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# Is the Grass Greener on the Other Side?

*Impacts of Cross-Border Alcohol Shopping on Tax Revenue*

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# Abstract

In this thesis, we examine how available cross-border shopping affects Vinmonopolet's sales volume and the affiliated loss of tax revenue. Leveraging COVID-19 border closures as an exogenous shock, it employs an imputation-based differences-in-differences methodology that offers a clean identification strategy for the causal effect of available cross-border shopping. We utilize a constructed panel data set with weekly sales data from all 345 Vinmonopolet liquor stores over the period 2018–2022.

The results indicate cross-border alcohol shopping reduces overall Vinmonopolet sales for treated outlets by 13%, reaching 48% for outlets within 45 minutes of Sweden. Heterogeneous effects are found across four main alcohol categories; beer, wine, fortified wine, and spirits. Total estimated tax revenue losses were NOK 871 million in 2019, driven primarily by lower alcohol excise tax receipts. The findings have implications for Norwegian alcohol policy and addressing the trade-off between public health goals and mitigating tax leakage from cross-border shopping. Our estimates are robust using several robustness checks.

***Keywords*** – NHH, master thesis, economics, 2sdid, cross-border shopping, Vinmonopolet, excise tax

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# 1 Introduction

Tax revenue from sales of alcoholic beverages is among the largest contributors to the Norwegian National Budget. With high inflation and a constantly aging population, the need to finance public expenditures is as pressing as ever. At the same time, Norwegians carry out millions of day trips to Sweden yearly to purchase cheaper alcohol, tobacco, sweets, and groceries. In fact, Milford et al. (2012) found that half of the Norwegian population engages in cross-border shopping, compared to one in ten for other European countries. Statistics Norway (2022) found that Norwegians spent over 2.5 billion NOK on cross-border shopping in the first quarter of 2022, with close to 80 percent being spent in Sweden. Cross-border shopping therefore constitutes a considerable economic phenomenon between Norway and Sweden, facilitated by their shared border and the countries' mutual agreement allowing citizens unrestricted travel.

The major reason for the extensive cross-border shopping is the price difference between Norway and Sweden, and the easily available shopping due to the long border and unrestricted travel. Norwegian alcohol policy is restrictive compared to other nations, and the prices for alcoholic beverages are among the highest in the world. A staple of the Norwegian alcohol policy is Vinmonopolet, a state-owned liquor monopoly. Without economic incentives to increase sales, and through being subject to legislation limiting the availability of alcohol, Vinmonopolet is meant to contribute to curbing the harmful usage of alcohol. However, it could also further drive leakage of alcohol sales to Sweden. If alcohol is made *too* unavailable, it might drive more people to go cross-border shopping, thereby further reducing Norwegian tax revenue. In our thesis, we wish to answer the following research question:

*"What is the effect of cross-border shopping on the sales volume of Vinmonopolet, and how large is the affiliated change in tax revenue?"*

To answer this question, we leverage border closures during the COVID-19 pandemic as a natural experiment that abruptly restricted access to lower-priced alcohol across the border in Sweden.

An imputation-based differences-in-differences methodology is employed using weekly sales data from all 345 Vinmonopolet stores over the period 2018–2022. By comparing stores proximate to Sweden with those farther away before and after border closures, we offer a clean identification strategy to isolate the effect of unavailable cross-border shopping. Economic theory suggests cross-border shopping will decrease for a good when transportation costs to purchase it abroad become too high relative to cross-country price differences. Thus, we anticipate larger effects for Vinmonopolet stores near the Swedish border that lost access to substantially cheaper alcohol options during COVID-19 restrictions.

The analysis reveals cross-border shopping for alcohol reduces overall Vinmonopolet sales for treated outlets by 13%, with a 48% sales drop within a 45-minute drive of Sweden. Heterogeneous effects are found across beverage categories related to factors like consumer preferences and alcohol import quotas. We estimate that cross-border shopping reduced tax revenues from Vinmonopolet's sales by NOK 871 million in 2019, with two-thirds of losses stemming from lower excise tax receipts.

This thesis contributes robust empirical evidence on the fiscal and economic impacts of cross-border shopping. The results have implications for Norwegian alcohol taxation policy and addressing the trade-off between public health objectives and mitigating tax leakage.

We have structured the paper in the following manner: In Chapter 2, we give a brief background relating to cross-border shopping between Norway and Sweden, the alcohol policy in these two countries, and a brief timeline of the COVID-19 pandemic from a Norwegian perspective. In Chapter 3 we give a brief overview of previous relevant literature on the subject of cross-border shopping before we present a theoretical model of consumer choices in Chapter 4. Chapter 5 gives an overview of the data sources used to construct our panel data set for the empirical analysis, as well as descriptive statistics. Chapter 6 presents the imputation-based differences-in-differences approach used for our analysis. Finally, we present our results and discuss them, along with several robustness checks, in Chapter 7.

# 2 Background

Cross-border shopping from Norway to Sweden is extensive, sustained by the countries' mutual agreement allowing unrestricted travel for their citizens and sharing the longest border on the European continent (Land Survey, 2023). Furthermore, Norway generally maintains higher cost levels, particularly in areas such as alcohol, tobacco, candy, and other goods detrimental to health, due to substantial excise taxes.

In this thesis, cross-border shopping is defined as: *The act of traveling to a foreign country to purchase goods that can be brought back to Norway without Norwegian taxes being imposed, with the clear intent of consuming these goods within Norway.*

Section 2.1 looks at the extent of cross-border shopping between Norway and Sweden, exploring its magnitude and implications. In Section 2.2, we examine the alcohol policy and consumption trends in both countries, shedding light on the factors influencing cross-border shopping behavior. Section 2.3 discusses the timeline and restrictions imposed during the COVID-19 pandemic, especially related to travel and alcohol consumption.

## 2.1 Cross-Border Shopping in Norway

Norwegian cross-border shopping in Sweden is widespread compared to its European counterparts. A 2012 survey conducted by Milford et al. (2012, p. 3) found that half of the Norwegian population participated in cross-border shopping, in contrast to the one in ten individuals engaging in similar activities in other European countries. Subsequent data from a September 2019 survey by Statistics Norway (SSB) further emphasized the prevalence, indicating that Norwegians spent a substantial NOK 2 billion on day trips to foreign countries, with nearly 88 percent (approximately NOK 1.8 billion) spent on cross-border shopping in Sweden (Statistics Norway, 2020, p. 12).

A more recent and comprehensive survey initiated by SSB in January 2022 painted a continued picture of substantial cross-border shopping. During the first quarter of 2022 alone, Norwegians spent NOK 2.5 billion on cross-border shopping, with approximately 80% (NOK 2 billion) spent in Sweden, showcasing a sustained and perhaps even growing trend (Statistics Norway, 2022, p. 15). Notably, this survey, like its 2019 predecessor, employed an online questionnaire, collecting data immediately after a month was over. This makes it interesting to compare and contrast the findings from these two distinct time periods, shedding light on any shifts or consistencies in cross-border shopping behavior (Statistics Norway, 2022, p. 7).

Table 2.1 presents the distribution of transaction amounts in 2010, 2019, and 2022. There was a decrease in spending on groceries and sweets but an increase in other categories from 2010 to 2019. Conversely, from 2019 to 2022, there was an upward trend in expenditures for groceries and sweets, along with other categories, while spending on the remaining categories declined.

**Table 2.1:** Share of cross-border shopping by category

| | % of total 2010 | % of total 2019 | % of total 2022 | Growth (%) 2010–2019 | Growth (%) 2019–2022 |
|---|---|---|---|---|---|
| Groceries and sweets | 49 | 40 | 46 | -9 | 6 |
| Alcoholic beverages | 16 | 18 | 13 | 2 | -5 |
| Tobacco | 14 | 16 | 12 | 2 | -4 |
| Non-alcoholic beverages | 6 | 11 | 10 | 5 | -1 |
| Other | 15 | 15 | 19 | 0 | 4 |

