Skatteforsk
Centre for Tax Research

Working Paper No. 11

# Cross-border shopping of alcoholic beverages and tax revenues: Evidence from a natural experiment

June 2024

**Eivind Bjørkås**
Norwegian University of Life Sciences

**Kyrre Rickertsen**
Norwegian University of Life Sciences

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Skatteforsk's Working Paper Series is financed through support from The Research Council of Norway (Grant number 341289).

# Cross-border shopping of alcoholic beverages and tax revenues: Evidence from a natural experiment

Eivind Bjørkås[1] Kyrre Rickertsen[1]

June 4, 2024

**Abstract**

Cross-border shopping of alcoholic beverages reduces domestic tax revenues. In this article, we estimate the magnitude of Norwegian cross-border shopping of hard liquor and wine and its effects on tax revenues by using the travel restrictions during the COVID-19 pandemic as a natural experiment. The Norwegian alcohol retail market is controlled by a state monopoly (Vinmonopolet), and our data set includes the complete transaction data of Vinmonopolet. The effects are identified by using a difference-in-difference approach comparing changes in sales in stores with different driving time to the nearest cross-border alcohol store. We find statistically significant effects of cross-border shopping for driving times up to three hours. The reduced sales in the stores of Vinmonopolet are estimated to be about 9% for wine and 6% for hard liquor corresponding to almost one billion NOK in lost annual tax revenues.

**Keywords**: alcoholic beverages, cross-border shopping, excise tax, natural experiment, value-added tax

**JEL Codes:** D12, F15, H26, I18

[1] Norwegian University of Life Sciences. E-mail adresses: eivind.bjorkas@nmbu.no (Bjørkås), kyrre.rickertsen@nmbu.no (Rickertsen).

## 1. Introduction

Cross-border shopping reduces domestic tax revenues from value-added tax (VAT) and excise taxes. In Norway, VAT alone accounts for 30% of total tax revenue (excluding oil related revenues), while excise taxes on alcoholic beverages make up for approximately 1.5% (Government of Norway, 2020).

Cross-border shopping is unregistered, and studies have identified cross-border shopping effects related to goods such as alcoholic beverages, tobacco, groceries, and gasoline by utilizing price variation caused by tax rate differentials (Johansson et al., 2014; Asplund et al., 2007; Manuszak and Moul, 2009; Chiou and Muehlegger, 2008; Ben Lakhdar et al., 2016) or exchange rate fluctuations (Friberg et al., 2022; Chandra et al., 2014). This literature generally shows that cross-border shopping is a positive function of price differentials, a negative function of the distance from the border, and have significant negative effects on tax revenues.

Excise taxes are also increasingly being used to correct externalities related to consumer behavior (OECD, 2022). When applied to consumer goods, these excise taxes are often labelled as sin taxes with tax rates that need to balance revenue collection and desirable behavior correction. Cross-border shopping is a legal form of avoiding sin taxes, and it results in reduced tax revenues and increased consumption of alcoholic beverages (Asplund et al., 2007; Johansson et al., 2014; Beatty et al., 2009). For example, a Danish tax cut on hard liquor in 2003 reduced the Danish prices by 27%, and Asplund et al. (2007) found that it also reduced Swedish tax revenues from sales of hard liquor by more than 2%. Johanson et al. (2014) studied a Finnish tax cut on hard liquor and wine and, besides revenue effects, found significantly higher workplace absenteeism in border regions in Sweden, presumably explained by increased cross-border shopping. Beatty et al. (2009) used scanner data and

found significant effects of lower Swedish beer prices on Norwegian beer sales up to 150 minutes from the border and also more drunk driving in border-near areas.

A few studies have recently used travel restrictions during the COVID-19 pandemic to investigate the effects of cross-border grocery shopping (Friberg et al., 2024; Zirgulis, 2023; Kluser, 2023). Due to border closures, the pandemic induced a natural experiment, which might provide a better basis for estimating the magnitude of cross-border shopping than exchange or tax rate fluctuations. Friberg et al. (2024) used data from a Norwegian grocery chain, and found significant effects up to 180 minutes driving time for highly taxed goods such as beer and tobacco with an estimated loss in total annual VAT and excise taxes of 2.3 billion NOK. Zirgulis (2023) used data from Carlsberg to investigate cross-border shopping of beer in the Baltic countries and found that beer sales increased by 14% in border regions due to restricted access to cross-border shopping during the pandemic. Kluser (2023) investigated effects in the Swiss grocery market using household transaction records and found significant effects for driving distances up to 70 minutes from the Swiss borders.

In this article, we follow the approach used in Friberg et al. (2024). The effects of access to cross-border shopping on sales of wine and hard liquor (hereafter referred to as alcoholic beverages) are investigated by using local travel restrictions during COVID-19. Norway has one of the highest excise tax rates on alcoholic beverages in the OECD (Ngo et al., 2021). Consequently, consumers residing close to the borders face strong price incentives for cross-border shopping, and consumers residing far away from the border constitute a natural control group. To identify causal effects of access to cross-border shopping, weekly sales in areas with different travelling time to foreign alcohol stores are combined with data on border closures and driving times to the nearest cross-border alcohol store. Our specific objectives are: (i) to investigate the effects of driving time on domestic sales of alcoholic

beverages, and (ii) to estimate the magnitude of cross-border shopping of alcoholic beverages and the associated loss in tax revenue.

As compared with previous studies, our study offers several contributions. First, tax avoidance for alcoholic beverages might be more serious than for groceries, both because of the externalities associated with alcohol consumption and potentially higher tax losses due to higher taxation. Current estimates of the magnitude of Norwegian cross-border shopping of alcoholic beverages are based on a survey performed by Statistics Norway (2023). The survey has gathered data on cross-border shopping in general since 2004, but did not ask specifically about alcoholic beverages before in 2023. It estimated the cross-border shopping of alcoholic beverages to be NOK 742 million in 2023. Our study serves as a revealed-preference alternative to this survey. Second, our data includes the complete transaction records for retail sales of wine and hard liquor in Norway rather than data from a single grocery chain (Friberg et al., 2024) or a single beer brand (Zirgulis, 2023). Consequently, there is less uncertainty in the estimates used to calculate the effects of cross-border shopping on sales and tax revenues. Third, prices of wine and hard liquor are uniform and without promotions across stores removing any (potentially endogenous) domestic price variation from competition between retail chains near the border.[2] Fourth, our data cover the period before, during, and after the pandemic while previous studies only included data before and during parts of the pandemic.

The article proceeds as follows. In Section 2, the market for alcoholic beverages and the effects of COVID-19 on cross-border shopping are described. In Section 3, the data and associated descriptive statistics are presented. The empirical models are discussed in Section 4, the results are presented in Section 5 and discussed in Section 6 before we conclude in Section 7.

[2] Most of the cross-border shopping is with Sweden and Finland. Both countries have national alcohol monopolies with uniform prices removing potential concerns about price endogeneity in foreign stores.

## 2. The market for alcoholic beverages and the COVID-19 pandemic

Norwegian alcohol policy is restrictive as compared to most other European countries. High taxation, a ban on advertising and price promotions for alcoholic beverages, age limits, limited hours of operation, and strict import quotas are used (Lai et al., 2013; Government of Norway, 2022). Due to one of the highest levels of excise taxes on alcoholic beverages within the OECD, the Norwegian real price has persistently been around 60% higher than the Swedish and substantially higher than the Finnish (Ngo et al., 2021; OECD, 2022). Figure 1 shows the development in real prices of alcoholic beverages in Norway, Sweden, and Finland over the 2003-2022 period.

Figure 1 about here

For at-home consumption, alcoholic beverages with an alcohol content above 4.7% can only be purchased in stores operated by a government-owned retail monopoly (Vinmonopolet) with 344 stores across Norway.[3] However, the quantities sold in Vinmonopolet are affected by other legal and illegal channels as illustrated in Figure 2. Sales in hotels, restaurants, catering, and bars go through the HORECA channel. Firms in the HORECA channel can decide whether they want to purchase alcohol from Vinmonopolet, the wholesalers and importers who are intermediaries between the producers and Vinmonopolet, or directly from the producers. In each case, the taxes are identical to the rates on sales through Vinmonopolet (Lai et al., 2013). In addition, there is duty-free shopping at airports and ferries, cross-border shopping, smuggling, and at-home production. At-home production is illegal for distilled beverages but legal for wine and beer. Finally, changes in sales in the

[3] Numbers as of December 31, 2022.

stores may be affected by changes in private storage over time. The table at the bottom of Figure 2 shows whether each channel is legal, taxed, and regulated with import quotas.

To estimate the magnitude of cross-border shopping, we use variations in sales in the stores of Vinmonopolet during the COVID-19 pandemic. However, these variations may also have been affected by changes in the other channels, and these changes should, as far as possible, be controlled for.

First, establishments in the HORECA channel faced social restrictions during the COVID-19 pandemic. These restrictions included closures, reduced opening hours, face mask requirements, and distancing rules. Variation in infection rates resulted in different local restrictions, which may have ambiguous effects on the sales in Vinmonopolet. On one hand, higher infection rates restricted activity and sales through the HORECA channel, suggesting increased sales in Vinmonopolet. On the other hand, higher infection rates may also have discouraged people from leaving their homes, suggesting reduced sales in Vinmonopolet. These effects are controlled for by including the number of new COVID-19 cases as a percentage of the population in the municipality where the store is located as a proxy variable representing the stringency of local social restrictions affecting the HORECA channel and the probability of getting infected.

Second, travel restrictions reduced duty-free shopping and may have led to increased sales in Vinmonopolet.[4] Data from the National Institute of Public Health (Bergsvik, 2023) show a reduction of more than 80% in duty-free sales at domestic airports in 2020 and 2021 as compared with 2019. The geographical distribution of duty-free shoppers is unknown, but

[4] International travelers may import 1 liter of hard liquor, 1.5 liter of wine, and 2 liters of beer (with some possible substitutions) without paying Norwegian excise or value-added taxes. Travelers who have been abroad for more than 24 hours can purchase duty-free alcohol on ferries and upon arrival at airports with international connections. This import is referred to as duty-free shopping. Travelers who have been away for less than 24 hours can import the same quantities without paying Norwegian taxes as long as purchases have been done in a taxed store within the European Economic Area. This import is referred to as cross-border shopping. For more details, see Norwegian Customs (2024).

spatial variation in access to duty-free shopping is controlled for by using the number of airline seats available for international flights at the domestic airport closest to the store combined with the driving time to that airport.

Due to data limitations, the effects from changes in at-home production, smuggling, and private storage cannot be controlled for beyond fixed store and week effects. Any changes in sales due to changes in prices and income are also implicitly controlled for by these fixed effects.

Figure 2 about here

## 3. Variables, data, and descriptive statistics

The dataset contains 209 weekly observations over the period 2019-2022 for sales of wine and hard liquor in each of the 344 physical stores of Vinmonopolet, in total 71,896 observations. Ten stores opened during the period of analysis (Vinmonopolet, 2022; 2019), no stores closed permanently, but some stores were closed for periods due to renovations. This led to some store-week combinations without sales, making the data set unbalanced.[5] The total annual sales of different categories of alcoholic beverages for the period 2013-2022 are shown in Figure 3. Sales were stable before the pandemic but increased by more than 40% during the pandemic. In 2022, the first year after the pandemic, total sales were 18% lower than in 2021 but 18% higher than the pre-pandemic level in 2019. Wine and hard liquor were the two dominant categories.[6]

The variables included in our empirical models with associated descriptive statistics are defined in Table 1. The mean weekly sale is 774 liters of hard liquor with a value of NOK

[5] The regression models include 70,565 and 70,568 observations for hard liquor and wine, respectively.
[6] Beer with alcohol content below 4.7% is sold in grocery stores and not in Vinmonopolet. Beer sold in Vinmonopolet has an alcohol content above 4.7% and also a higher tax rate than beer with a lower alcohol content. For details see The Norwegian Tax Administration (2024).

