0.178]	[0.118]
$\Delta_{12}\ln$[Income/Cap.]	1.385***	1.047***	0.651***
	[0.044]	[0.053]	[0.047]
$\Delta_{12}\ln$[Stores/Cap.]	0.132***	0.179***	0.170***
	[0.007]	[0.009]	[0.008]
$\Delta_{12}\ln$[Fridays]	0.088***	0.227***	0.160***
	[0.005]	[0.006]	[0.005]
Δ_{12}Holidays	0.034***	0.016***	0.026***
	[0.001]	[0.001]	[0.001]
Constant	-0.064***	0.023***	0.013***
	[0.001]	[0.002]	[0.001]
Observations[a]	25641	25641	25641
"R2"	0.202	0.090	0.113
Test[b]	0.00	0.00	0.00

*** and ** indicate significance at the 1 and 5 percent level, respectively.
Weighted SUR with weights equal to the population in the municipality.
a) Sample excludes municipalities bordering Norway or Finland.
b) Test is the probability of $Dist\times\Delta_{12}\ln[P^F]= Dist^2\times\Delta_{12}\ln[P^F]= Dist^3\times\Delta_{12}\ln[P^F]=0$.

Figure 1. Estimated sources of alcohol consumption and distance to the Danish border from the approximate population center in different Swedish regions in 2003.