**Source:** Statistics Norway (2020, 2022) and The Confederation of Norwegian Enterprise (2020)

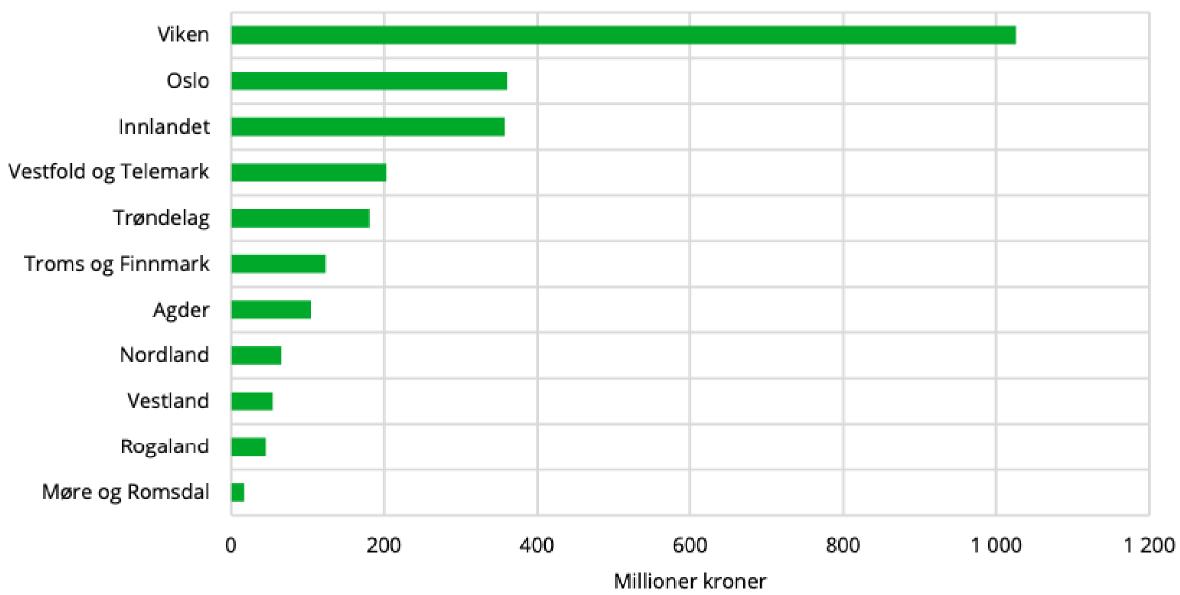
Of particular interest to our thesis is the observation that the proportion of spending on alcoholic beverages decreased from 2019 to 2022. This shift in consumer behavior could indicate that Norwegian consumers increased purchases of alcoholic beverages at Vinmonopolet, which we will look into further in Chapter 7.

A Danish survey conducted in 2018 revealed that Danes allocated one-third of their cross-border transaction amount to highly taxed goods. This stands in contrast to Norwegians, who, in comparison, dedicate over half of their total transaction amount to similar goods (Statistics Norway, 2020, p. 9). There could be several reasons for this, the most apparent one being that the "highly taxed goods" have higher tax rates in Norway than in Denmark, especially when compared to neighboring countries. This could indicate that Norwegians are "saving" more on cross-border shopping relative to Danes.

Indeed, this seems to be the case concerning Norwegian cross-border shopping in Sweden, with price levels generally being lower in Sweden, especially for highly taxed goods such as alcohol, tobacco, and sweets (Eurostat, 2022). This price discrepancy, in addition to Norway and Sweden sharing the longest land border within Europe, positions Swedish grocery and retail stores as easily accessible for a significant portion of the Norwegian population (Land Survey, 2023).

As highlighted by Statistics Norway (2022), the geographical distribution of cross-border shopping within Norway further supports this pattern. Residents of eastern Norway exhibit a higher tendency for cross-border shopping in Sweden compared to their counterparts in western Norway. Figure 2.1 illustrates this trend, revealing that people from eastern Norway spend the most on cross-border shopping in Sweden. Viken is the county with the highest transaction amount, closely followed by Oslo and Innlandet as the two counties with the joint second-highest transaction amounts (Statistics Norway, 2022, p. 20). This geographical variation in spending emphasizes the interaction between accessibility, price differences, and consumer behavior in shaping the landscape of cross-border shopping between Norway and Sweden.

**Figure 2.1:** Transaction amount used on cross-border shopping by county




**Source:** Statistics Norway (2022)

To better understand cross-border shopping behavior, it is important to explore other considerations, in addition to the geographical location of cross-border consumers, such as income level. The Institute of Transport Economics looked at this demographic factor in a survey conducted in 2005.

The findings indicated that low-income consumers were more inclined to engage in cross-border shopping compared to their high-income counterparts (Institute of Transport Economics, 2006, p. 24). The relationship between income and cross-border shopping behavior suggests that the nature of consumer decisions in the context of cross-border shopping is complex. Economic factors play an important role in shaping the motivations and patterns of cross-border shopping among different demographic groups. Understanding these dynamics contributes to a more nuanced and comprehensive perspective on the factors influencing cross-border shopping behavior.

The scope of cross-border shopping by Norwegians has undergone a notable transformation from the early 2000s to the present day. Initially, it served as a supplement for Norwegians to complement their domestic shopping. However, in recent years, cross-border shopping has become a competitor for the Norwegian food and beverage industry. This shift in dynamics, where cross-border shopping now directly competes with domestic consumption, has large consequences for the Norwegian economy.

As the scope of cross-border shopping continues to expand, the competitiveness of the Norwegian food and beverage industry may diminish. The Confederation of Norwegian Enterprise (2023) states that this could result in fewer jobs, diminished value creation, and a reduction in investments within the industry. Furthermore, The Confederation of Norwegian Enterprise (NHO) conducted calculations to examine the potential impact of policy changes. Specifically, removing taxes on items such as chocolate, sugar products, and non-alcoholic beverages, along with cutting the taxes on alcohol and tobacco in half, is estimated to result in the creation of 3000 new jobs in the food industry and 4800 new jobs in the retail sector (The Confederation of Norwegian Enterprise, 2020).

These calculations highlight the interaction between taxation, cross-border shopping dynamics, and societal considerations. The results suggest that an adjustment in taxation could mitigate revenue losses for the government through decreased cross-border shopping, and thereby foster economic growth and new employment opportunities.

## 2.2 Alcohol Policy in Norway and Sweden

Norway distinguishes itself from many European counterparts through the implementation of a highly restrictive alcohol policy aimed at limiting alcohol consumption and its associated negative impacts (Ministry of Health and Care Services, 2022a). Higher alcohol consumption in the population is related to a greater prevalence of harmful and high-risk consumption patterns. The Norwegian government believes that an effective strategy to address this issue involves reducing overall alcohol consumption in the population. Harmful and high-risk consumption, in this context, refers to increased alcohol intake, heightening the likelihood of unfortunate consequences such as a rise in alcohol abuse and alcohol-related injuries, thereby increasing societal costs. The main pillars of Norway's restrictive alcohol policy include a state-owned liquor monopoly, excise taxes on alcohol, a licensing system, an advertising ban, and age restrictions (Ministry of Health and Care Services, 2021, p. 17). In the following, we look closer at the first two.

Vinmonopolet, the state-owned liquor monopoly, was established in 1922 to ensure the supply and sale of wine across the country, while at the same time taking social considerations into account. This state retail monopoly holds exclusive rights to sell alcoholic products with an alcohol by volume (ABV) exceeding 4.7 percent. By being a government-owned entity, Vinmonopolet operates without any incentive or economic interest to increase sales. Consequently, it can effectively restrict and regulate the availability of alcohol, employing measures such as controlling opening hours (Ministry of Health and Care Services, 2022b). Additionally, high excise taxes on alcohol in Norway contribute significantly to higher alcohol prices, serving as a complementary mechanism to discourage excessive consumption.

Table 2.2 shows the level of the excise tax on alcohol in Norway in NOK from 2017 to 2023. The tax is calculated through two distinct methods: for spirits and for alcoholic beverages with an ABV ranging from 4.7% to 22%, it is calculated per volume percent per litre, while for the rest, it is calculated per litre. The tax has been increased nominally all years, except for 2021.

**Table 2.2:** Alcohol tax in Norway 2017–2023, NOK

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Spirits above 0.7% | 7.46 | 7.58 | 7.69 | 7.84 | 8.11 | 8.22 | 8.45 |
| Alcoholic beverages 0.7–2.7% | 3.34 | 3.39 | 3.44 | 3.51 | 3.27 | 3.31 | 3.40 |
| Alcoholic beverages 2.7–3.7% | 12.54 | 12.74 | 12.93 | 13.18 | 12.28 | 12.44 | 12.79 |
| Alcoholic beverages 3.7–4.7% | 21.72 | 22.07 | 22.50 | 22.83 | 21.27 | 21.55 | 22.15 |
| Alcoholic beverages 4.7–22% | 4.86 | 4.94 | 5.01 | 5.11 | 4.76 | 4.82 | 4.95 |

**Source:** The Norwegian Tax Administration (2023b)

In accordance with standard economic theory, there is an anticipated inverse relationship between price and demand, leading to a decrease in consumption as prices rise[1]. Vinmonopolet's ability to limit availability in combination with excise taxes on alcohol are therefore two of the main contributions of Norwegian policy aimed at reducing alcohol consumption (Ministry of Health and Care Services, 2022b).