103,151 (exclusive VAT and excise tax). More than twice of this amount is paid as excise taxes. The mean weekly sale of wine is 4,654 liters with a value of NOK 390,390 (exclusive VAT and excise tax) of which more than 70% is paid in excise taxes. There is also a large variation in the size of the stores, and the maximum weekly sale in any store is more than 48,000 liters of wine.

Spatial variation in the access to cross-border shopping was measured by driving time from each store to 18 foreign cross-border alcohol stores. We obtained these driving times from Google Distance Matrix API (Google, 2023a).[7] Figure 4 illustrates the large variation in the availability of cross-border shopping. Stores in the Western part of Norway face little competition from cross-border shopping while densely populated areas in the Eastern part are frequently quite close to the border. From stores in Oslo, there is between 85 and 105 minutes driving time to the nearest cross-border store in Sweden (Strömstad). Figure 5 shows the strong correlation between driving time in minutes and percentage increases in annual sales before and during the pandemic as estimated by a reciprocal model. Almost all stores experienced increased sales between 2019 and 2021, but the increases were much higher for shorter distances. A few stores located in city centers experienced reduced sales due to extensive use of home-offices during the pandemic.[8]

Time-varying cross-border shopping accessibility was measured by the timing of quarantines, which was required for entering Norway from each of the eight foreign regions with a cross-border alcohol store.[9] Figure 6 shows the timing of these quarantines in six Swedish, one Finnish, and one Russian region based on data scrapped from the webpage of the

[7] We retrieved the driving times without specifying a departure time to ensure that the choice of optimal routes and estimated driving times are independent of traffic conditions (Google, 2023b).
[8] No municipality experienced reduced sales between 2019 and 2021. This shows that the reduced sales in the stores located in city centers were compensated by increased sales in other stores in the same municipality.
[9] During a quarantine, people were not allowed to leave home other than for short walks alone. One was required to keep distance to people living in the same household and not participate in any organized activities outside home (Norwegian Institute of Public Health, 2021).

National Institute of Public Health (2023a).[10] As shown in Figure 6, the quarantines for each region changed on a weekly basis based on infection rates in each region. We defined a foreign store as accessible in the weeks when a visit did not lead to a quarantine.[11]

Spatial and time-varying access to cross-border shopping was measured using two sets of dummy variables. The first set, $D_s^i$, measures whether a cross-border alcohol store is located in bins of 30 minutes driving time from each domestic store. These dummy variables are time-invariant and unaffected by travel restrictions. Approximately 4% of the domestic stores have a foreign alternative within one hour, about 38% have one between one and two hours, and about 76% have one between two and three hours driving. Many stores have several foreign alternatives, and several $D_s^i$ will equal 1 for these stores.

The second set of dummy variables, $A_{s,w}^i$, indicates the driving time to the nearest accessible foreign store, measured in bins of 30 minutes. These variables represent the variation in access to cross-border shopping induced by the travel quarantines, which vary across stores and weeks. Less than 3% of the observed store-week combinations are less than one hour away from the nearest foreign alcohol store, about 19% are between one and two hours away, and about 14% are between two and three hours away. 35% of all store-week observations have a foreign accessible store within 180 minutes driving time.

To control for the effects of social restrictions on establishments served by the HORECA channel, we used monthly per capita numbers on new COVID-19 cases in each municipality (National Institute of Public Health, 2023b). The average monthly infection rate is 0.5%, varying from no to 17% new infections.

[10] Cross-border shopping on daytrips is not permitted in countries outside the European Economic Area, i.e. Russia. Nevertheless, a cross-border store in the border region of Russia was included, as cross-border shopping on trips lasting more than 24 hours is legal and might affect domestic sales. Furthermore, our identification strategy does not separate legal and illegal border shopping in the other countries either.

[11] The quarantines usually lasted for 10 or 14 days. If a visit on any day in a given week resulted in a quarantine, the store was defined as inaccessible in that week.

To control for access to duty-free shopping, we used the number of airline seats available for international flights at the domestic airport closest to each store. Norway has 13 airports with international flights. We determined the domestic airport nearest to each store, using data from Google Distance Matrix API (Google, 2023a). The monthly number of commercially available international airline seats in each airport was obtained from Statistics Norway (2024a). The average driving time is 94 minutes, while the average monthly number of available seats is 446,000. The number of available seats varies from 0 to 2.3 million seats. We assume effective access to duty-free shopping is a negative function of driving time to the nearest airport and a positive function of the number of airline seats available at that airport by dividing the driving time by the number of seats.

The monthly unemployment rate in each municipality is included as a control for changes in the local labor markets (NAV, 2024). The mean monthly unemployment rate is below 3% and the maximum almost 30%.

Finally, 68% of the store-week combinations are Swedish, and we include a dummy variable when the nearest accessible store is Swedish. Furthermore, 12% of the store-week combinations have a pick-up store for only online orders as its nearest, and a dummy variable is included for these stores.

Figures 3 – 6 about here

Table 1 about here

## 4. Empirical models

To estimate the effects of driving time on domestic sales (in liters) of wine and hard liquor, we specify the following two-way fixed effects model:

$$\log Y_{s,w}^{j} = \alpha_s + \gamma_w + \sum_{i=1}^{7} \beta_i \, (D_s^i \cdot A_{s,w}^i) + \delta_1 C19_{s,w} + \delta_2 (AS_{s,w}/DT_s)$$

$$+ \delta_3 UR_{s,w} + \delta_4 SWE_{s,w} + \delta_5 ONL_{s,w} + \varepsilon_{s,w}^{j} \quad (1)$$

where the variables are defined in Table 1, $\alpha_s$ and $\gamma_w$ represent fixed store and week effects, and $j$ = hard liquor or wine. The store effects capture unobserved spatial effects such as at-home production or smuggling, while the week effects capture unobserved time effects such as changes in prices, exchange rates, income, or private storage. The actual access to cross-border shopping for different driving times is captured by the interaction terms between the driving time without any travel quarantines, $D_s^i$, and the accessibility due to travel quarantines, $A_{s,w}^i$. Driving times up to 210 minutes are included.[12] The control group consists of two types of stores, stores with more than 210 minutes driving time without COVID-19 travel restrictions ($D_s^1$ to $D_s^7 = 0$), and stores affected by quarantines related to travelling in the specific week resulting in a driving time to the nearest accessible foreign store of more than 210 minutes ($A_{s,w}^1$ to $A_{s,w}^7 = 0$). Some control variables in Table 1 measure monthly variations across municipalities rather than weekly variations across stores. These variables were transformed to weekly observations based on the month of the Thursday each week, and to store observations based on the municipality where each store is located.

To estimate the effect of cross-border shopping on total domestic sales (in liters) of wine and hard liquor, we specify the following two-way fixed effects model:

[12] The 210 minutes limit was selected after testing for the significance of adding 30 minutes bins up to 360 minutes stopping when no more significant effects were found for either wine or hard liquor.

$$\log Y_{s,w}^{j} = \alpha_s + \gamma_w + \beta \sum_{i=1}^{6} (D_s^i \cdot A_{s,w}^i) + \delta_1 C19_{s,w} + \delta_2 (AS_{s,w}/DT_s)$$

$$+ \delta_3 UR_{s,w} + \delta_4 SWE_{s,w} + \delta_5 ONL_{s,w} + \varepsilon_{s,w}^{j}. \quad (2)$$

The access to cross-border shopping is now measured by one dummy variable, which is the sum of the first six interaction terms between $D_s^i$ and $A_{s,w}^i$. By construction this dummy variable is 1 for driving times less than 180 minutes from a store to the nearest accessible foreign store in any given week.[13]

To estimate the effects of cross-border shopping on the value of domestic sales (exclusive VAT and excise tax) and excise tax revenue, we estimate four models using the value of sales and excise tax revenue of wine and hard liquor as a dependent variable in Equation (2), i.e. $V_{s,w}^{Wine}, V_{s,w}^{HL}, T_{s,w}^{Wine}$, and $T_{s,w}^{HL}$ in Table 1. Separate models for the value and excise tax revenue are estimated to take account of the possibility that cross-border purchased alcoholic beverages have different unit prices than beverages purchased domestically. The estimated coefficients from these models are used to calculate the loss in tax revenue from cross-border shopping in a counterfactual scenario where all cross-border purchased alcoholic beverages are purchased domestically.

## 5. Results

The validity of the estimates provided by Equations (1) and (2) are based on an assumption of parallel trends in the sales in stores with and without access to cross-border shopping given no travel restrictions. The developments in sales of wine and hard liquor in stores belonging to different groups of driving times are plotted in Figure 7. The

[13] The driving time interaction terms in Equation (1) are insignificant for both products after 180 minutes, which is selected as the cutoff point in Equation (2).

developments in sales are similar across the groups in the years before the pandemic supporting the plausibility of the parallel trends assumption.

*5.1 Driving time and sales quantities*

The estimated coefficients and associated standard errors of Equation (1) are reported in Table 2 and illustrated in Figure 8. The estimated coefficients multiplied by 100 give the approximate percentage effects. However, this approximation is imprecise for larger values, and the coefficients are transformed by using the exponential function $\left(e^{\beta}-1\right)\cdot 100$, where $\beta$ are the estimated coefficients in the table, before we interpret them as percentage effects in the presentation below.

The coefficients from the models with and without control variables are presented in the table. The effects of driving time are slightly higher in the models without control variables. When a foreign cross-border shopping store is accessible within 30 minutes driving time, the quantities sold of wine and hard liquor in the stores of Vinmonopolet are reduced by 47 and 32% in the model with control variables. The corresponding reductions are about 49 and 34% in the model without control variables. A likelihood-ratio test rejects no joint effects of the control variables ($p << 0.01$), and the results for the unrestricted models are discussed below.

For driving times between 30 and 60 minutes, the reductions are about 31 and 20% for wine and hard liquor, respectively. The reductions remain significant at the 5% level up to driving times between 150 and 180 minutes. For these driving times, the reductions are 4% for wine and 3% for hard liquor. Many stores in the densely populated Oslo-area lie within 90 minutes driving time from a foreign store resulting in substantial effects on domestic sales of alcoholic beverages. There are no significant effects for driving times more than 180 minutes. The estimated effects are consistently larger for wine than hard liquor.

All the control variables are significant at the 5% level. A one percentage point increase in the COVID-19 infection rate is associated with more than 1% increases in the quantities sold of wine and hard liquor in Vinmonopolet. Access to duty-free shopping and increased unemployment rate are associated with 2-3% decreased sales. When the nearest accessible cross-border store is located in Sweden, sales of wine and hard liquor are 8% and 4% lower, respectively. When the nearest accessible cross-border store is a pick-up location for online orders, sales of wine and hard liquor in the stores of Vinmonopolet increase by 4 and 5%.

Figures 7 and 8 about here

Table 2 about here

*5.2 Sales quantities, sales values, and tax revenue*

The estimated coefficients and associated standard errors of Equation (2) on the quantities sold are reported in Table 3. In the models with control variables, access to cross-border shopping reduces the quantities sold by 9 and 6% for wine and hard liquor, while the corresponding reductions in the model without any control variables are 12 and 9%. Again, a likelihood-ratio test rejects no joint effects of the control variables ($p << 0.01$), and all the control variables are significant at the 5% level. The magnitudes of the control variables are similar to the estimates from Equation (1).