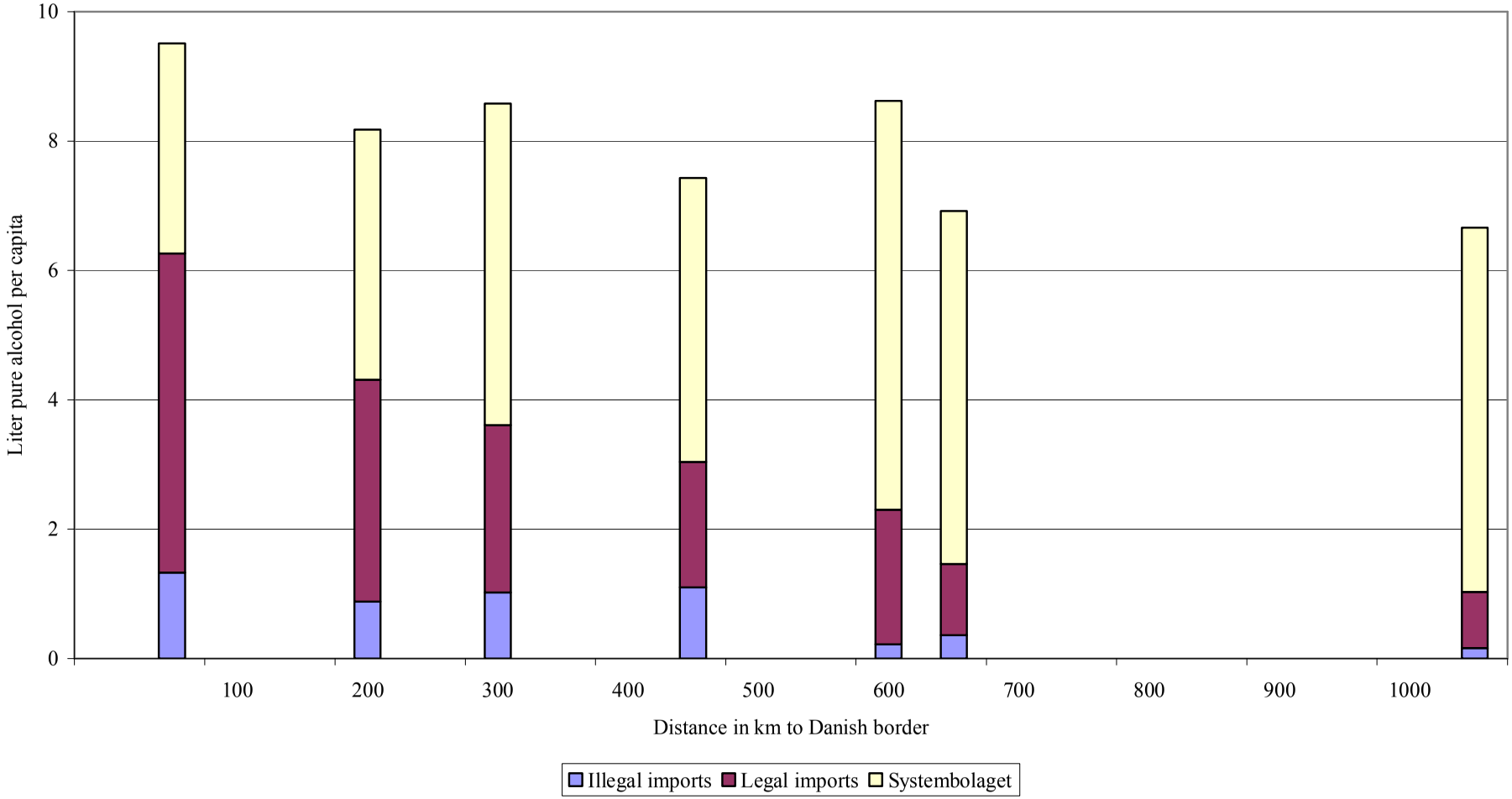
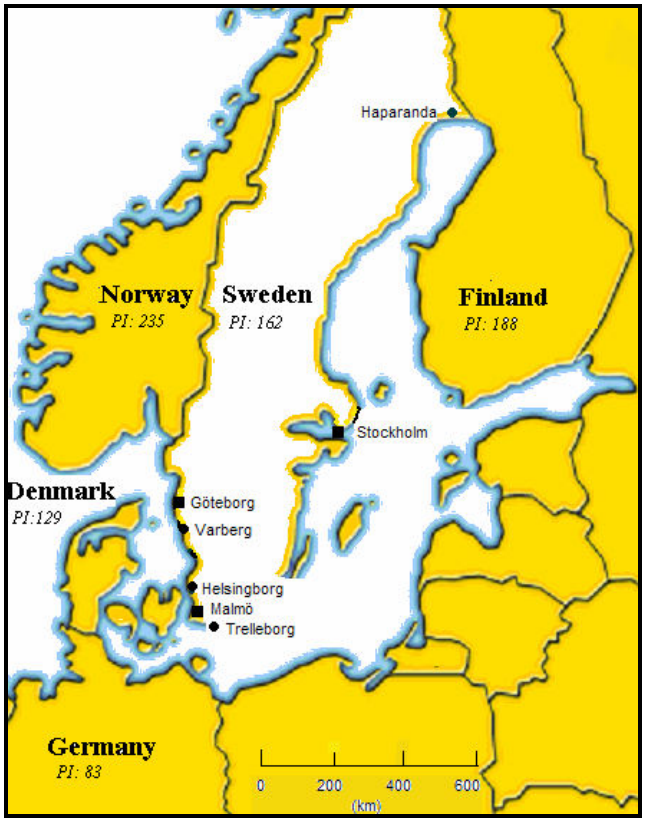
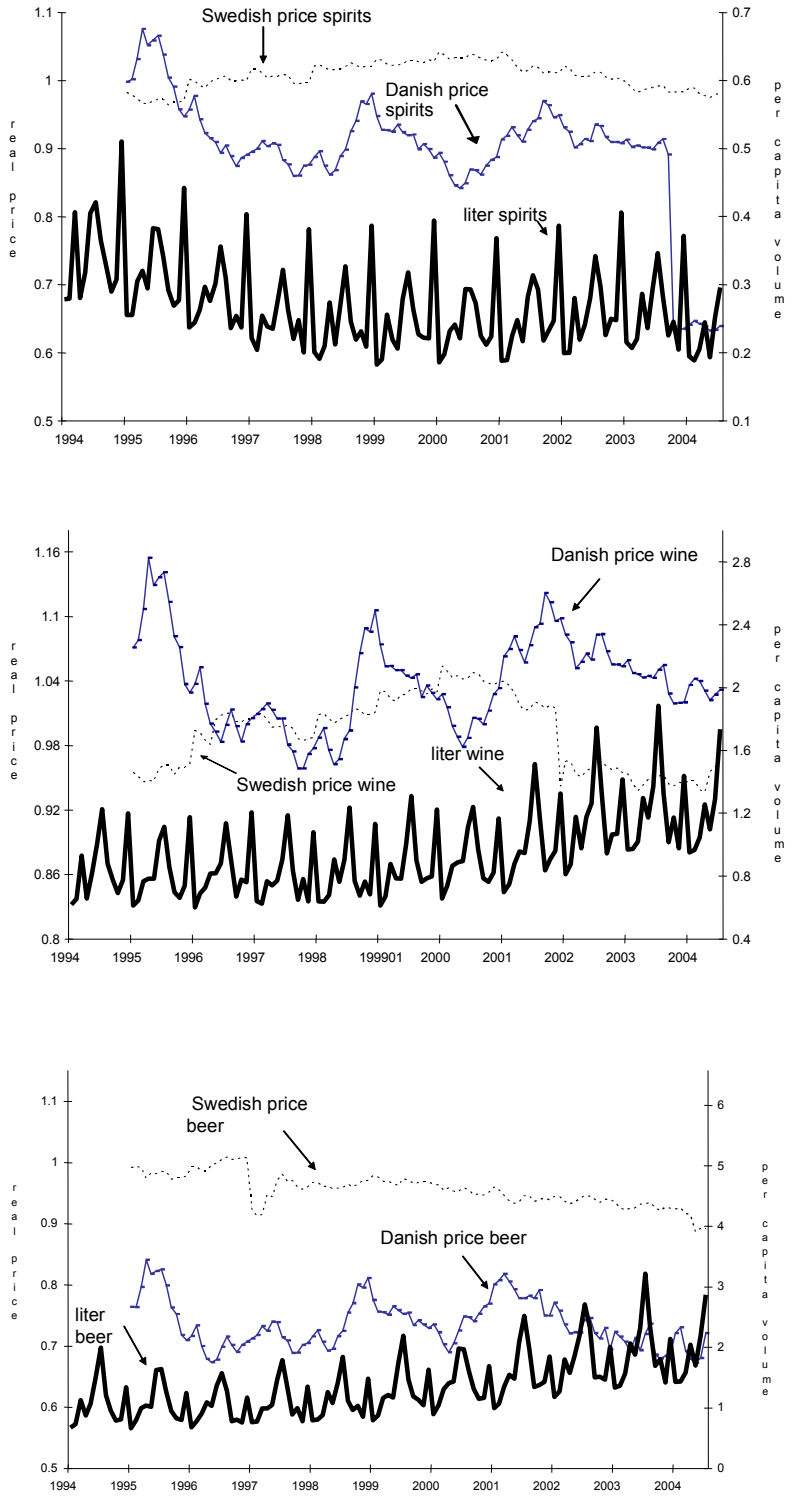