In addition to the excise tax, alcohol sales in Norway are subject to both Value Added Tax (VAT) of 25 percent and a beverage packaging tax, which comprises an environmental tax and a basic tax. Both components of the beverage packaging tax are paid per unit, but the environmental tax varies based on the type of beverage packaging and can be reduced depending on the return percentage. Specifically, if the return percentage is 95% or higher, only the basic tax is applicable. However, the basic tax is only paid if the packaging cannot be reused in its original form (The Norwegian Tax Administration, 2023a). Table 2.3 provides an overview of the different tax rates for beverage packaging from 2017 to 2023, with all values denominated in NOK.

[1] There will be an exception for Giffen goods, as for such goods the consumption will decrease as prices decrease and vice versa.

**Table 2.3:** Beverage packaging tax, NOK

| | Glass and Metals | Plastic | Cartons and Cardboard |
|---|---|---|---|
| *2017* | | | |
| Environmental Tax | 5.70 | 3.44 | 1.41 |
| Basic Tax | 1.17 | 1.17 | 1.17 |
| *2018* | | | |
| Environmental Tax | 5.79 | 3.50 | 1.43 |
| Basic Tax | 1.19 | 1.19 | 1.19 |
| *2019* | | | |
| Environmental Tax | 5.88 | 3.55 | 1.45 |
| Basic Tax | 1.21 | 1.21 | 1.21 |
| *2020* | | | |
| Environmental Tax | 5.99 | 3.62 | 1.48 |
| Basic Tax | 1.23 | 1.23 | 1.23 |
| *2021* | | | |
| Environmental Tax | 6.20 | 3.75 | 1.53 |
| Basic Tax | 1.27 | 1.27 | 1.27 |
| *2022* | | | |
| Environmental Tax | 6.28 | 3.80 | 1.55 |
| Basic Tax | 1.29 | 1.29 | 1.29 |
| *2023* | | | |
| Environmental Tax | 6.46 | 3.91 | 1.59 |
| Basic Tax | 1.33 | 1.33 | 1.33 |

**Source:** Ministry of Finance (2017, 2018, 2020, 2023)

The excise tax on alcohol is the fifth-largest contributor to the Norwegian national budget excluding offshore activities, following employer's national insurance contributions, taxes on income and wealth, VAT, and taxes on automobiles (Prop 1. S, 2023-2024, p. 216). Table 2.4 provides the nominal revenue generated from the excise tax on alcohol, as well as its share within the total tax revenue in the period 2017–2023.

**Table 2.4:** Total revenue from excise tax on alcohol and share, 2017–2023, excluded oil

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Revenue from excise tax on alcohol (MNOK) | 13,692 | 14,138 | 14,425 | 17,660 | 17,954 | 16,369 | 15,000 [2] |
| Share of total tax revenue | 1.3 % | 1.4 % | 1.4 % | 1.7 % | 1.6 % | 1.3 % | 1.1 % |

**Source:** Prop 1. S (2022-2023, 2023-2024)

In an interview with VG, Petter Haas Brubakk, the CEO of Food Drink Norway (NHO Mat og Drikke), highlighted a concerning trend resulting from the increasing alcohol taxes. He suggested that the increasing taxes are leading to a shift in alcohol sales away from Vinmonopolet to alternative channels, such as cross-border and tax-free shopping, as well as smuggling activities. According to their calculations, the tax loss related to cross-border and tax-free shopping alone is estimated to be around NOK 2 billion. Beyond the direct financial impact, this shift in consumption patterns is also expected to lead to a loss in value creation, job opportunities, and increased costs associated with organized smuggling (Haugan & Bergan, 2017).

Therefore, it is important for the government to balance the consideration of higher taxes to limit alcohol consumption against the unintended consequences of individuals seeking alternatives, such as cross-border shopping, engaging in the production of homemade alcohol (moonshine), or resorting to smuggling as a means of evading these high taxes (Ministry of Health and Care Services, 2021). This emphasizes the complex challenge faced by policymakers in managing the trade-off between public health goals and the potential economic and societal consequences associated with shifts in consumer behavior driven by tax policies.

Another important aspect of the Norwegian alcohol policy is the import quota on tobacco and alcohol, allowing consumers to bring a specified amount of these products into Norway without incurring additional taxes. The current quotas are: 1 litre of spirits, 1.5 litres of wine, 2 litres of beer, and 100 cigarettes or 125g of other tobacco products and 100 sheets of cigarette paper (Norwegian Customs, 2023). The allowance for spirits can be exchanged for an additional 1.5 litres of wine or beer, and the initial allowance for wine can be

[2] Estimate from National Budget.

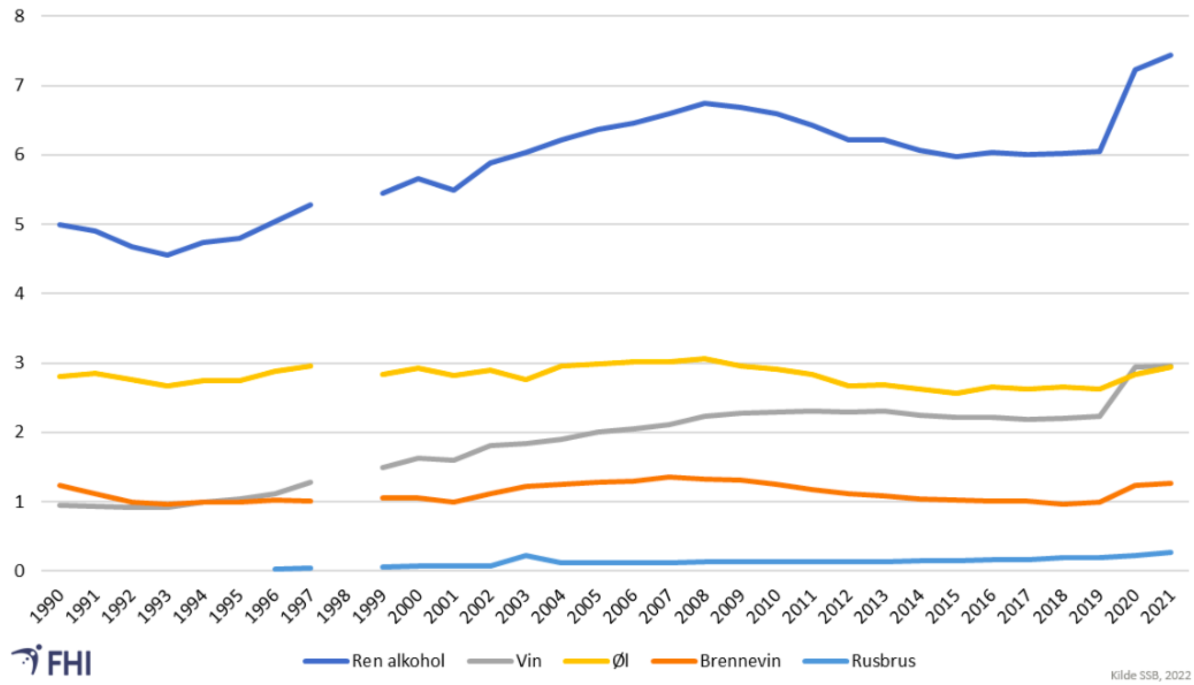
exchanged per litre for additional beer/cider. Before 1st January 2022, the allowance for tobacco could be exchanged for an additional 1.5 litres of wine or beer. However, after this date it was no longer possible to exchange the tobacco quota for additional wine or beer (Ministry of Finance, 2021a).

There is generally a broad consensus concerning Norwegian alcohol policy, although there are still some variations across the political spectrum. The traditional left, represented by parties such as Arbeiderpartiet (AP), Rødt (R), and Sosialistisk Venstreparti (SV), wants to maintain the restrictive alcohol policy. This includes maintaining a high excise tax on alcohol, preserving the existence of Vinmonopolet, and transferring the airport tax-free arrangement to Vinmonopolet. Additionally, SV wants a reduction in the import quota on alcohol (Sosialistisk Venstreparti, 2021). Continuing with a high excise tax on alcohol while reducing the import quota could reduce cross-border shopping as long as compliance levels are high enough.

Contrastingly, the traditional right, with parties such as Høyre (H) and Fremskrittspartiet (FrP), leans towards a more liberal stance on alcohol policy. Their agenda involves reducing the excise tax on alcohol to levels more aligned with neighboring countries and extending the opening hours for the sale of alcoholic beverages. This positioning highlights a key distinction between political ideologies, with parties on the right adopting a more liberal approach compared to their counterparts on the left.