The estimated coefficients and associated standard errors of Equation (2) applied to sales values and excise tax revenue are reported in Table 4. Access to cross-border shopping is estimated to reduce the sales values of hard liquor and wine by 6.5 and 8.9%, and to reduce excise tax revenue by 6.3 and 9.5%. The fact that the coefficients are similar in magnitudes to those in Table 3, indicates that in terms of unit prices the alcoholic beverages bought

domestically, in the absence of cross-border shopping, are similar to those bought when cross-border shopping is available.

To estimate the loss in sales value and tax revenue in the stores of Vinmonopolet due to cross-border shopping, we use these estimated reductions combined with observed sales and excise tax revenue. Our benchmark is the observed sales values and excise tax revenue from alcoholic beverages in the last pre-pandemic year (2019) as given by our data. Counterfactual sales values and excise tax revenue are calculated by using the estimated reductions from Table 4. The difference between the observed and the counterfactual values are then used to calculate the VAT of 25%. The total loss in tax revenue from cross-border shopping is the sum of the lost excise tax revenue and the VAT revenue.

The calculations are shown in Table 5. The observed sales value (exclusive VAT and excise tax) for hard liquor was NOK 1,421 million in 2019. According to our estimates, cross-border shopping reduced the sales value by 6.5%, and the counterfactual value is $1{,}421/(1-0.065) = 1{,}520$ million, i.e., 99 million higher than the observed value. Observed excise tax revenue on hard liquor was 3,102 million, or 6.3% lower than the counterfactual value of $3{,}102/(1-0.063) = 3{,}311$, yielding an estimated loss of 209 million. A 25% VAT is levied on the sum of the sales value and the excise tax, i.e., $(0.25 \cdot [99+209]) = 77$ million in lost VAT. The total lost tax from cross-border shopping of hard liquor is the sum of the lost excise tax and VAT or NOK 286 million. Corresponding calculations for wine result in a lost tax revenue of NOK 657 million. The total loss in tax revenue for wine and hard liquor is NOK 943 million in 2019 prices.[14]

Tables 3 – 5 about here

[14] There was a reduction in the excise tax on wine by approximately 10% in January 2021. Accounting for this reduce this estimate to NOK 890 million in 2019 prices, assuming full pass-through of the tax reduction.

*5.3 Robustness*

The robustness of the estimated models is checked, and the results are available in Tables A1-A4 in the Appendix. First, during the pandemic there was less commuting, which resulted in reduced sales in some stores in the business districts of major cities. Local social restrictions were imposed on the municipality level. To check for contamination of the estimates by intra-municipality responses, we estimate the models using data aggregated to the municipality level. The driving time from each municipality to the nearest cross-border store is measured as the unweighted average of the driving times from all the stores in the municipality.[15] Correspondingly, the number of airline seats and driving times to the nearest airport and to the nearest accessible cross-border store are calculated as the averages for the stores in the municipality.[16] The results are reported in Column (2) in Table A1 and A2 for driving time and sales quantities of wine and hard liquor, respectively, and Column (2) in Tables A3 and A4 for sales quantities in the stores of Vinmonopolet of wine and hard liquor, respectively. The estimated effects of driving time are somewhat larger as compared to the baseline models reported in Column (1) of the tables. The effect of driving times between 30 and 60 minutes, increases from about 31 to 32% for wine and 20 to 22% for hard liquor. In Equation (2), access to cross-border shopping reduce the sales from 9 to 10% for wine and from 6 to 8% for hard liquor. Aggregating data to the the municipality level has minor effects on the significance, however, for hard liquor the effect of being a Swedish store becomes insignificant.[17]

[15] To estimate the models at the municipality level is potentially problematic for municipalities with a large area, a rural settlement pattern, and several stores.
[16] The dummy variable indicating if the nearest store is a pick-up location for online orders becomes a number between 0 and 1 for some municipalities. To maintain the dummy variable specification, we round these values up or down.
[17] Using the baseline models with data on the store level, as reported in Column (1) of the tables, but clustering the standard errors on the municipality instead of on the store level does not change any conclusions regarding inference.

Second, ten stores opened during the period, no store closed permanently, but some stores were partly closed for renovation. In the baseline models, all stores with a positive sale during any week of the period is included. To investigate the effects of only including the stores in full operation during the whole period, we run the models on a balanced panel of these stores. The results are reported in Column (3) of Tables A1-A4 and show that the coefficients for all practical purposes are unchanged compared with the baseline models.

Third, we check the effects of including stores with driving times up to 360 minutes, i.e., changing the control group to stores with less competition from cross-border shopping.[18] The results are shown in Column (4) in Tables A1-A4. The coefficients of Equation (1) are quite insensitive to this change of cutoff point, however, the coefficient for driving times between 210 and 240 minutes is positive and significant at the 1% level for hard liquor but remains insignificant for driving times between 150 and 210 minutes. The coefficients of Equation (2) are insensitive to this change of control group.

Fourth, forbidden comparisons can occur in two-way fixed effects models where units are treated at different times and the treatment effects are heterogenous, and such comparisons have been shown to be a potentially serious problem (Borusyak, Jaravel and Spiess, 2024). COVID-19 border closures varied over space and time, and we investigate this potential problem by implementing an informal test used by Friberg et al. (2024). The coefficients of the baseline model are compared to the estimates obtained by using a sample period with identical treatment of all units. All international borders were closed during the first 13 weeks of the pandemic, and the model is estimated only using these observations and the observations before the pandemic (week 1, 2019 to week 24, 2020). The results are reported

[18] Note that there is a slight difference between how this check is implemented in Equations (1) and (2). In Equation (1), interactions between $A^i_{s,w}$ and $D^i_s$ for driving bins up to 360 minutes is included, i.e., interactions up to $A^{12}_{s,w} \cdot D^{12}_s$. Equation (2) only have one variable capturing the effect of distance, and the way to change the control group to only stores with more than 360 minutes driving time in this equation is to drop observations between 180 and 360 minutes driving time and let our coefficient of interest still capture the effect for driving times less than 180 minutes.

in Column (5) in Tables A1-A4. Despite the large reduction in number of observations, the coefficients of interest remain reasonably similar to the coefficients based on the full sample.

## 6. Discussion

We find strong effects on sales of alcoholic beverages and tax revenues of cross-border shopping in areas near the border. The effects diminish (nearly) monotonically with distance, but remain significant up to 180 minutes driving time to a foreign alcohol shop. The effects on sales of travelling times are similar to effects found for other important Norwegian cross-border shopping products like beer, tobacco, and meat (Friberg et al., 2024; Beatty et al., 2009; Friberg et al., 2022). Strong and declining effects of travel time was also observed by Kluser (2023) in the Swiss grocery market.

The cross-border shopping survey of Statistics Norway (2023) estimated the value of alcoholic beverages purchased during cross-border shopping to be NOK 742 million in 2023. Our estimates suggest a value of NOK 1,784 million in 2023 prices.[19] This large discrepancy might be explained in at least two ways. First, cross-border shopping levels may not yet have normalized after the pandemic. As shown in Figure 3, sales in the stores of Vinmonopolet were substantially higher in 2022 than in 2019, and they were also 16% higher in in 2023 than in 2019. It is an open question to what extent the pandemic led to a permanent structural break in cross-border shopping habits or if they will return to pre-pandemic levels. If there has been a permanent structural break, our estimate may overestimate the current value of cross-border shopping. Second, the estimate of Statistic Norway is based on a survey while our estimate is based on revealed preferences. In survey settings, underreporting of alcohol consumption is a well-documented problem (Stockwell et al., 2004; Livingston and Callinan, 2015; Boniface et

[19] Taking the tax loss from Table 5 (NOK 943 million) and adding the lost sales value (NOK 582 million) yields a tax-inclusive product value of NOK 1,525 million in 2019 prices. Adjusting this number for the consumer price index, this corresponds to NOK 1,784 million in 2023 prices (Statistics Norway, 2024c).

al., 2014). It may arise because respondents have purchased more than the import quota or because they do not want to report to have purchased alcohol.

Our results provides valuable input for policymakers regarding the magnitude of cross-border shopping and the associated loss in tax revenues. An annual loss of tax revenue of NOK 943 million is about 4.4% of the total excise tax revenue collected from alcohol sales in 2019 (Government of Norway, 2020, p. 133).[20] Even though this is a non negligible amount of money, it is less than 0.1% of the total Norwegian tax revenue (excluding oil related revenues) in 2019. Furthermore, the lost tax revenue cannot be fully collected given the practical impossibility of prohibiting cross-border shopping of alcohol, and our estimate must be interpreted as an upper bound for the tax revenue potential. However, this upper bound provides valuable input into the on-going public debate regarding reductions in alcohol taxes to mitigate cross-border shopping (Berge, 2020; Lepperød and Ripegutu, 2021; Svendsrud, 2020). Furthermore, a main objective of Vinmonopolet is to reduce alcohol consumption. Our estimates suggest that cross-border shopping of wine and hard liquor reduces sales in Vinmonopolet by 9 and 6%, which indicates that cross-border trade constitutes a not inconsiderable share of alcohol consumption in Norway.

This study has some limitations. First, some of our control variables are measured on the monthly level. Our findings might have been different given data on weekly level. A similar problem relates to control variables that were measured on the municipality level. However, our robustness checks indicate that the results are robust across several specifications suggesting that these data issues do not affect the results substantially.

Second, the lack of data on changes in private storage, smuggling, and at-home production makes our result conditional on identical effects on sales in Vinmonopolet of changes in these channels in the treated and the control units. Commuting and travel habits

[20] The 2019 tax revenue excluding oil-related revenues amounted to NOK 1,030.9 billion (Government of Norway, 2020, p. 56).

changed significantly during the pandemic which might have resulted in changes in the private stocks of alcohol.[21] Changed access to alcohol from smuggling and at-home production during the pandemic may also have affected the sales. However, there is no indication on substantial changes, and these changes are hopefully captured by the fixed effects.[22]

Third, the identification of a causal relationship of cross-border shopping accessibility and domestic alcohol sales assumes that people did not anticipate periods with quarantines and planned their cross-border shopping activities accordingly. Given that the travel restrictions were generally hard to predict during the pandemic this should be a minor problem.

## 7. Conclusions

This study adds to the cross-border shopping literature by providing estimates of the effect of cross-border shopping on sales of alcoholic beverages in Norway. The lockdowns during the COVID-19 pandemic provided a natural experiment for studying the effects on domestic sales and tax revenue, and we use variations in cross-border shopping accessibility for identification of these effects. Access to cross-border shopping is estimated to reduce the domestic quantities sold of wine and hard liquor by 9 and 6%, respectively. We find significant effects of cross-border shopping up to 180 minutes driving time from the nearest cross-border store. Cross-border shopping is more important for wine than for hard liquor. If the cross-border purchased quantities in 2019 were replaced by domestic purchases in the

[21] Analysts in Vinmonopolet noticed significantly lower sales in the first weeks after the initial lockdown in March 2020 but did not observe similar reductions during other periods of the pandemic.
[22] Aasness and Nygård (2014) estimated the share of smuggled and illegal at-home produced alcohol to be 4.5% of the total spendings on alcoholic beverages in Norway, but the authors emphasized the uncertainty of this estimate.

stores of Vinmonopolet, it would have resulted in an additional NOK 943 million in annual tax revenue from VAT and excise taxes.

The sales in Vinmonopolet after the pandemic indicate that cross-border shopping either have changed permanently after the pandemic or has yet to return to normal levels. Identifying potential drivers for discrepancy between the short- and long-term effects of the pandemic on cross-border shopping is an interesting and policy relevant question for future research.