Figure 2 Map with associated price indices.

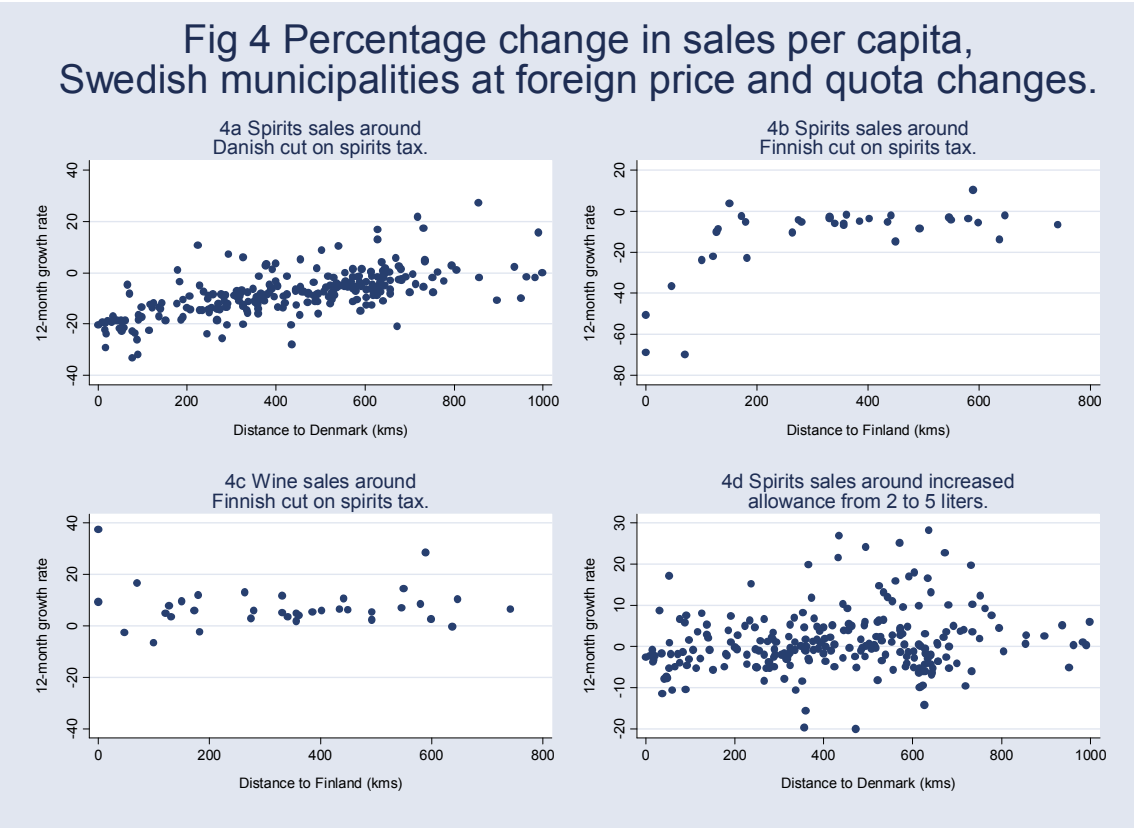


Note: *PI* is the average alcoholic PPP price index for each country over the period 1995-2003, constructed to reflect absolute differences in price levels between countries. EU average each year=100.