Since the year 2000, Norway has consistently reported the lowest alcohol turnover among the Nordic countries, while Denmark has recorded the highest levels. Reported alcohol turnover excludes cross-border and tax-free shopping and smuggling. In 2020, the per capita alcohol turnover among residents aged 15 or older in the different Nordic countries was as follows: 9.3 litres in Denmark, 8.1 litres in Finland, 7.3 litres in Sweden, and 7.2 litres in Norway (Lund & Bye, 2022). Examining the historical trajectory in Norway from 1993 to 2008, there was a notable increase in alcohol turnover during this period before a subsequent decline that continued until 2020. Figure 2.2 shows this development.

**Figure 2.2:** Alcohol turnover in Norway, litre per capita aged 15 or older




**Source:** Bergsvik (2022)

In 2021, the reported alcohol turnover per Norwegian resident aged 15 or older was 7.44 litres of pure alcohol, marking the highest level ever recorded in Norway's alcohol statistics (Bergsvik, 2022). This represented a notable increase in reported alcohol consumption compared to the previous year, with a rise of 2.9%. Two primary factors likely contributed to this increase.

Firstly, the increase in alcohol consumption during the pandemic, when individuals were largely confined to their homes, played a significant role. The unique circumstances and challenges posed by the pandemic potentially influenced behaviors, including heightened alcohol consumption.

Secondly, the unavailability of cross-border shopping due to travel restrictions and closed borders potentially contributed to increased alcohol sales within Norway. With traditional avenues for cross-border shopping restricted, individuals turned to domestic sources for their alcohol purchases, resulting in a notable uptick in reported alcohol turnover.

The alcohol policy in Sweden is similar to that of Norway, featuring relatively high excise taxes on alcohol and the restriction of alcohol sales above 3.5% to Systembolaget, a state-owned liquor monopoly, which is highly similar to Norway's Vinmonopolet. Recently, Systembolaget has faced legal challenges in the Swedish Supreme Court. The court ruled in favor of Winefinder, a Danish online wine retailer, allowing it to sell wine in Sweden based on the European Union's principle of free movement of goods (Högsta Domstolen, 2023).

Like Norway, Sweden employs pricing mechanisms, particularly excise taxes, to curb alcohol consumption. However, the excise tax in Sweden is lower than that in Norway, and overall alcohol prices tend to be lower in Sweden. Table 2.5 illustrates the Swedish excise tax from 2017 to 2023, denominated in SEK. The tax is calculated in two different ways: for spirits and beer, it is calculated per volume percent per litre, while for other categories, it is calculated per litre. Sweden did not adjust the nominal tax rates for inflation in the period 2017–2022, but increased most nominal rates in 2023. Real tax rates therefore decreased in the time period.

**Table 2.5:** Alcohol tax Sweden 2017–2023, SEK

| | 2017-2022 | 2023 |
|---|---|---|
| Beer above 2.8% | 2.12 | 2.02 |
| Wine and other fermented beverages 2.25–4.5% | 9.19 | 9.65 |
| Wine and other fermented beverages 4.5–7% | 13.58 | 14.26 |
| Wine and other fermented beverages 7–8.5% | 18.69 | 19.62 |
| Wine and other fermented beverages 8.5–15% | 26.18 | 27.49 |
| Wine and other fermented beverages 15–18% | 54.79 | 57.53 |
| Mid-range products 1.2–15% | 32.99 | 34.64 |
| Mid-range products 15–22% | 54.79 | 57.33 |
| Spirits above 1.2% | 516.59 | 521.76 |

**Sources:** The Swedish Tax Agency (2023a, 2023b)

Comparing the figures in Table 2.2 with those in Table 2.5 it is apparent that Sweden has lower excise taxes on alcohol than Norway. To illustrate the magnitude of this difference, we have constructed a "basket", Table 2.6, comprising 22 different alcoholic beverages within 4 different categories. The basket utilizes the average price, inclusive VAT, in NOK within each category.[3] We converted the excise tax levels in Sweden from Swedish kronor to Norwegian kroner using the average exchange rate through October 2023, which equaled 98.98 (DNB, 2023).

The example highlights significant variations, with instances where the Norwegian excise

[3]More details are provided in Table A.1 and Table A.2 in the Appendix.

tax on alcohol is more than twice the amount levied in Sweden. For the overall "basket", the excise tax in Norway is 43.44% higher than that in Sweden. Without considering additional costs such as transportation expenses, this substantial difference implies that Norwegian consumers can achieve cost savings by engaging in cross-border shopping. The economic rationale for cross-border shopping becomes evident when individuals seek to capitalize on the more favorable excise tax environment across the border in Sweden.

**Table 2.6:** Price difference Norway and Sweden 2023, NOK

| | Wine | Spirits | Fortified Wine | Beer | Total |
|---|---|---|---|---|---|
| Price Norway | 150.57 | 399.55 | 221.65 | 51.40 | 823.17 |
| Price Sweden | 112.82 | 288.69 | 156.09 | 24.78 | 582.38 |
| Difference Price | 37.75 | 110.86 | 65.56 | 26.62 | 240.78 |
| Difference % | 25.07 % | 27.75 % | 29.58 % | 51.79 % | 29.25 % |
| Excise Tax Norway | 43.62 | 240.30 | 67.29 | 10.14 | 361.35 |
| Excise Tax Sweden | 20.41 | 146.86 | 37.06 | 0.04 | 204.37 |
| Difference Excise Tax | 23.21 | 93.43 | 30.23 | 10.10 | 156.98 |
| Difference % | 53.22 % | 38.88 % | 44.93 % | 99.58 % | 43.44 % |

**Note:** The basket is constructed based on the two most sold products at Vinmonopolet in 2022 within 11 alcohol categories sold in both Norway and Sweden.

## 2.3 The COVID-19 Pandemic

The initial cases of COVID-19 were identified in Wuhan, China, in December 2019, initially referred to as cases of "pneumonia of unknown causes" (World Health Organization, 2022). In early January 2020, the World Health Organization (WHO) issued its first Disease Outbreak Report, where, based on information from the Chinese investigation team, it was initially reported that there was no evidence of human-to-human transmission (World Health Organization, 2020). However, by 9$^{th}$ January, it was confirmed that the outbreak was attributed to a novel coronavirus. Approximately two weeks after the initial Disease Outbreak Report, WHO acknowledged in a press briefing that limited human-to-human transmission was possible. During this period, the first death linked to the virus was reported in China, and the first case outside China was identified.

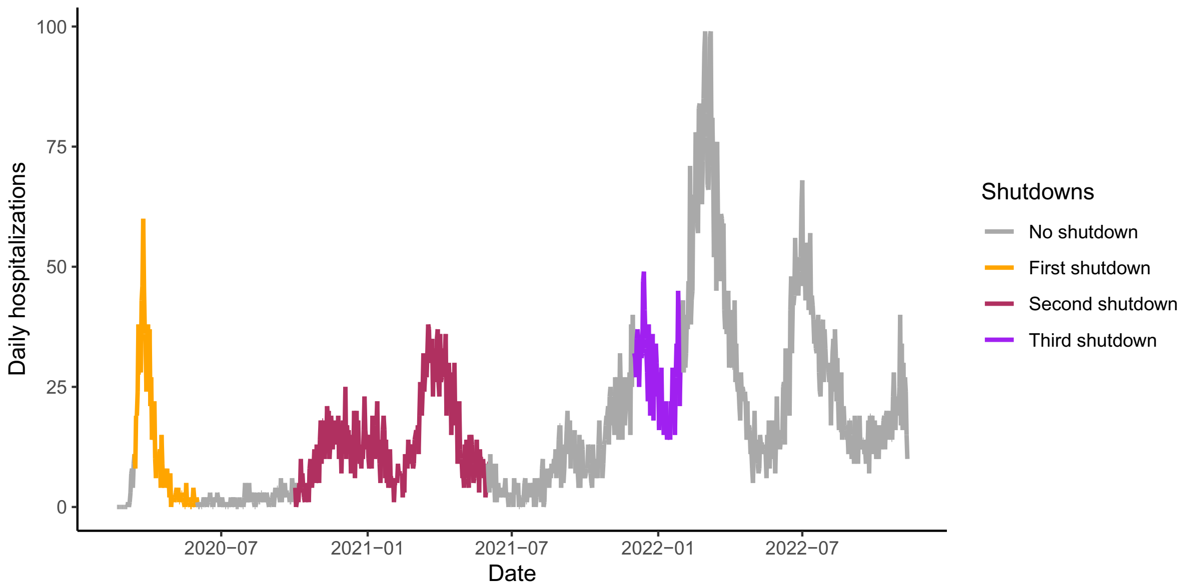
By the end of January 2020, the Director-General of WHO declared the outbreak a public health emergency of international concern, the organization's highest level of alarm. On 11$^{th}$ February, WHO officially named the coronavirus COVID-19 (World Health

Organization, 2022).