**Acknowledgements**

The authors want to thank Vinmonopolet for providing the data. Dario Tortarolo, Jakob Miethe, James Prieger, Dayea Oh, Christian Brauer Johanssen, and participants in seminars at Skatteforsk - Centre for Tax Research (grant number 341289 from The Research Council of Norway) at the Norwegian University of Life Sciences, Vinmonopolet, and the School of Public Policy at Pepperdine University who provided useful comments to previous versions of this paper.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**References**

Aasness, J. and Nygård, O.E. (2014). Revenue functions and Dupuit curves for indirect taxes with cross-border shopping. *International Tax and Public Finance*, 21: 272–297. https://doi.org/10.1007/s10797-013-9268-x

Asplund, M., Friberg, R., and Wilander, F. (2007). Demand and distance: Evidence on cross-border shopping. *Journal of Public Economics*, 91: 141–157. https://doi.org/10.1016/j.jpubeco.2006.05.006

Beatty, T. K. M., Larsen, E.R., and Sommervoll, D.E. (2009). Driven to drink: Sin taxes near a border. *Journal of Health Economics,* 28 (6): 1175–1184. https://doi.org/10.1016/j.jhealeco.2009.08.002

Ben Lakhdar, C., Vaillant, N.G., and Wolff, F.C. (2016). Does smoke cross the border? Cigarette tax avoidance in France. *European Journal of Health Economics*, 17: 1073–1089. https://doi.org/10.1007/s10198-015-0746-1

Berge, J. (2020, September 6). "Høyre vil ha billigere sprit og vin - møter sterk motstand: – Ikke riktig tidspunkt midt i en koronapandemi". [The Conservative Party wants cheaper hard liquor and wine – face strong opposition: Not the right time in the middle of a pandemic]. *Nettavisen Nyheter*. https://www.nettavisen.no/nyheter/hoyre-vil-ha-billigere-sprit-og-vin-moter-sterk-motstand-ikke-riktig-tidspunkt-midt-i-en-koronapandemi/s/12-95-3424014359

Bergsvik, D. (2023, December 22). "Alkoholomsetningen i Norge". [Alcohol sales in Norway]. https://www.fhi.no/le/alkohol/alkoholinorge/omsetning-og-bruk/alkoholomsetningen-i-norge/?term=

Boniface, S., Kneale, J., and Shelton, N. (2014). Drinking pattern is more strongly associated with under-reporting of alcohol consumption than socio-demographic factors: evidence from a mixed-methods study. *BMC public health*, 14: 1–9.

Borusyak, K., Jaravel, X., and Spiess, J. (2024). Revisiting event-study designs: Robust and efficient estimation. *The Review of Economic Studies*, rdae007. https://doi.org/10.1093/restud/rdae007

Chandra, A, Head, K., and Tappata, M. (2014). The economics of cross-border travel. *The Review of Economics and Statistics*, 96 (4): 648–661. https://doi.org/10.1162/REST_a_00404

Chiou, L. and Muehlegger, E. (2008). Crossing the line: Direct estimation of cross-border cigarette sales and the effect on tax revenue. *The B.E. Journal of Economic Analysis & Policy*, 8 (1). https://doi.org/10.2202/1935-1682.2027

Eurostat. (2024a). Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates. Eurostat Data Browser. Retrieved January 29, 2024. https://ec.europa.eu/eurostat/databrowser/view/PRC_PPP_IND__custom_4728663/default/table

Eurostat. (2024b). Purchasing power parities (prc_ppp). Reference Metadata in Euro SDMX Metadata Structure (ESMS). Retrieved January 29, 2024. https://ec.europa.eu/eurostat/cache/metadata/en/prc_ppp_esms.htm

Friberg, R., Halseth, E.M.S., Steen, F., and Ulsaker, S.A. (2024). The effect of cross-border shopping on commodity tax revenue: results from Norway's COVID-19 border closings. *Scandinavian J. of Economics*. https://doi.org/10.1111/sjoe.12559

Friberg, R., Steen, F., and Ulsaker, S.A. (2022). Hump-shaped cross-price effects and the extensive margin in cross-border shopping. *American Economic Journal: Microeconomics,* 14 (2): 408–38. https://doi.org/10.1257/mic.20190302

Google. (2023a). Distance Matrix API overview. Retrieved January 4, 2023. https://developers.google.com/maps/documentation/distance-matrix/overview

Google. (2023b). Distance Matrix API request and response. Retrieved January 4, 2023. https://developers.google.com/maps/documentation/distance-matrix/distance-matrix

Government of Norway. (2022, September 9). “Alkoholpolitikk”. [Alcohol policy]. https://www.regjeringen.no/no/tema/helse-og-omsorg/psykisk-helse/innsikt/alkohol/id2528164/

Government of Norway. (2020). “Meld. St. 1 (2020-2021). Nasjonalbudsjettet 2021”. [Meld. St. 1 (2020-2021). The National Bugdet 2021]. Ministry of Finance. https://www.regjeringen.no/contentassets/53adf7ea24b54e4a961005443231fd08/no/pdfs/stm202020210001000dddpdfs.pdf

Johansson, P., Pekkarinen, T., and Verho, J. (2014). Cross-border health and productivity effects of alcohol policies. *Journal of Health Economics,* 36: 125–136. https://doi.org/10.1016/j.jhealeco.2014.04.002

Kluser, F. (2023). Cross-border shopping: Evidence from Swiss household consumption. Technical report, Universitaet Bern, Departement Volkswirtschaft-CRED. https://frederickluser.github.io/

Lai, M.B., Cavicchi, A., Rickertsen, K., Corsi, A.M., and Casini, L. (2013). Monopoly and wine: The Norwegian case. *British Food Journal*, 115: 314–326. https://doi.org/10.1108/00070701311302267

Lepperød, T. and Ripegutu, H. (2021, October 12). “Raser mot alkohol-smell: – Nå jubler svenskene”. [Outrage over alcohol setback: Now the Swedes are celebrating]. *Nettavisen Økonomi*. https://www.nettavisen.no/okonomi/raser-mot-alkohol-smell-na-jubler-svenskene/s/12-95-3424189605

Livingston, M. and Callinan, S. (2015). Underreporting in alcohol surveys: whose drinking is underestimated? *Journal of studies on alcohol and drugs*, 76 (1): 158–164. https://doi.org/10.15288/jsad.2015.76.158

Manuszak, M.D. and Moul, C.C. (2009). How far for a buck? Tax differences and the location of retail gasoline activity in Southeast Chicagoland. *The Review of Economics and Statistics*, 91 (4): 744–765. https://doi.org/10.1162/rest.91.4.744

Melo, R.A. and Zarruk, D. (2022). Gmapsdistance: Distance and travel time between two points from Google Maps. R package version 4.0.0. https://CRAN.R-project.org/package=gmapsdistance

NAV. (2024). "Helt ledige". [Completely unemployed]. Retrieved March 12, 2024. https://www.nav.no/no/nav-og-samfunn/statistikk/arbeidssokere-og-stillinger-statistikk/helt-ledige

Ngo, A.P., Wang, X., Slater, S., Chriqui, J.F., Chaloupka, F.J., Yang, L., Smith, L., Li, Q. and Shang, C. (2021). Alcohol excise taxes as a percentage of retail alcohol prices in 26 OECD countries. *Drug and Alcohol Dependence*. 219. https://doi.org/10.1016/j.drugalcdep.2020.108415

Norwegian Customs. (2024). Shopping abroad. Retrieved February 10, 2023. https://www.toll.no/en/shopping-abroad/

Norwegian Institute of Public Health. (2023a). Earlier versions of maps – entry quarantine. Retrieved February 7, 2023. https://www.fhi.no/en/archive/covid-19-archive/covid-19-guidance-archived-articles/earlier-versions-of-maps/

Norwegian Institute of Public Health. (2023b). "Meldingssystem for smittsomme sykdommer (MSIS)". [Notification system for infectious diseases.] Retrieved February 10, 2023. https://statistikk.fhi.no/msis/sykdomshendelser?etter=diagnose&fordeltPaa=maaned&diagnose=713

Norwegian Institute of Public Health. (2021). "Til deg som har fått beskjed om å være hjemme i isolasjon eller karantene". [To those who have been told to stay at home in isolation or quarantine]. Retrieved March 12, 2023.

https://www.fhi.no/contentassets/9648bb76836841468f9f11022d2e0cf8/vedlegg/norsk-bokmal_hjemme-i-isolasjon-eller-karantene.pdf

The Norwegian Tax Administration. (2024). Alcoholic beverage tax. Retrieved April 16, 2024. https://www.skatteetaten.no/en/business-and-organisation/vat-and-duties/excise-duties/about-the-excise-duties/alcoholic-beverage-tax/

OECD. (2022). *Consumption Tax Trends 2022: VAT/GST and Excise, Core Design Features and Trends.* OECD Publishing, Paris. https://doi.org/10.1787/6525a942-en

Statistics Norway. (2024a). Air transport. Aircraft movements and available seats, by airport, traffic type and domestic/international flights 2009M01–2024M02. Retrieved March 12, 2024. https://www.ssb.no/en/statbank/table/08503/

Statistics Norway. (2024b, February 21). "Nordmenn grensehandlet for 9,3 milliarder kroner i 2023". [Norwegians cross-border shopped for 9.3 billion kroner in 2023]. https://www.ssb.no/varehandel-og-tjenesteyting/varehandel/statistikk/grensehandel/artikler/nordmenn-grensehandlet-for-9-3-milliarder-kroner-i-2023

Statistics Norway. (2024c). Consumer price index. Retrieved April 27, 2024. https://www.ssb.no/en/priser-og-prisindekser/konsumpriser/statistikk/konsumprisindeksen

Statistics Norway. (2023, November 24). Cross border trade. https://www.ssb.no/en/varehandel-og-tjenesteyting/varehandel/statistikk/grensehandel

Stockwell, T., Donath, S., Cooper-Stanbury, M., Chikritzhs, T., Catalano, P., and Mateo, C. (2004). Under-reporting of alcohol consumption in household surveys: a comparison of quantity–frequency, graduated–frequency and recent recall. *Addiction*, 99 (8): 1024–1033. https://doi.org/10.1111/j.1360-0443.2004.00815.x

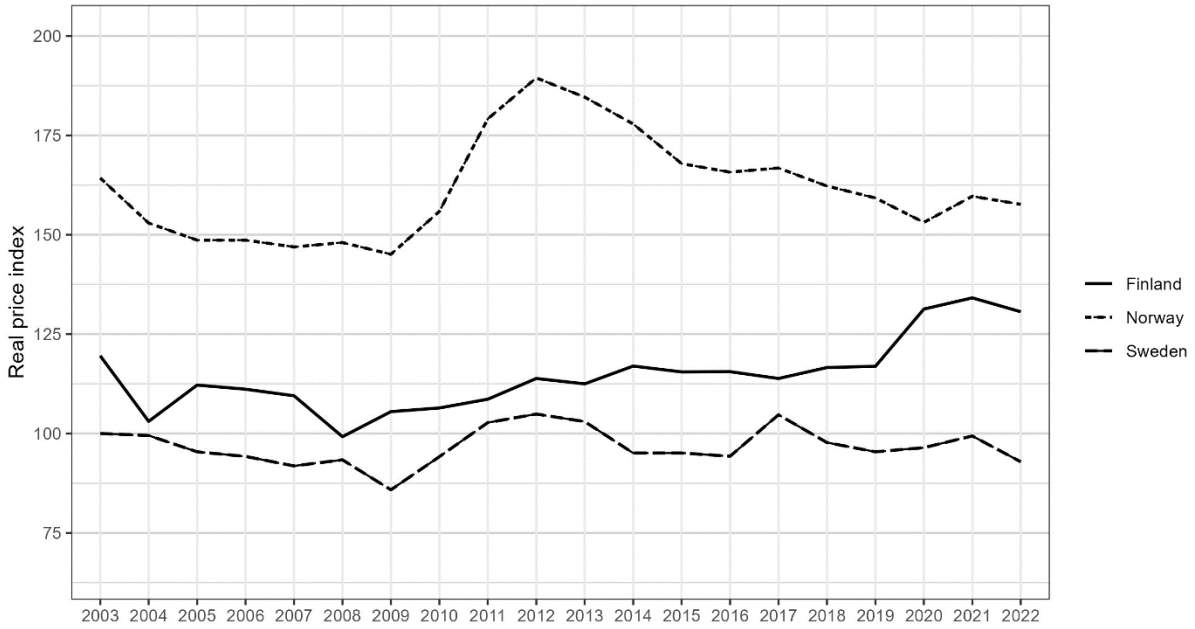
Svendsrud, B.K. (2020, October 15). “Norsk alkoholpolitikk i et nøtteskall”. [Norwegian alcohol policy in a nutshell]. https://civita.no/okonomi/skatt-og-avgifter/avgifter/norsk-alkoholpolitikk-i-et-notteskall/