Figure 3a-3c. Per capita volume and real prices of spirits, wine and beer. Sweden January 1994–July 2004.

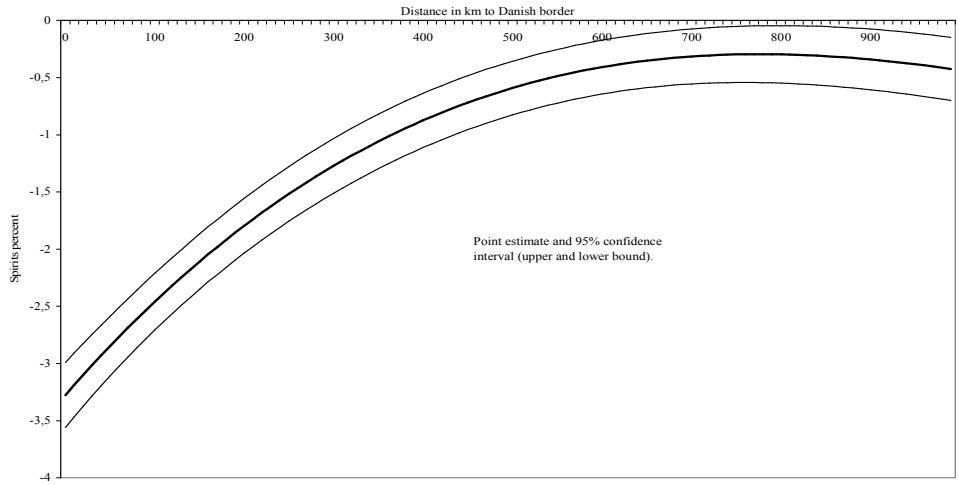


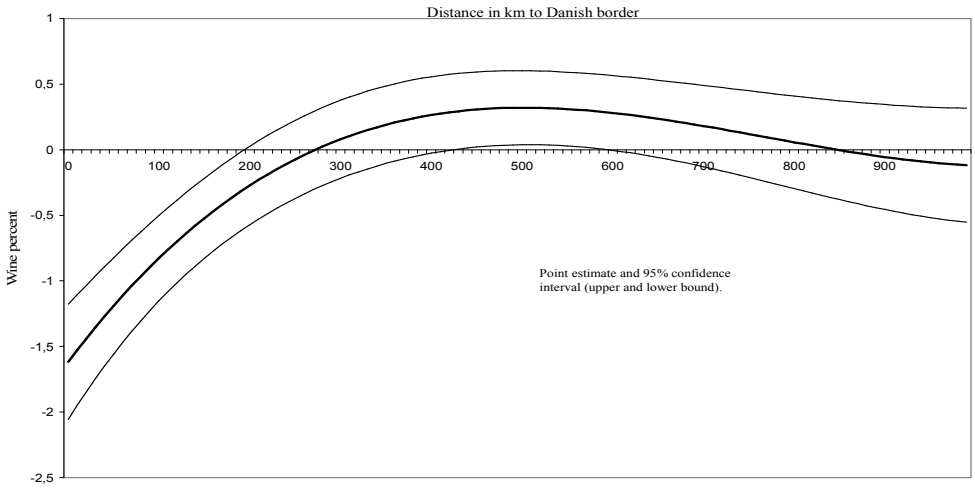
Figures show Eurostat price indices as described in Table 1. Danish prices translated into Swedish prices using monthly exchange rates. All prices deflated by the Swedish Consumer price index. Indices normalized such that the Swedish price index equals 1 in June 1999 and the Danish price index in this month set to 0.9 for spirits, 0.73 for beer and 1.015 for wine.