In February 2020, Norway reported its first case of COVID-19, and by the end of March, the number of infections had surged dramatically. The first death associated with COVID-19 was reported on 12th March 2020. On that same day, Norwegian authorities made the decision to implement comprehensive measures aimed at reducing the infection rate (Tjernshaugen et al., 2023). This marked a pivotal moment in Norway's response to the pandemic, as the gravity of the situation became apparent, prompting swift and significant actions to mitigate the spread of the virus and safeguard public health.

In the trajectory of the COVID-19 pandemic, infection rates, hospitalizations, and mortality rates followed a cyclical pattern commonly referred to as "waves" (NOU 2023: 16, 2023, p. 18). As illustrated in Figure 2.3, seven distinct waves occurred throughout the course of the pandemic. The varying colors represent periods when different mutations of the virus were predominant. These waves of infection prompted three significant shutdowns initiated by the Norwegian government.

**Figure 2.3:** Daily hospitalizations due to COVID-19




**Note:** The figure plots daily hospitalizations with COVID-19 as the main reason throughout the pandemic. It also indicates the three major shutdowns of Norwegian society, in which most daily life was subdued.

The first shutdown commenced on 12th March 2020 and extended until the summer of 2020. The second shutdown spanned from the autumn of 2020 to the spring of 2021. The final shutdown was implemented in December 2021 and concluded in early 2022 (NOU

2023: 16, 2023, pp. 19–21). These shutdowns played a crucial role in curbing the spread of the virus, effectively bringing an end to the pandemic's impact on everyday life.

## Restrictions

Throughout the three major shutdowns, a variety of measures were implemented to mitigate the spread of COVID-19. These restrictions were dynamic and could vary across different periods. In essence, the measures aimed to limit gatherings, both in terms of the number of people and their proximity, while also restricting domestic and international travel to contain the spread of the disease. The timeline of these measures was intricate, with restrictions being imposed, lifted, and reinstated multiple times during the course of the outbreak.

Given the complexity of the timeline, the focus here will be on the restrictions most pertinent to this thesis. These measures were pivotal in shaping the context of cross-border shopping and its impact on alcohol consumption during the pandemic.

The COVID-19 regulation, constituting enforceable legislation, was enacted on 27$^{\text{th}}$ March 2020. Its primary objectives were to establish infection control measures and ensure that the healthcare system had the necessary capacity to navigate the evolving situation. Simultaneously, it aimed to maintain regular health services amidst the challenges posed by the pandemic (Ministry of Health and Care Services, 2020a). This regulation played a crucial role in providing a legal framework for addressing the public health crisis and guiding the implementation of various measures to curb the spread of COVID-19.

The introduced measures during the COVID-19 pandemic led to a comprehensive shutdown of various aspects of society. Schools were closed, cultural and sporting events were prohibited, and numerous businesses had to cease operations. Establishments such as catering businesses that did not serve food, hairdressers, wellness centers, fitness facilities, swimming pools, amusement parks, and similar entities were all required to shut down. Catering establishments serving food were allowed to remain open, provided they could ensure a two-meter distance between visitors and staff.

The regulations also imposed travel restrictions, including a mandatory 14-day quarantine for everyone arriving in Norway (this was later shortened to a 10-day quarantine). One exception to this rule was made for individuals crossing the border between Sweden and

Norway or Finland and Norway for work-related purposes (Ministry of Health and Care Services, 2020c). However, in early April 2020, an amendment was made to the regulation. Notably, the exception no longer applied if a person had visited malls, retail stores, or related businesses or if they had close contact with someone outside their household (Ministry of Health and Care Services, 2020b).

Figure 5.2, presented in Section 5.2, illustrates the periods when the border to Sweden was open and closed during the pandemic. The figure reveals that domestic shutdowns were fewer and shorter in duration compared to travel restrictions. Travel restrictions were influenced by infection rates abroad, guided by the recommendations of the Norwegian Institute of Public Health (2022).

The COVID-19 regulation underwent multiple changes, with restrictions being both eased and tightened in response to the evolving infection rate. During the first wave of the pandemic, numerous measures, as described earlier, were implemented. Additionally, international and domestic travel recommendations and restrictions were introduced.

Starting from Thursday, $12^{th}$ March 2020, individuals arriving from abroad, excluding Sweden and Finland, were required to undergo a 14-day quarantine. However, by Tuesday, $17^{th}$ March, the exemption for Sweden and Finland was lifted, effectively closing the border for private travel from these countries. On $19^{th}$ March 2020, a national ban on visiting second homes was implemented and remained in effect until $20^{th}$ April 2020 (NOU 2023: 16, 2023, pp. 19–20). Throughout the outbreak, other measures included recommendations and restrictions on remote work, the use of face masks, limitations on social gatherings, and the practice of social distancing. The dynamic nature of these regulations reflected the authorities' efforts to adapt to the changing circumstances and mitigate the spread of the virus.

The restrictions imposed during the initial phase of the pandemic were gradually eased in the summer of 2020 as the infection rate decreased. Schools reopened, sporting events were permitted, and travel restrictions were lifted for certain countries. However, in the late summer of 2020 and early autumn, the infection rate began to rise again. Consequently, further relaxation of restrictions was put on hold, and many previous measures were reinstated. Additionally, a national ban on serving alcohol after midnight was implemented (NOU 2022: 5, 2022, pp. 16–17).

During the onset of this second wave, substantial local variations in infection numbers led to the implementation of localized restrictions. This allowed for the lifting of certain national restrictions, such as the ban on serving alcohol, provided that corresponding local restrictions were in place. In late October and early November, as infection numbers continued to rise, several national restrictions were reintroduced. These included limitations on private and public gatherings, along with an appeal for people to stay at home (NOU 2022: 5, 2022, pp. 17–25).

During Christmas 2020, various measures were implemented, including restrictions on socializing and mobility, along with stricter border controls. As Christmas and the early months of 2021 unfolded, Norway commenced its vaccination efforts. By April, a significant portion of the elderly population and individuals at high risk of infection had been vaccinated, marking the beginning of the reopening process (NOU 2022: 5, 2022, p. 22).

During the summer and early autumn of 2021, the process of reopening society continued. However, in November of that year, a new mutation of the COVID-19 virus was identified. This mutation proved to be more infectious than its predecessors, raising concerns about its potential to evade immunity from vaccination. Consequently, in late November and early December, a reintroduction of restrictions occurred. Measures such as social distancing, mandatory face masks, limitations on social gatherings, remote work, border restrictions, and a complete national ban on serving alcohol were reimposed (NOU 2022: 5, 2022, pp. 31–32).

Subsequent assessments revealed that the new mutation did not cause as severe infections as the previous variants. Therefore, in January and early February 2022, restrictions were gradually lifted, culminating in the complete removal of all restrictions on 12$^{\text{th}}$ February (NOU 2023: 16, 2023, pp. 41–42).

# 3 Literature Framework

Each year, Norwegians allocate billions to cross-border shopping and tax-free retail at airports and ports. The prevalence of cross-border shopping is significantly influenced by real price differences, which, in turn, are shaped by overall price levels, taxes, and transportation expenses. In this section, we will delve into existing literature that addresses cross-border shopping and the impact of travel distances.

## 3.1 Friberg et al. (2022)

A discussion paper by Friberg et al. (2022) examines the effects of cross-border shopping to Sweden on Norwegian commodity tax revenue. Using a natural experiment provided by border closures during the beginning of the COVID-19 pandemic, they estimate the causal impact of cross-border shopping to Sweden on grocery sales in Norway and how close to the border one must be for this impact to be economically significant.

Friberg et al. (2022) utilized a data set comprising weekly sales and volumes at the store level from Norgesgruppen for the years 2019 and 2020. Additionally, they incorporated data containing location details and estimated yearly sales for all Norwegian grocery stores in 2019, along with information about the locations of all grocery stores situated in Swedish counties bordering Norway. The study focused on regulations governing travel to Sweden and the openness of specific Swedish counties on given dates in 2020. A county was considered "open" if it could be visited without triggering a quarantine. The driving duration from a given Norwegian store to the nearest Swedish store located in an open border county was employed to measure the availability of cross-border shopping. The empirical analyses included robustness checks with various control variables such as COVID-19 infection rates, unemployment rates, and population.

The study initiated by employing stores located 180 minutes or more from the nearest Swedish grocery store as a control group. A binary variable, denoted as $B_{st}$, was introduced to signify whether there exists an accessible Swedish store within a 180-minute drive of store $s$ in period $t$. The findings indicate that cross-border shopping leads to a 6.1 percent reduction in grocery sales for stores situated within a 180-minute drive from the nearest accessible Swedish store. To delve deeper, they introduced an interaction between the binary variable and a categorical variable $D_{st}$, representing the driving duration from store $s$ to the closest accessible Swedish store at time $t$ in 30-minute bins within the range of 0 to 180 minutes. The final category encapsulates scenarios where the closest Swedish store is more than 180 minutes away or when all borders to the Swedish counties are closed. The results underscore that cross-border shopping significantly diminishes grocery sales by more than 25 percent for stores located in close proximity to the border (30 minutes), with the impact gradually diminishing as one moves farther away from the border. In terms of total grocery sales in Norway, the study estimates a sales loss exceeding 3 percent, accompanied by a corresponding reduction in VAT income.