Vinmonopolet. (2022, November 10). “Vinmonopolet åpner minst seks nye butikker i 2023”. [Vinmonopolet opens at least six new stores in 2023]. https://www.vinmonopolet.no/content/om-oss/butikker-og-vareutvalg/nye-vinmonopol-2023

Vinmonopolet. (2019, November 15). “Vinmonopolet åpner minst fem nye butikker i 2020”. [Vinmonopolet opens at least five new stores in 2020]. https://www.vinmonopolet.no/content/om-oss/pressemelding/2019/nye-vinmonopol-2020

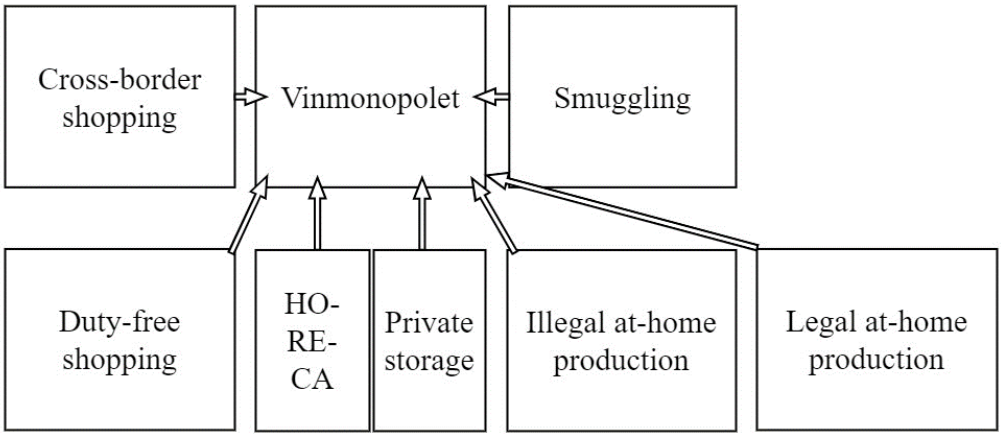
Zirgulis, A. (2023). Examining the effects of beer excise taxation on cross-border sales in border regions of the Baltic States. *Regional Studies.* https://doi.org/10.1080/00343404.2023.2228358

Figure 1. Real prices of alcoholic beverages in Norway, Sweden, and Finland, 2003-2022




*Notes*: Purchasing power parity (PPP) real price indexes for alcoholic beverages. The Swedish price = 100 in 2003.
*Source:* The figure is made by the authors based on data from Eurostat (2024a). For more details on the price indexes, see Eurostat (2024b).

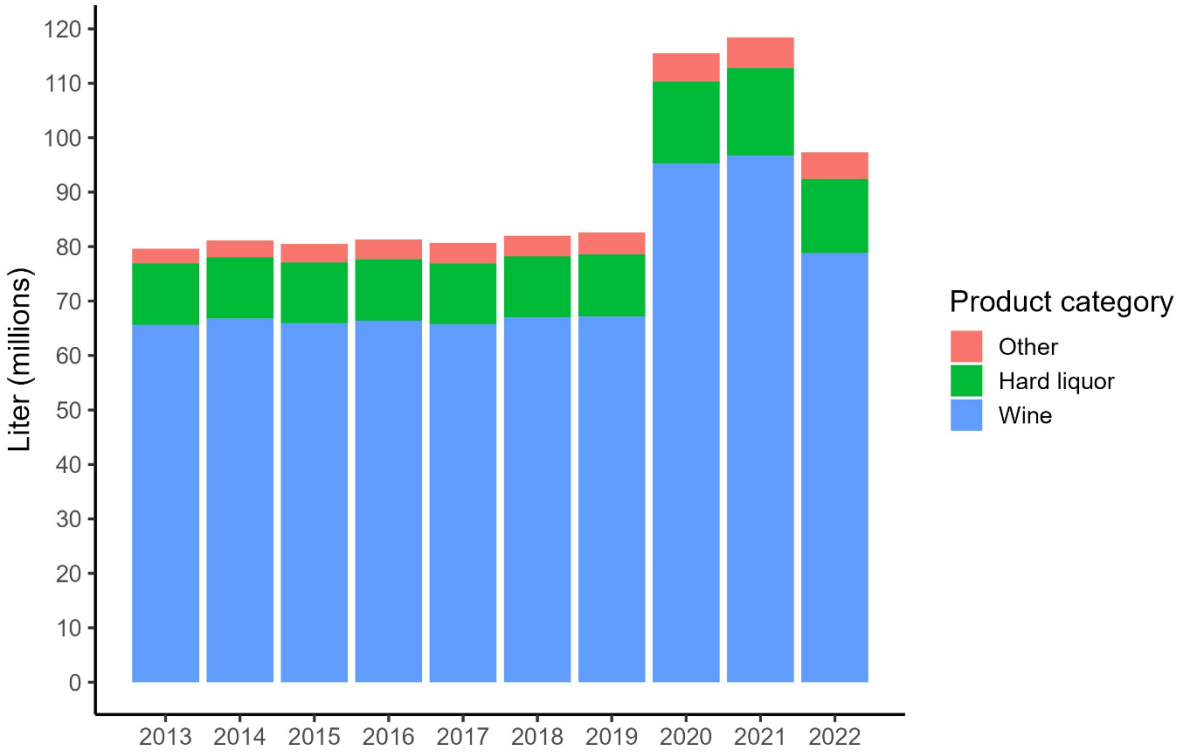
Figure 2. The Norwegian market for alcoholic beverages




| | | | | |
|---|---|---|---|---|
| Legal | Yes | Yes | No | Yes |
| Taxed | No | Yes | No | No |
| Quotas | Yes | No | No | No |

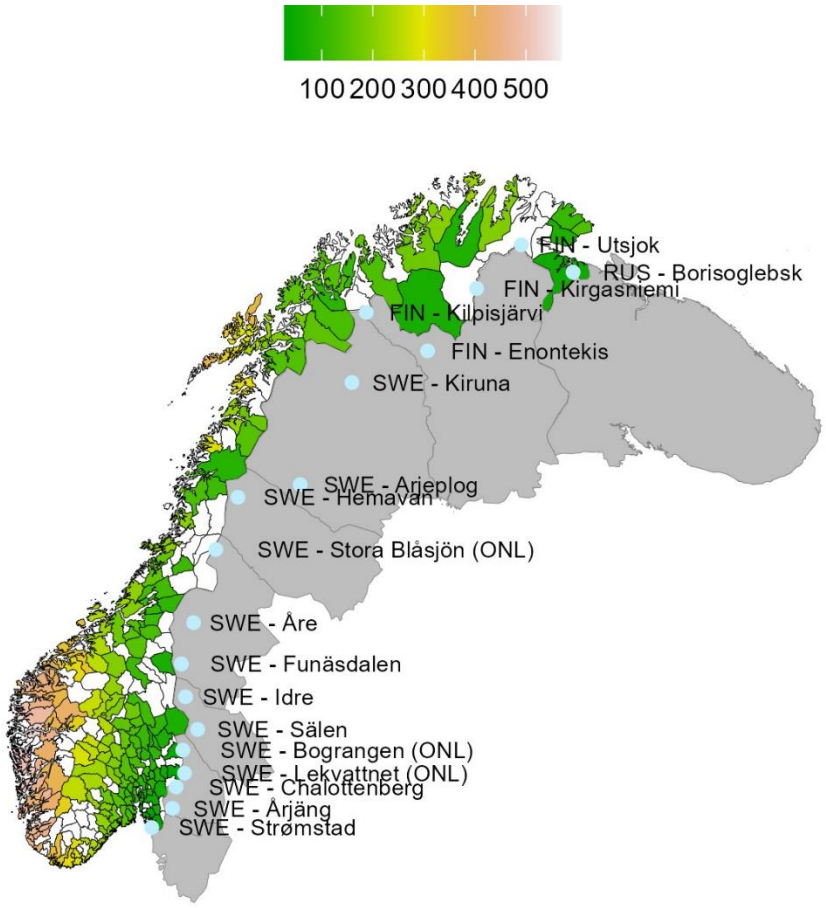
*Notes*: The channels affecting domestic sales of alcoholic beverages in the stores of Vinmonopolet are shown in the boxes. The HORCEA channel is responsible for sales to hotels, restaurants, and catering.

Figure 3. Total sales of different categories in the stores of Vinmonopolet



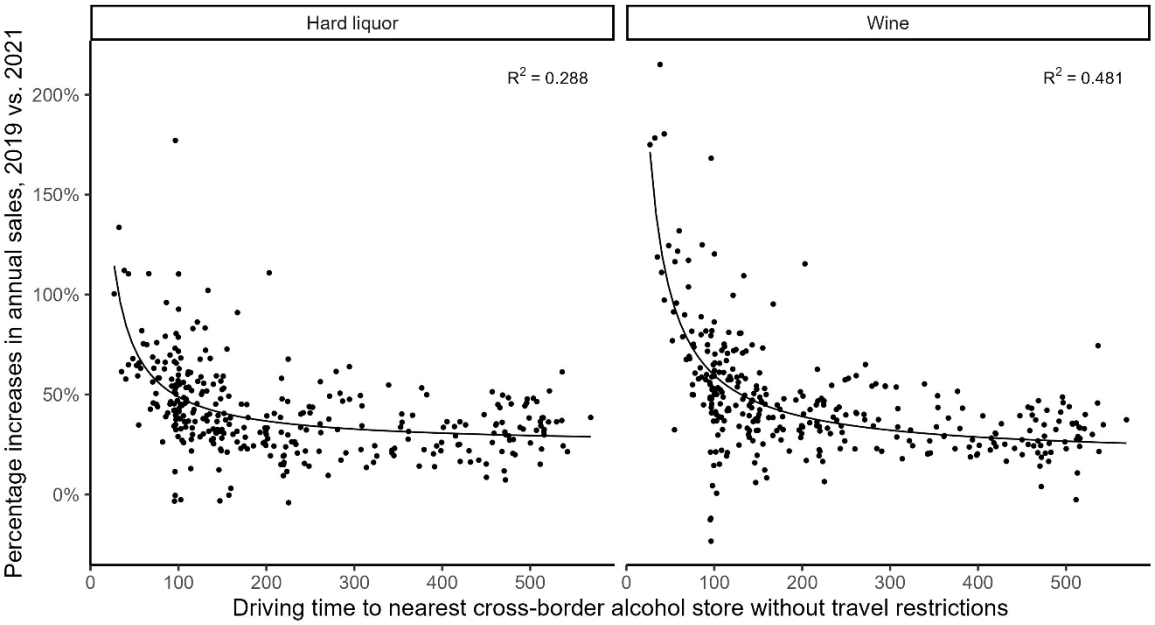

*Source:* The figure is made by the authors based on data from Vinmonopolet. Other consist of beer, fortified wine and alcohol free beverages.