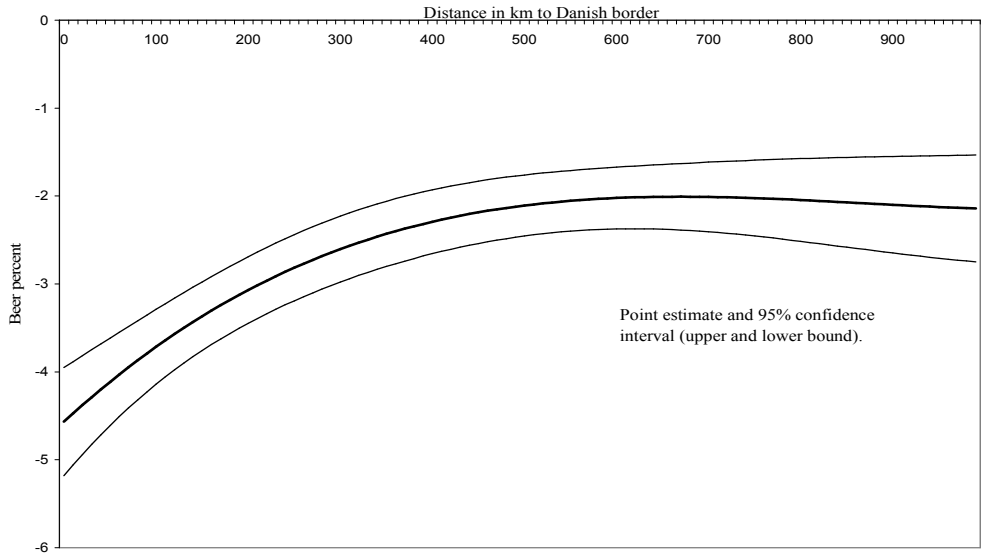


Figures 4a-4d show the percentage change in volume in the quantity sold per capita in Swedish municipalities between a particular month and the corresponding month a year before. Months were chosen so as to minimize the difference in the number of Fridays, Saturdays and public holidays. Figure 4a compares Dec 2003 to Dec 2002 (Danish tax change October 2003). Figures 4b and 4c compare April 2004 to April 2003 (Finnish tax change March 2004). Figure 4d compares February 2003 to February 2002 (quota increases on January 2003). In figures 4a and 4d, municipalities bordering Norway are excluded.

Figure 5a-5c. Estimated effect on sales volumes for spirits, wine and beer in Swedish regions, following a 10% reduction in the corresponding Danish price.







Figures based on parameter estimates from columns (1)-(3) in Table 3.

Appendix Table 1. Descriptive statistics for variables used in regressions.

	Mean	St.Dev.	Min	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	Max	Obs.[a]
$\Delta_{12}\ln[P^D]$ SPIRITS	0.001	0.016	-0.030	-0.020	-0.014	0.004	0.010	0.024	0.037	25641
$\Delta_{12}\ln[P^D]$ WINE	-0.002	0.031	-0.098	-0.056	-0.016	0.004	0.019	0.040	0.059	25641
$\Delta_{12}\ln[P^D]$ BEER	-0.008	0.023	-0.084	-0.040	-0.016	-0.009	0.004	0.015	0.058	25641
$\Delta_{12}\ln[P^F]$ SPIRITS	-0.048	0.118	-0.359	-0.333	-0.071	-0.024	0.017	0.078	0.119	25641
$\Delta_{12}\ln[P^F]$ WINE	-0.007	0.062	-0.155	-0.065	-0.041	-0.021	0.020	0.088	0.138	25641
$\Delta_{12}\ln[P^F]$ BEER	-0.010	0.056	-0.163	-0.070	-0.047	-0.014	0.030	0.065	0.118	25641
$\Delta_{12}\ln[q]$ SPIRITS	-0.038	0.118	-1.765	-0.177	-0.105	-0.036	0.028	0.089	1.821	25641
$\Delta_{12}\ln[q]$ WINE	0.031	0.128	-2.010	-0.113	-0.043	0.030	0.103	0.172	2.788	25641
$\Delta_{12}\ln[q]$ BEER	0.057	0.139	-1.970	-0.109	-0.025	0.056	0.140	0.222	2.543	25641
DISTANCE	0.488	0.328	0.000	0.090	0.271	0.455	0.628	0.951	1.563	25641
$\Delta_{12}\ln$[INCOME/CAP]	0.022	0.013	-0.041	0.006	0.013	0.023	0.031	0.040	0.091	25641
$\Delta_{12}\ln$[STORES/CAP]	0.007	0.067	-0.700	-0.009	-0.004	0.002	0.009	0.016	1.099	25641
$\Delta_{12}\ln$[FRIDAYS]	0.002	0.130	-0.223	-0.223	0.000	0.000	0.000	0.223	0.223	25641
Δ_{12}HOLIDAYS	0.000	0.681	-2.000	-1.000	0.000	0.000	0.000	1.000	2.000	25641

a) Sample excludes municipalities bordering Norway and Finland.

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