The study further examined the impact of cross-border shopping on various product categories suited and not suited to such shopping practices. Notably, the findings indicate that, for products not suited for cross-border shopping, the effect is estimated to be between a 10–20% reduction in sales for stores located within 30 minutes of a Swedish grocery store. For product categories suited for cross-border shopping, the study found that sales of soda are diminished by 7 percent even at distances as far as 90–120 minutes. However, the most pronounced effects are observed in beer and tobacco product categories. Cigarette sales experienced a substantial reduction of 67 percent in proximity to the border and a noteworthy 40 percent decrease for beer. Remarkably, these effects persist and remain significant even for distances exceeding 120 minutes from the border.

## 3.2 Asplund et al. (2006)

The study conducted by Asplund et al. (2006) focuses on understanding how sales at Systembolaget are influenced by changes in prices for alcohol in neighboring countries, considering the distance to the border. They analyze monthly volume data on sales from Systembolaget spanning from January 1995 to July 2004. Additionally, they incorporate price indices from Eurostat, converting them into Swedish kronor using the corresponding monthly exchange rates. To account for potential influencing factors causing regional and temporal variations in sales, the study includes controls for income differences, store density, the number of holidays, and the number of Fridays. The analysis's main focus is on Swedish cross-border shopping in Denmark. Therefore, it excludes all municipalities bordering Norway and Finland, as sales in these areas are impacted by cross-border shoppers from the respective countries.

The findings from Asplund et al. (2006) reveal a negative correlation between price sensitivity and distance to the border. This indicates that individuals residing and stores located farther from the border are less influenced by price changes in neighboring countries, such as Denmark. Specifically, for wine, the study observes that the impact diminishes rapidly with distance, reaching zero at 200 km from the border. Conversely, for beer, while the effect does not entirely converge to zero, it tapers out 400–500 km from the border. This implies that some consumers residing far from the border still capitalize on the lower beer prices in Denmark, which are reported to be around 25–35% lower than in Sweden.

In terms of tax revenue implications, the paper adopts 2002 volumes and prices as a benchmark to estimate potential tax losses with a 27% lower price on spirits in Denmark. The study reveals that Sweden would have experienced a direct loss of 2.2% of the total tax revenue for spirits, amounting to SEK 141 million. However, the distribution of this loss across the country is uneven. Within 100 km from the border, tax revenues would decline by 7.5%, constituting over a quarter of the total tax loss. In municipalities situated within 300 km from the border, the loss would surpass 2/3 of the total tax loss.

Asplund et al. (2006) further explores the consequences of a hypothetical 40% reduction in Swedish spirit taxes, resulting in a 30% reduction in prices. In this scenario, the estimated tax revenue loss would amount to SEK 646 million, equivalent to a 13.3% reduction in pre-tax revenue. Notably, this type of tax reduction would result in a more substantial decline in tax revenues compared to the impact of cross-border shopping, as cross-border shopping primarily affects municipalities in close proximity to the border.

## 3.3 Bygvrå (2009)

The study by Bygvrå (2009) focuses on understanding how the distance from the border influences the purchase of alcoholic beverages in Germany by Danish residents and how these purchasing patterns change in response to evolving framework conditions.

The data for this study was gathered through 6,977 face-to-face interviews conducted by the Danish Department of Border Region Studies between 1986 and 2003. During these interviews, Danish travelers returning from Germany were questioned about various aspects of their trip, including background information such as their municipality of residence, the purpose of the trip, the number of adults in the group, and the types of products purchased (Bygvrå, 2009, p. 144).

In addition to examining the distance to the border, the paper investigated how purchases changed in response to alterations in framework conditions. Some of these changes included:

**Table 3.1:** Important changes

| | |
|---|---|
| 1986–1989 | * Reintroduction of a legal limit of 10 litres of beer per adult[4]<br>* Increased allowances of wine and cigarettes |
| 1989–1991 | * Increasing beer allowances |
| 1991–1996 | *Petrol prices levelled out<br>* Decreasing Danish taxes on beer and wine<br>* European Single Market (1993) |
| 1996–1999 | * Decreasing Danish taxes on spirits<br>* New shopping centres in Flensburg |
| 1999–2000 | - |
| 2000–2001 | * Denmark signed the Schengen agreement |
| 2001–2003 | - |

**Sources:** Bygvrå (2009)

The study found that the volumes of cross-border shopping experienced fluctuations over time. There was an increase in the first two periods, followed by a decline from 1991 until the mid-1990s, after which the traffic increased again. Additionally, the research revealed that individuals residing at varying distances from the border exhibited different shopping behaviors. Those living farther away from the border were less likely to engage in cross-border shopping, with 25 km identified as the dividing line between close and distant travelers (Bygvrå, 2009, pp. 148–151).

[4]Previously, the allowed volume of beer was only limited by the total spending amount allowed.

# 4 Theoretical Framework

In this chapter, we introduce a theoretical framework designed to model consumer behavior concerning cross-border shopping for alcohol.[5] This simplified two-step framework provides insights into crucial factors influencing the decision-making process. Additionally, we will present an extension to the theoretical model aimed at shedding light on the impact of cross-border shopping.[6]

The traditional approach to modeling consumer behavior relies on the assumption that consumers possess a set of preferences. Although these preferences are unobservable, adherence to a set of rationality assumptions allows predictions about consumer choices based on certain regularities. Understanding such behavior enables the anticipation of how consumers make decisions in the market, and these predictions can be employed to assess the welfare consequences of public policies. The rationality assumptions include reflexivity (each bundle of goods is at least as good as itself), completeness (the ability to rank all pairs of alternatives), and transitivity (consistent preferences). The addition of the continuity assumption, stating that a infinitesimal change in an alternative doesn't alter its ranking relative to another alternative, allows the representation of preferences through the utility function $u(\cdot)$ (Banerjee, 2015, pp. 35–56).

## 4.1 Utility Maximization

The consumer's decision-making process regarding cross-border shopping can be conceptualized as a two-step process solved through backward induction. In the initial step, the consumer maximizes utility concerning alcohol and other goods. Here, the consumer must decide the allocation of the budget $M$ between alcohol $X$ and other goods $Y$, with the price of other goods normalized to 1 (we will revisit the price for alcohol, $P_X$). In the subsequent step, the consumer maximizes the utility of alcohol purchased in Norway and Sweden. In this stage, the consumer needs to determine how much of the alcohol budget $m_X$ to allocate to alcohol bought in Norway and in Sweden.

The overall utility function for the consumer is assumed to be a CES-utility function,

[5] We would like to thank our supervisor Fred Schroyen for his help in creating the models presented in the chapter.

[6] For detailed calculations used in the models, refer to Appendix B.

which is useful as it allows for goods to be either substitutes or complements:

$$U = \left(\alpha X^{\frac{\varepsilon-1}{\varepsilon}} + (1-\alpha)Y^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}. \tag{4.1}$$

Here, $X$ represents the total amount of alcohol consumed, and $Y$ represents the amount of "other goods". The parameter $\alpha \in (0, 1)$ serves as a measure of the expenses used on alcohol, indicating the proportion of the utility derived from alcohol consumption relative to the consumption of other goods. The parameter $\varepsilon \geq 0$ is the substitution elasticity between alcohol and other goods, likely to be less than 1 given that alcohol is a poor substitute for "other goods". We assume that the consumer has solved the problem, determining that the budget for alcohol is $m_X = P_X \times X$.

### 4.1.1 Step Two

To solve the maximization problem, we begin with the second step and examine the utilities in the scenarios where (1) the consumer engages in cross-border shopping and (2) the consumer refrains from cross-border shopping.

The utility function if the consumer goes cross-border shopping, also assumed to be a CES-utility function, will be:

$$u = \left((x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{4.2}$$

Here, $x_N$ and $x_S$ represent the quantities of alcohol purchased in Norway and Sweden, respectively. $\sigma$ denotes the substitution elasticity between alcohol bought in Norway and Sweden. We assume a relatively large value for $\sigma$ (significantly greater than 1) since retailers in both countries offer similar brands, making the consumer rather indifferent between alcohol purchased in Norway and Sweden. $\gamma_N$ and $\gamma_S$ represent additional utility derived from shopping in Norway or Sweden, not related to alcohol. For simplicity, we assume both are zero in this model. In reality, however, these could be positive, reflecting the utility gained from aspects other than alcohol purchase, such as the experience of the trip to Sweden itself.