Figure 4. Driving times in minutes to nearest cross-border alcohol store



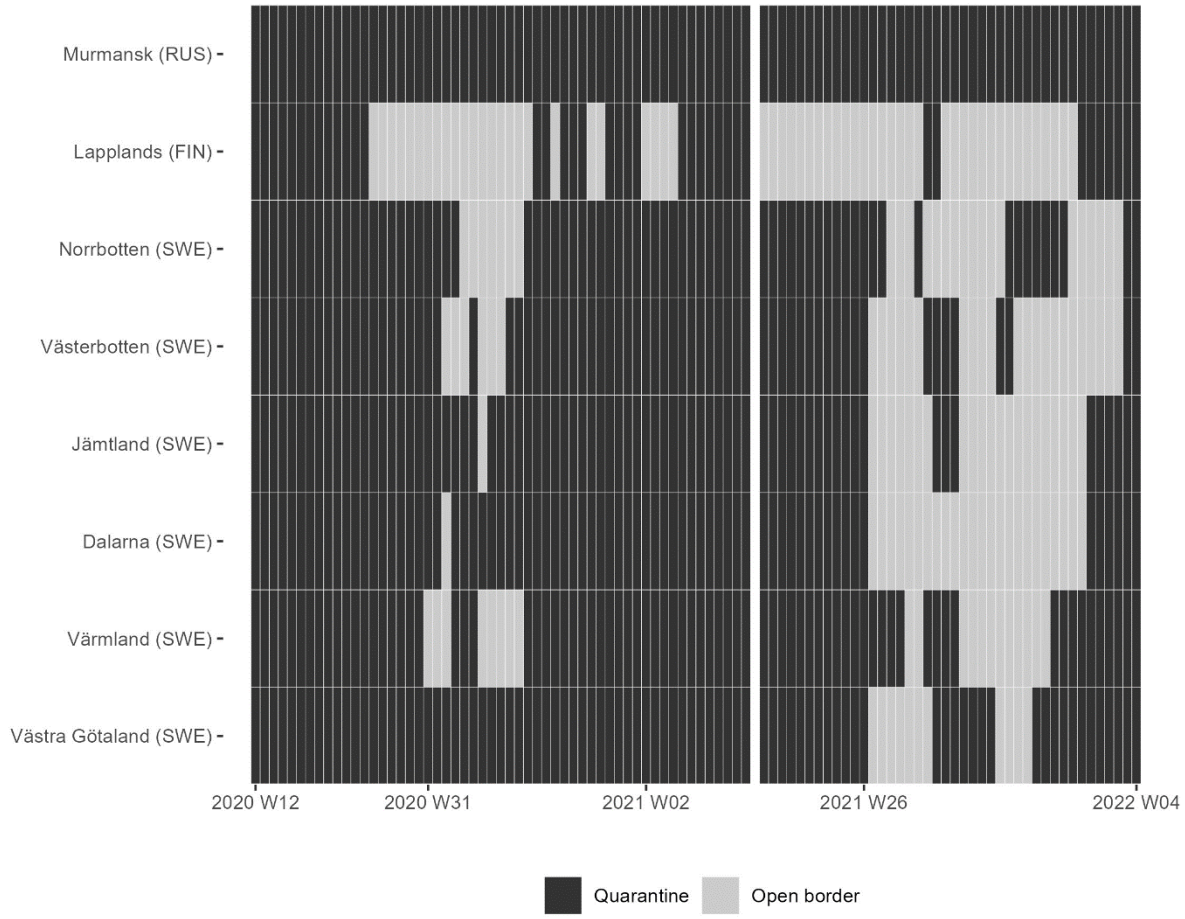

*Notes*: In the figure, SWE is Sweden, FIN is Finland, RUS is Russia, and (ONL) is a pick-up location for online orders. In white colored municipalities, there was no alcohol store during the period. In municipalities where Vinmonopolet had several stores, the average driving time is used for illustrative purposes in the figure.
*Source:* Data obtained from Google Matrix API (2023a) retrieved with an R-script using the *gmapsdistance* package developed by Melo and Zarruk (2022).

Figure 5. Percentage increases in annual sales from 2019 to 2021 and driving time



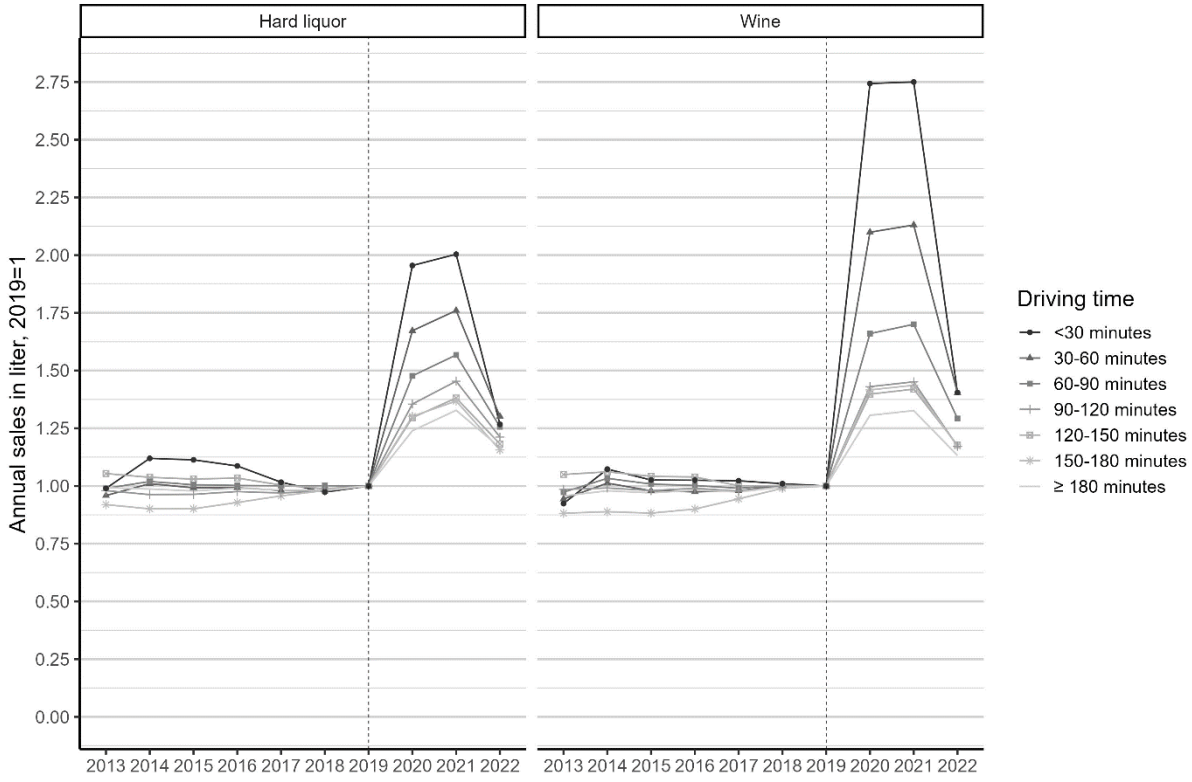

*Notes*: Each dot shows the correlation between the percentage increase in annual sales in a store and the driving time to the nearest cross-border alcohol store. Stores that opened during 2019 or were closed for periods due to renovations are not included in the plots. The curves are fitted by a reciprocal model.

Figure 6. Timing of travel restrictions to cross-border regions during the COVID-19 pandemic



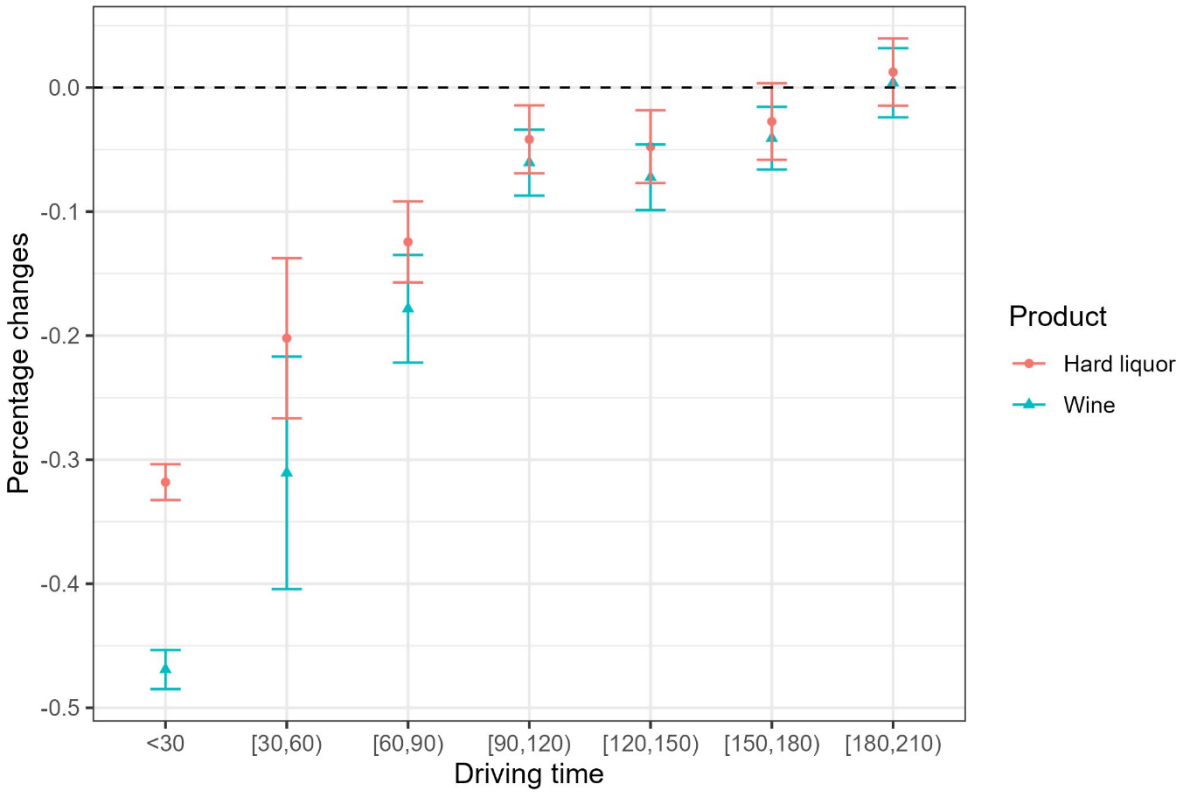

*Notes*: Periods when travels to each cross-border region resulted in a quarantine upon return. Data is missing for week 14 in 2021 (as indicated by white vertical line in Figure 6). The week numbers are defined according to the ISO week date standard (ISO-8601).
*Source:* The figure is made by the authors based on data from Norwegian Institute of Public Health (2023).

Figure 7. Developments in sales for each group of driving times




*Note*: The vertical dashed lines indicate 2019, which is the last year before the COVID-19 pandemic.

Figure 8. Driving time and changes in sales in the stores of Vinmonopolet




*Notes*: The estimated coefficients and 95% confidence intervals as estimated by Equation (1). The estimates are transformed by the exponential formula for interpretation as percentage changes.

Table 1. Descriptive statistics

| Variable | Definition | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| $Y_{s,w}^{HL}$ | Sales of hard liquor in liters in store *s* and week *w* | 774 | 594 | 0 | 6,826 |
| $Y_{s,w}^{Wine}$ | Sales of wine in liters in store *s* and week *w* | 4,654 | 4,114 | 0 | 48,170 |
| $V_{s,w}^{HL}$ | Value of sales of hard liquor (in NOK exclusive VAT and excise tax) in store *s* and week *w* | 103,151 | 87,681 | 0 | 1,309,654 |
| $V_{s,w}^{Wine}$ | Value of sales of wine (in NOK exclusive VAT and excise tax) in store *s* and week *w* | 390,390 | 415,557 | 0 | 6,586,148 |
| $T_{s,w}^{HL}$ | Excise tax revenue from hard liquor (in NOK) in store *s* and week *w* | 221,073 | 168,044 | 0 | 1,944,283 |
| $T_{s,w}^{Wine}$ | Excise tax revenue from wine (in NOK) in store *s* and week *w* | 283,716 | 251,149 | 0 | 3,070,326 |
| $C19_{s,w}$ | New COVID-19 cases as percent of population in the municipality of store *s* in (the month of) week *w* | 0.489 | 1.570 | 0 | 17.096 |
| $AS_{s,w}$ | International airline seats (in 10,000) available at the airport closest to store *s* in (the month of) week *w* | 44.6 | 67.0 | 0.0 | 231.7 |
| $DT_s$ | Driving time (in minutes) to the domestic airport closest to store *s* | 93.6 | 105.7 | 2.1 | 716.2 |
| $UR_{s,w}$ | Unemployment rate (in percent) in the municipality of store *s* in (the month of) week *w* | 2.888 | 2.022 | 0 | 29.800 |
| $D_s^1$ | 1 if there is a cross-border alcohol store < 30 min driving time away | 0.003 | | | |
| $D_s^2$ | 1 if there is a cross-border alcohol store between 30 and 60 minutes driving time away | 0.038 | | | |
| $D_s^3$ | 1 if there is a cross-border alcohol store between 60 and 90 minutes driving time away | 0.093 | | | |
| $D_s^4$ | 1 if there is a cross-border alcohol store between 90 and 120 minutes driving time away | 0.291 | | | |
| $D_s^5$ | 1 if there is a cross-border alcohol store between 120 and 150 minutes driving time away | 0.392 | | | |
| $D_s^6$ | 1 if there is a cross-border alcohol store between 150 and 180 minutes driving time away | 0.369 | | | |
| $D_s^7$ | 1 if there is a cross-border alcohol store between 180 and 210 minutes driving time away | 0.387 | | | |
| $A_{s,w}^1$ | 1 if driving time to the nearest accessible cross-border store < 30 minutes | 0.002 | | | |
| $A_{s,w}^2$ | 1 if driving time to the nearest accessible cross-border store is between 30 and 60 minutes | 0.023 | | | |
| $A_{s,w}^3$ | 1 if driving time to the nearest accessible cross-border store is between 60 and 90 minutes | 0.047 | | | |
| $A_{s,w}^4$ | 1 if driving time to the nearest accessible cross-border store is between 90 and 120 minutes | 0.145 | | | |
| $A_{s,w}^5$ | 1 if driving time to the nearest accessible cross-border store is between 120 and 150 minutes | 0.087 | | | |
| $A_{s,w}^6$ | 1 if driving time to the nearest accessible cross-border store is between 150 and 180 minutes | 0.050 | | | |
| $A_{s,w}^7$ | 1 if driving time to the nearest accessible cross-border store is between 180 and 210 minutes | 0.038 | | | |
| $SWE_{s,w}$ | 1 if the nearest accessible cross-border store is located in Sweden | 0.675 | | | |
| $ONL_{s,w}$ | 1 if the nearest accessible cross-border store is an online pick-up store | 0.120 | | | |

*Notes:* The dataset contains 209 weekly observations for 344 stores, in total 71,896 observations. All dummy variables are set to 0 if the condition specified in the definition is not met.

Table 2. Driving time and sold quantities in the stores of Vinmonopolet

| | Log of sales in liters | | | |
|---|---|---|---|---|
| | Hard liquor | | Wine | |
| $D_s^1 \cdot A_{s,w}^1$ | -0.416*** | -0.383*** | -0.669*** | -0.633*** |
| | (0.006) | (0.007) | (0.006) | (0.008) |
| $D_s^2 \cdot A_{s,w}^2$ | -0.259*** | -0.226*** | -0.408*** | -0.372*** |
| | (0.035) | (0.032) | (0.051) | (0.047) |
| $D_s^3 \cdot A_{s,w}^3$ | -0.167*** | -0.133*** | -0.231*** | -0.196*** |
| | (0.015) | (0.016) | (0.019) | (0.022) |
| $D_s^4 \cdot A_{s,w}^4$ | -0.085*** | -0.043*** | -0.106*** | -0.062*** |
| | (0.017) | (0.014) | (0.018) | (0.013) |
| $D_s^5 \cdot A_{s,w}^5$ | -0.062*** | -0.049*** | -0.086*** | -0.075*** |
| | (0.015) | (0.015) | (0.014) | (0.013) |
| $D_s^6 \cdot A_{s,w}^6$ | -0.036** | -0.028* | -0.050*** | -0.042*** |
| | (0.016) | (0.016) | (0.012) | (0.013) |
| $D_s^7 \cdot A_{s,w}^7$ | 0.004 | 0.012 | -0.006 | 0.004 |
| | (0.013) | (0.014) | (0.013) | (0.014) |
| $C19_{s,w}$ | | 0.012*** | | 0.013*** |
| | | (0.002) | | (0.002) |
| $AS_{s,w}/DT_s$ | | -0.023*** | | -0.030*** |
| | | (0.004) | | (0.005) |
| $UR_{s,w}$ | | -0.023*** | | -0.035*** |
| | | (0.003) | | (0.004) |
| $SWE_{s,w}$ | | -0.044** | | -0.078*** |
| | | (0.017) | | (0.016) |
| $ONL_{s,w}$ | | 0.049*** | | 0.037*** |
| | | (0.008) | | (0.008) |
| *N* | 70,565 | 70,565 | 70,568 | 70,568 |
| $R^2$ | 0.95 | 0.95 | 0.96 | 0.96 |
| Within $R^2$ | 0.03 | 0.05 | 0.06 | 0.08 |

*Notes*: The estimated coefficients of Equation (1) with fixed store and week effects. Store clustered standard errors in the parentheses. The number of observations is lower than the number of observations in the dataset (71,896) since some stores opened during the period of analysis and some were closed for periods due to renovations. The difference in the number of observations between hard liquor and wine is because three store-week observations had zero sales of hard liquor and non-zero sales of wine. $R^2$ denotes the share of explained variance between stores and within $R^2$ denotes the share of explained variance within each store. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 3. Cross-border shopping and sold quantities in the stores of Vinmonopolet

| | Log of sales in liters | | | |
|---|---|---|---|---|
| | Hard liquor | | Wine | |
| $\sum_{i=1}^{6}(D_s^i \cdot A_{s,w}^i)$ | -0.094*** | -0.066*** | -0.127*** | -0.099*** |
| | (0.011) | (0.009) | (0.012) | (0.011) |
| $C19_{s,w}$ | | 0.013*** | | 0.013*** |
| | | (0.002) | | (0.002) |
| $AS_{s,w}/DT_s$ | | -0.024*** | | -0.031*** |
| | | (0.005) | | (0.005) |
| $UR_{s,w}$ | | -0.024*** | | -0.037*** |
| | | (0.003) | | (0.005) |
| $SWE_{s,w}$ | | -0.043** | | -0.076*** |
| | | (0.019) | | (0.017) |
| $ONL_{s,w}$ | | 0.052*** | | 0.042*** |
| | | (0.009) | | (0.011) |
| *N* | 70,565 | 70,565 | 70,568 | 70,568 |
| $R^2$ | 0.95 | 0.95 | 0.96 | 0.96 |
| Within $R^2$ | 0.02 | 0.03 | 0.02 | 0.05 |

*Notes*: The estimated coefficients of Equation (2) with fixed store and week effects. Store clustered standard errors in the parentheses. The number of observations is lower than the number of observations in the dataset (71,896) since some stores opened during the period of analysis and some were closed for periods due to renovations. The difference in the number of observations between hard liquor and wine is because three store-week observations had zero sales of hard liquor and non-zero sales of wine. $R^2$ denotes the share of explained variance between stores and within $R^2$ denotes the share of explained variance within each store. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 4. Cross-border shopping, sales values, and excise tax revenue in the stores of Vinmonopolet

| | Log of sales value | | Log of excise tax revenue | |
|---|---|---|---|---|
| | Hard liquor | Wine | Hard liquor | Wine |
| $\sum_{i=1}^{6}(D_s^i \cdot A_{s,w}^i)$ | -0.067*** | -0.093*** | -0.065*** | -0.100*** |
| | (0.010) | (0.010) | (0.009) | (0.011) |
| $C19_{s,w}$ | 0.016*** | 0.016*** | 0.014*** | 0.013*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| $AS_{s,w}/DT_s$ | -0.027*** | -0.034*** | -0.024*** | -0.031*** |
| | (0.005) | (0.005) | (0.005) | (0.005) |
| $UR_{s,w}$ | -0.027*** | -0.041*** | -0.024*** | -0.037*** |
| | (0.003) | (0.005) | (0.003) | (0.005) |
| $SWE_{s,w}$ | -0.046** | -0.070*** | -0.042** | -0.076*** |
| | (0.018) | (0.017) | (0.018) | (0.017) |
| $ONL_{s,w}$ | 0.054*** | 0.041*** | 0.052*** | 0.042*** |
| | (0.009) | (0.010) | (0.009) | (0.011) |
| *N* | 70,227 | 70,230 | 70,227 | 70,230 |
| $R^2$ | 0.95 | 0.96 | 0.95 | 0.96 |
| Within $R^2$ | 0.04 | 0.05 | 0.04 | 0.05 |

*Notes*: The estimated coefficients of Equation (2) with fixed store and week effects using sales value (exclusive VAT and excise tax) or excise tax as the dependent variable. Store clustered standard errors in the parentheses. The number of observations is lower than the number of observations in the dataset (71,896) since some stores opened during the period of analysis and some were closed for periods due to renovations. The difference in the number of observations between hard liquor and wine is because three store-week observations had zero sales of hard liquor and non-zero sales of wine. $R^2$ denotes the share of explained variance between stores and within $R^2$ denotes the share of explained variance within each store. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table 5. Estimated losses in sales and tax revenues in million NOK in 2019 prices

| | Hard liquor | Wine | Total |
|---|---|---|---|
| Sales value (exclusive VAT and excise tax) | | | |
| Observed | 1,421 | 4,943 | 6,364 |
| Counterfactual | 1,520 | 5,426 | 6,946 |
| Loss | 99 | 483 | 582 |
| Excise tax | | | |
| Observed | 3,102 | 4,087 | 7,189 |
| Counterfactual | 3,311 | 4,516 | 7,827 |
| Loss | 209 | 429 | 638 |
| VAT [a] | | | |
| Observed | 1,131 | 2,258 | 3,389 |
| Counterfactual | 1,208 | 2,486 | 3,694 |
| Loss | 77 | 228 | 305 |
| Total tax loss (VAT + excise tax) | 286 | 657 | 943 |

*Note*: [a)] 25% VAT is levied on the sum of the sales value and excise tax.