The consumer maximizes utility function (4.2) given the budget constraint:

$$p_N x_N + p_S x_S = m_X - T, \tag{4.3}$$

where $p_i$ is the price in country $i = N, S$ and $T$ is the cost of transportation to Sweden.

If we maximize $u$ with respect to $x_N$ and $x_S$ under the budget constraint we get the optimal expenditure on alcohol on either side of the border:

$$p_N x_N = \left(\frac{p_N}{P_X}\right)^{1-\sigma}(m_X - T), \tag{4.4}$$

$$p_S x_S = \left(\frac{p_S}{P_X}\right)^{1-\sigma}(m_X - T), \tag{4.5}$$

where $P_X$ is a price index for alcohol, defined as: $P_X = P(p_N, p_S) = (p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}$.

These equations reveal that the optimal expenditure on alcohol in Norway and Sweden hinges on the relative prices in the two countries. When alcohol prices in Norway are higher compared to Swedish prices, the consumer will purchase less alcohol in Norway, and vice versa. Additionally, both expenditures decrease with transportation costs. This implies that when transportation costs are high, a smaller portion of the budget will be allocated to alcohol.

If we substitute the optimal expenditures, equations (4.4) and (4.5), back into the utility function (4.2), we will get the indirect utility of alcohol consumption for a border-shopping consumer:

$$v(p_N, p_S, m_X - T) = \frac{m_X - T}{P(p_N, p_S)}. \tag{4.6}$$

The indirect utility, equivalent to the overall expenditure on alcohol, is decreasing in transportation costs. This implies that consumers residing farther from the border will have a smaller sum to allocate for alcohol compared to those living in closer proximity to the border. The indirect utility is also contingent on alcohol prices in Norway and Sweden; higher prices result in the alcohol budget covering fewer units of alcohol.

If the consumer does not go cross-border shopping, he/she uses the entire budget $m_X$ on Vinmonopolet in Norway:

$$v(p_N, m_X) = \frac{m_X}{p_N}. \tag{4.7}$$

This amount is then equal to the utility derived from alcohol consumption for a non-cross-border-shopping consumer. As the consumer exclusively acquires alcohol in Norway, the relative price index becomes $p_N$. In this scenario, the total alcohol expenditure solely relies on the alcohol budget and prices for alcohol in Norway, as indicated by Equation (4.7). It's crucial to note that this scenario is applicable only when the consumer has the option of abstaining from consuming alcohol purchased in Sweden. Given CES preferences, we therefore exclude all cases where $\sigma \leq 1$, when $\gamma_N = 0$ and $\gamma_S = 0$. For instance, if we assume $\sigma = 1$, the utility function (4.2) transforms into a Cobb-Douglas utility function and takes the form:

$$u = x_N^{\frac{1}{2}} x_S^{1-\frac{1}{2}}. \tag{4.8}$$

The reasoning behind this is that if $\sigma \leq 1$, the consumer will not be indifferent between alcohol bought in Norway and Sweden, suggesting that the degree of complementarity between Norway and Sweden is too high. In such a case, $x_S = 0$ is no longer a viable option, as it would result in a utility of zero. If we assume that the consumer desires $u > 0$, it implies that the consumer will invariably buy *some* alcohol in Sweden.

### 4.1.2 Step One

We now go back to the first step, where the utility function of the consumer can be written as:

$$U = \left( \alpha X^{\frac{\varepsilon-1}{\varepsilon}} + (1-\alpha) Y^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}. \tag{4.1 revisited}$$

If the consumer goes cross-border shopping the budget constraint will be:

$$M - T = P_X X + Y. \tag{4.9}$$

When the consumer engages in cross-border shopping, the total budget $M$ includes transportation costs $T$, the prices for each type of good (alcohol ($P_X$) and other goods (normalized to 1)), and the amounts consumed ($X$ and $Y$). In this scenario, the relevant price index for alcohol will be $P_X = P(p_N, p_S)$. Similar to the alcohol budget, the entire budget is also decreasing in transportation costs. This implies that a cross-border shopping individual residing farther away from the border will have a reduced budget for spending on alcohol and other goods.

If the consumer does not go cross-border shopping the budget constraint will be:

$$M = P_X X + Y. \tag{4.10}$$

In this case, the budget will only consist of the price for each type of good and the amounts consumed, and the price index for alcohol will be $P_X = p_N$. The optimal budget for alcohol is then:

$$m_X = \alpha^{\varepsilon}\Big(\frac{p_N}{P_T}\Big)^{1-\varepsilon} M, \tag{4.11}$$

where $P_T$ is the overall price index defined as $P_T = P(P_X, 1) = \Big(\alpha^{\varepsilon} P_X^{1-\varepsilon} + (1-\alpha)^{\varepsilon}\Big)^{\frac{1}{1-\varepsilon}} = P(p_N, 1)$ since $P_X = p_N$.

In Equation (4.11), the alcohol budget when the consumer refrains from cross-border shopping is determined by the proportion of the total budget allocated to alcohol and the price of alcohol in Norway relative to other goods. The budget is also influenced by the substitution elasticity between alcohol and other goods, denoted as $\varepsilon$. As $\varepsilon$ increases (indicating higher substitutability between alcohol and other goods), the share of the budget allocated to alcohol decreases (increases), assuming that alcohol purchased in Norway is more (less) expensive than other goods in Norway.

We then find the overall utility without cross-border shopping in Step 1:

$$V^{NC-BS} = \frac{M}{P_T}. \tag{4.12}$$

The overall utility without cross-border shopping corresponds to the total expenditure when the consumer opts not to shop in Sweden. In this scenario, the total expenditure is determined by the entire budget and the price index for goods purchased in Norway. A higher price index leads to a reduced quantity that the consumer can afford, while a larger total budget allows for a higher quantity.

We now move to a situation where the consumer does go cross-border shopping. In this situation, we find that the optimal budget for alcohol will be:

$$m_X = T + \alpha^{\epsilon}\Big(\frac{P(p_N, p_S)}{P_T}\Big)^{1-\varepsilon}(M - T), \tag{4.13}$$

where $P_T$ is the same as above, but now with $P_X = P(p_N, p_S)$.

In Equation (4.13), the budget for alcohol when the consumer engages in cross-border shopping is influenced by the fraction of the total budget allocated to alcohol, the relative prices of alcohol in Norway and Sweden, and the transportation cost. Consequently, the consumer's capacity to spend on alcohol in both countries decreases with higher transportation costs.

The utility of cross-border shopping in Step 1 will be:

$$V^{C-BS} = \frac{M-T}{P_T}. \tag{4.14}$$

As shown in Equation (4.14), the utility derived from cross-border shopping is contingent on the budget, transportation costs, and the price index, which comprises goods bought in both Norway and Sweden. The utility diminishes with higher transportation costs, signifying that consumers will have a reduced budget for alcohol and other goods when facing increased transportation expenses. The utility is also decreasing in $P_T$, and $P_T$ is dependent on the prices for alcohol, other goods, and the budget share allocated to alcohol compared to other goods.

The consumer then has to decide whether or not to go cross-border shopping in Sweden. The consumer will go cross-border shopping if:

$$V^{C-BS} > V^{NC-BS}. \tag{4.15}$$

If we then plot in for $V^{C-BS}$ and $V^{NC-BS}$ and rearrange, we get that the consumer will go cross-border shopping if

$$\frac{M-T}{M} > \frac{\left(\alpha^{\epsilon} P(p_N, p_S)^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^{\epsilon} p_N^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}. \tag{4.16}$$

The left-hand side of the equation decreases with transportation costs, implying that as transportation costs rise, a smaller fraction of the budget can be allocated to alcohol and other goods during cross-border shopping. Essentially, the left-hand side represents the relative available budget for the consumer engaging in cross-border shopping. On the other hand, the right-hand side compares the price index during cross-border shopping with the price index when the consumer does not engage in cross-border shopping, providing a measure of the relative overall price during cross-border shopping. Therefore, the equation suggests that the consumer opts for cross-border shopping if the available budget surpasses the overall price, signifying that a sufficiently large price difference between Norway and Sweden compensates for the budget reduction caused by transportation costs, prompting the consumer to choose cross-border shopping.

### 4.1.3 Two Cases

Let's examine two distinct scenarios to gain insight. The first scenario is a special case where the consumer only values alcohol, denoted by $\alpha \to 1$. The second scenario is when $0 < \alpha < 1$, indicating that the consumer values both alcohol and other goods.