**Appendix tables for robustness checks** (or for referee's use)

Table A1. Driving time and sold quantities of wine in the stores of Vinmonopolet, robustness checks

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $D_s^1 \cdot A_{s,w}^1$ | -0.633*** | -0.640*** | -0.633*** | -0.636*** | -0.647*** |
| | (0.008) | (0.008) | (0.008) | (0.009) | (0.013) |
| $D_s^2 \cdot A_{s,w}^2$ | -0.372*** | -0.387*** | -0.371*** | -0.373*** | -0.440*** |
| | (0.047) | (0.055) | (0.047) | (0.047) | (0.055) |
| $D_s^3 \cdot A_{s,w}^3$ | -0.196*** | -0.214*** | -0.201*** | -0.197*** | -0.252*** |
| | (0.022) | (0.027) | (0.022) | (0.022) | (0.043) |
| $D_s^4 \cdot A_{s,w}^4$ | -0.062*** | -0.098*** | -0.062*** | -0.063*** | -0.078*** |
| | (0.013) | (0.012) | (0.014) | (0.014) | (0.028) |
| $D_s^5 \cdot A_{s,w}^5$ | -0.075*** | -0.071*** | -0.074*** | -0.076*** | -0.077*** |
| | (0.013) | (0.012) | (0.013) | (0.014) | (0.029) |
| $D_s^6 \cdot A_{s,w}^6$ | -0.042*** | -0.042*** | -0.041*** | -0.042*** | -0.055* |
| | (0.013) | (0.012) | (0.013) | (0.013) | (0.030) |
| $D_s^7 \cdot A_{s,w}^7$ | 0.004 | -0.005 | 0.007 | 0.004 | 0.034 |
| | (0.014) | (0.015) | (0.014) | (0.014) | (0.068) |
| $D_s^8 \cdot A_{s,w}^8$ | | | | 0.004 | |
| | | | | (0.009) | |
| $D_s^9 \cdot A_{s,w}^9$ | | | | -0.001 | |
| | | | | (0.017) | |
| $D_s^{10} \cdot A_{s,w}^{10}$ | | | | -0.026 | |
| | | | | (0.019) | |
| $D_s^{11} \cdot A_{s,w}^{11}$ | | | | 0.009 | |
| | | | | (0.013) | |
| $D_s^{12} \cdot A_{s,w}^{12}$ | | | | 0.006 | |
| | | | | (0.016) | |
| $C19_{s,w}$ | 0.013*** | 0.010*** | 0.012*** | 0.013*** | 0.182* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.096) |
| $AS_{s,w}/DT_s$ | -0.030*** | -0.033*** | -0.030*** | -0.030*** | -0.008 |
| | (0.005) | (0.005) | (0.005) | (0.004) | (0.006) |
| $UR_{s,w}$ | -0.035*** | -0.033*** | -0.034*** | -0.035*** | -0.029*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| $SWE_{s,w}$ | -0.078*** | -0.053*** | -0.079*** | -0.078*** | -0.088*** |
| | (0.016) | (0.016) | (0.016) | (0.016) | (0.033) |
| $ONL_{s,w}$ | 0.037*** | 0.033*** | 0.038*** | 0.037*** | 0.065*** |
| | (0.008) | (0.009) | (0.009) | (0.008) | (0.021) |
| *N* | 70,568 | 56,850 | 69,248 | 70,568 | 8,001 |
| $R^2$ | 0.96 | 0.99 | 0.96 | 0.96 | 0.98 |
| Within $R^2$ | 0.08 | 0.12 | 0.08 | 0.08 | 0.16 |

*Notes*: Results of robustness checks of Equation (1) with log of sales of wine in liters as the dependent variable. Column (1) is the last column in Table 2 and is included for ease of comparison. Column (2) reports the results from a model estimated at the municipality (rather than store) level. Column (3) reports the results from a model estimated using a balanced panel of the stores that operated during the whole period. Column (4) reports the results from a model including stores with up to 360 minutes (rather than 210 minutes) driving time. Column (5) reports the results from a model estimated for the period week 1, 2019 to week 24, 2020 when all borders were either open or closed resulting in identical treatment of the stores. Store clustered standard errors in the parentheses except for in Column (2) with municipality clustered standard errors. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table A2. Driving time and sold quantities of hard liquor in the stores of Vinmonopolet, robustness checks

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $D_s^1 \cdot A_{s,w}^1$ | -0.383*** | -0.393*** | -0.382*** | -0.375*** | -0.313*** |
| | (0.007) | (0.007) | (0.007) | (0.009) | (0.010) |
| $D_s^2 \cdot A_{s,w}^2$ | -0.226*** | -0.246*** | -0.225*** | -0.217*** | -0.262*** |
| | (0.032) | (0.036) | (0.032) | (0.033) | (0.039) |
| $D_s^3 \cdot A_{s,w}^3$ | -0.133*** | -0.145*** | -0.135*** | -0.124*** | -0.185*** |
| | (0.016) | (0.018) | (0.017) | (0.017) | (0.031) |
| $D_s^4 \cdot A_{s,w}^4$ | -0.043*** | -0.079*** | -0.042*** | -0.034** | -0.067*** |
| | (0.014) | (0.012) | (0.014) | (0.014) | (0.022) |
| $D_s^5 \cdot A_{s,w}^5$ | -0.049*** | -0.051*** | -0.048*** | -0.041*** | -0.046 |
| | (0.015) | (0.016) | (0.015) | (0.015) | (0.029) |
| $D_s^6 \cdot A_{s,w}^6$ | -0.028* | -0.034** | -0.027* | -0.020 | -0.070*** |
| | (0.016) | (0.016) | (0.016) | (0.016) | (0.027) |
| $D_s^7 \cdot A_{s,w}^7$ | 0.012 | 0.004 | 0.013 | 0.021 | 0.023 |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.042) |
| $D_s^8 \cdot A_{s,w}^8$ | | | | 0.026*** | |
| | | | | (0.010) | |
| $D_s^9 \cdot A_{s,w}^9$ | | | | 0.018 | |
| | | | | (0.015) | |
| $D_s^{10} \cdot A_{s,w}^{10}$ | | | | 0.004 | |
| | | | | (0.016) | |
| $D_s^{11} \cdot A_{s,w}^{11}$ | | | | 0.016 | |
| | | | | (0.011) | |
| $D_s^{12} \cdot A_{s,w}^{12}$ | | | | 0.006 | |
| | | | | (0.016) | |
| $C19_{s,w}$ | 0.012*** | 0.010*** | 0.012*** | 0.012*** | 0.111* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.061) |
| $AS_{s,w}/DT_s$ | -0.023*** | -0.023*** | -0.024*** | -0.023*** | -0.003 |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.005) |
| $UR_{s,w}$ | -0.023*** | -0.022*** | -0.023*** | -0.023*** | -0.021*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| $SWE_{s,w}$ | -0.044** | -0.022 | -0.044*** | -0.047*** | 0.000 |
| | (0.017) | (0.016) | (0.017) | (0.017) | (0.036) |
| $ONL_{s,w}$ | 0.049*** | 0.044*** | 0.050*** | 0.052*** | 0.058*** |
| | (0.008) | (0.009) | (0.009) | (0.008) | (0.016) |
| *N* | 70,565 | 56,850 | 69,245 | 70,565 | 8,001 |
| $R^2$ | 0.95 | 0.98 | 0.95 | 0.95 | 0.97 |
| Within $R^2$ | 0.05 | 0.07 | 0.05 | 0.05 | 0.10 |

*Notes*: Results of robustness checks of Equation (1) with log of sales of hard liquor in liters as the dependent variable. Column (1) is the second column in Table 2 and is included for ease of comparison. Column (2) reports the results from a model estimated at the municipality (rather than store) level. Column (3) reports the results from a model estimated using a balanced panel of the stores that operated during the whole period. Column (4) reports the results from a model including stores with up to 360 minutes (rather than 210 minutes) driving time. Column (5) reports the results from a model estimated for the period week 1, 2019 to week 24, 2020 when all borders were either open or closed resulting in identical treatment of the stores. Store clustered standard errors in the parentheses except for in Column (2) with municipality clustered standard errors. Significance codes: * $p <$ 0.10, ** $p < 0.05$, and *** $p < 0.01$.

Table A3. Cross-border shopping and sold quantities of wine in the stores of Vinmonopolet, robustness checks

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $\sum_{i=1}^{6}(D_s^i \cdot A_{s,w}^i)$ | -0.099*** | -0.110*** | -0.099*** | -0.102*** | -0.129*** |
| | (0.011) | (0.013) | (0.011) | (0.011) | (0.022) |
| $C19_{s,w}$ | 0.013*** | 0.011*** | 0.012*** | 0.013*** | 0.188* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.099) |
| $AS_{s,w}/DT_s$ | -0.031*** | -0.038*** | -0.031*** | -0.032*** | -0.009 |
| | (0.005) | (0.006) | (0.005) | (0.005) | (0.006) |
| $UR_{s,w}$ | -0.037*** | -0.034*** | -0.036*** | -0.041*** | -0.031*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.004) |
| $SWE_{s,w}$ | -0.076*** | -0.050*** | -0.077*** | -0.088*** | -0.097*** |
| | (0.017) | (0.018) | (0.017) | (0.019) | (0.035) |
| $ONL_{s,w}$ | 0.042*** | 0.039*** | 0.043*** | 0.047*** | 0.072*** |
| | (0.011) | (0.012) | (0.011) | (0.012) | (0.023) |
| *N* | 70,568 | 56,850 | 69,248 | 64,091 | 8,001 |
| $R^2$ | 0.96 | 0.99 | 0.96 | 0.96 | 0.98 |
| Within $R^2$ | 0.05 | 0.07 | 0.05 | 0.05 | 0.09 |

*Notes*: Results of robustness checks of Equation (2) with log of sales of wine in liters as the dependent variable. Column (1) is the last column in Table 3 and is included for ease of comparison. Column (2) reports the results from a model estimated at the municipality (rather than store) level. Column (3) reports the results from a model estimated using a balanced panel of the stores that operated during the whole period. Column (4) reports the results from a model where the control group consist of stores with more than 360 minutes (rather than 180 minutes) driving time. Column (5) reports the results from a model estimated for the period week 1, 2019 to week 24, 2020 when all borders were either open or closed resulting in identical treatment of the stores. Store clustered standard errors in the parentheses except for in Column (2) with municipality clustered standard errors. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table A4. Cross-border shopping and sold quantities of hard liquor in the stores of Vinmonopolet, robustness checks

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $\sum_{i=1}^{6}(D_s^i \cdot A_{s,w}^i)$ | -0.066*** | -0.080*** | -0.066*** | -0.065*** | -0.094*** |
| | (0.009) | (0.011) | (0.009) | (0.010) | (0.017) |
| $C19_{s,w}$ | 0.013*** | 0.010*** | 0.012*** | 0.012*** | 0.115* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.065) |
| $AS_{s,w}/DT_s$ | -0.024*** | -0.026*** | -0.025*** | -0.024*** | -0.004 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| $UR_{s,w}$ | -0.024*** | -0.023*** | -0.024*** | -0.026*** | -0.022*** |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.003) |
| $SWE_{s,w}$ | -0.043** | -0.021 | -0.043** | -0.052*** | -0.004 |
| | (0.019) | (0.017) | (0.019) | (0.020) | (0.039) |
| $ONL_{s,w}$ | 0.052*** | 0.048*** | 0.053*** | 0.057*** | 0.061*** |
| | (0.009) | (0.010) | (0.009) | (0.010) | (0.017) |
| *N* | 70,565 | 56,850 | 69,245 | 64,088 | 8,001 |
| $R^2$ | 0.95 | 0.98 | 0.95 | 0.95 | 0.97 |
| Within $R^2$ | 0.03 | 0.05 | 0.04 | 0.04 | 0.07 |

*Notes*: Results of robustness checks of Equation (2) with log of sales of hard liquor in liters as the dependent variable. Column (1) is the second column in Table 3 and is included for ease of comparison. Column (2) reports the results from a model estimated at the municipality (rather than store) level. Column (3) reports the results from a model estimated using a balanced panel of the stores that operated during the whole period. Column (4) reports the results from a model where the control group consist of stores with more than 360 minutes (rather than 180 minutes) driving time. Column (5) reports the results from a model estimated for the period week 1, 2019 to week 24, 2020 when all borders were either open or closed resulting in identical treatment of the stores. Store clustered standard errors in the parentheses except for in Column (2) with municipality clustered standard errors. Significance codes: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.