In the special case where the consumer only purchases alcohol, the entire budget is allocated to alcohol, represented by $M = m_X$. This implies that $\frac{M-T}{M} = \frac{m_X - T}{m_X}$. The comparison in Equation (4.15) can then be expressed as:

$$\frac{M-T}{M} > \frac{P(p_N, p_S)}{p_N}, \tag{4.17}$$

$$1 - \frac{P(p_N, p_S)}{p_N} > \frac{T}{M}. \tag{4.18}$$

In this scenario where the consumer cares exclusively for alcohol, the decision to go cross-border shopping is determined by whether the share of the budget allocated to transportation costs is less than the remaining budget after subtracting the relative price for alcohol when cross-border shopping. In essence, the consumer's choice hinges on the amount of the budget available for transportation costs after considering the relative price of alcohol.

By expressing the Norwegian price of alcohol, $p_N$, as the Swedish price multiplied by the price difference, $p_N = (1 + t_N)p_S$, where $t_N$ is the relative price difference between alcohol bought in Norway and Sweden, the left-hand side of the Inequality (4.18) can be written as:

$$1 - \frac{P(p_N, p_S)}{p_N} = 1 - (1 + (1 + t_N)^{\sigma-1})^{\frac{1}{1-\sigma}}. \tag{4.19}$$

This means that the consumer will prefer to buy alcohol in Sweden if

$$1 - (1 + (1 + t_N)^{\sigma-1})^{\frac{1}{1-\sigma}} > \frac{T}{M}. \tag{4.20}$$

From the inequality, we observe that as the relative price difference $t_N$ grows, the transportation cost as a share of the budget can be higher for the consumer to still go cross-border shopping. However, this effect is influenced by the value of $\sigma$. If alcohol in Norway and Sweden are poor substitutes ($\sigma$ is low), the left-hand side of the equation increases, and vice versa for good substitutes. In summary, if Norwegian and Swedish-bought alcohol are good substitutes, a consumer will only cross-border shop for alcohol if transportation costs are low and/or the price difference is high.

To emphasize the point, we assume that alcohol in Norway and Sweden are perfect substitutes and $\sigma \to \infty$. The left-hand side of Inequality (4.18) will then be equal to:

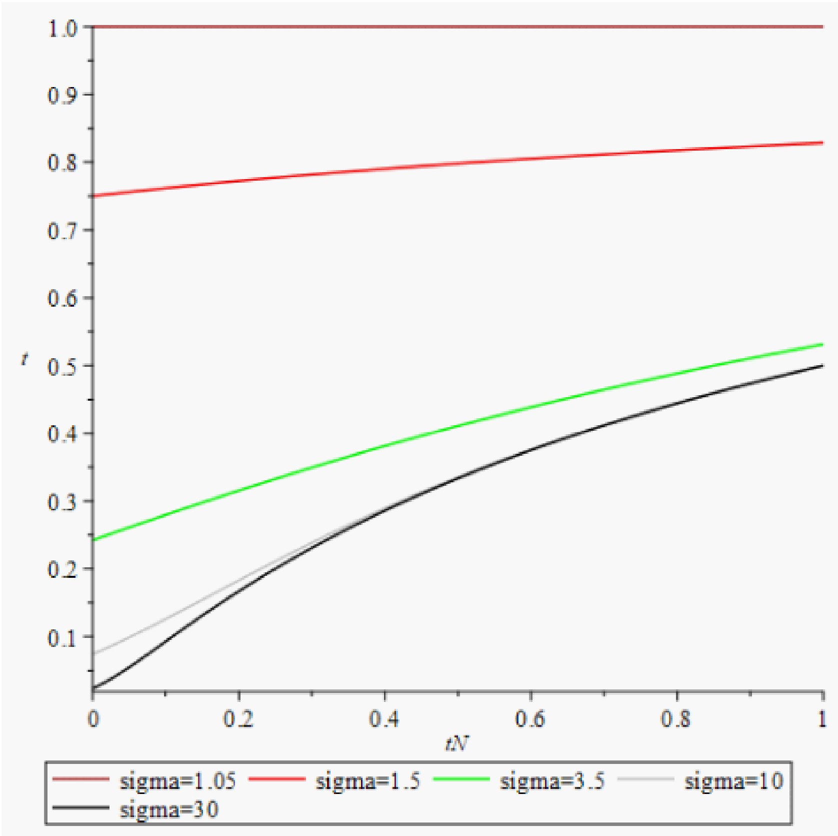
$$\lim_{\sigma \to \infty} 1 - \frac{P(p_N, p_S)}{p_N} = \frac{t_N}{1 + t_N}, \tag{4.21}$$

$\frac{t_N}{1+t_N}$ is the "tax" on Norwegian alcohol, expressed as a fraction of the consumption price which includes this tax. When the consumer only cares about alcohol consumption, and alcohol in Norway and in Sweden are perfect substitutes then the consumer will prefer to buy alcohol in Sweden if

$$\frac{t_N}{1 + t_N} > \frac{T}{M}. \tag{4.22}$$

From this inequality, we observe that the consumer will engage in cross-border shopping if the "tax" in Norway is higher than the fraction of the budget used on transportation costs. Let's denote $\frac{T}{M}$ as $t$, $t = \frac{T}{M}$. Figure 4.1 illustrates combinations of $t$ and $t_N$ such that Inequality (4.18) strictly holds. In other words, it visualizes how high the fraction of the budget used on transportation costs must be, for a given level of $t_N$, for it to no longer be beneficial for the consumer to go cross-border shopping. When alcohol bought in Norway and Sweden are good or perfect substitutes ($\sigma = 30$), the upper bound for $t$ will be lower. As depicted in the figure, if $\sigma = 30$ (nearly perfect substitutes), then $t$ cannot exceed 16.7% if $t_N = 20\%$ for the consumer to find cross-border shopping advantageous.

**Figure 4.1:** Threshold for cross-border shopping




We will now look at the more general case where the consumer both cares for alcohol and other goods, meaning that $0 < \alpha < 1$. The comparison of the utilities with and without cross-border shopping can then be written as:

$$1 - \frac{\left(\alpha^{\epsilon} P(p_N, p_S)^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^{\epsilon} p_N^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}} > \frac{T}{M}. \tag{4.23}$$

Now, assuming $p_S = 2$, meaning that alcohol bought in Sweden is expensive compared to other goods (as the price of other goods is normalized to 1), and $\epsilon = 0.5$, signifying that alcohol and other goods are poor substitutes, along with $\alpha = 0.3$ (indicating that expenses on alcohol are 30% of the total budget), and $\sigma = 30$ (implying that alcohol bought in Norway and Sweden are as good as perfect substitutes), let's explore a scenario with $t_N = 0.2$. This implies that alcohol bought in Norway is 20% more expensive than alcohol bought in Sweden, making the left-hand side of the inequality equal to 0.088. In other words, for the consumer to engage in cross-border shopping, transportation costs cannot exceed 8.8% of the total budget.

Considering that the consumer will spend some of the budget on other goods, which are poor substitutes for alcohol, this reduces the attractiveness of cross-border shopping. It's important to note that there could be other activities to engage in while in Sweden besides buying alcohol. This suggests that alcohol bought in Norway and Sweden will not be perfect substitutes, and the substitution elasticity between them will not approach infinity. Consequently, the consumer might be willing to accept a higher fraction of the budget as transportation costs, deriving utility from other activities in Sweden.

Comparing the results from the two cases, when $t = 16.7\%$ ($\alpha \to 1$) and $t = 8.8\%$ ($0 < \alpha < 1$), we observe that the threshold for the budget fraction to be spent on transportation costs is almost twice the size when the consumer only cares about alcohol. This aligns with the model's logic, as the appeal of cross-border shopping for alcohol diminishes when some of the budget is allocated to other goods purchased in Norway. However, it's crucial to note that the model does not account for potential benefits of cross-border shopping, such as shopping for other goods, utility from the trip, vacation time, etc. Therefore, it is likely that the case where the consumer cares about both alcohol and other goods understates the threshold, as the consumer can also purchase other goods in Sweden.

## 4.2 Effect of Cross-Border Shopping

Up to this point in the chapter, we have examined various factors influencing the decision-making process regarding whether to engage in cross-border shopping or not through a CES-model. In this section, we shift our focus to more general demand functions to investigate how cross-border shopping affects the demand for alcohol in Norway by estimating $logD_N(p_N, p_S, M, m) - logD_N^{closed}(p_N, p_S, M, m)$. This will allow us to examine the direct effect of a price change on demand for alcohol through a simplified model. The simplified model portrays a scenario where only alcohol matters, whereas in reality other goods will also matter. However, this simplification allows us to get an understanding of the underlying dynamics influencing the effect of interest.

We assume that the demand for alcohol bought at Vinmonopolet for a Norwegian consumer with income $M$ that lives $m$ minutes from a Systembolaget outlet is:

$$D_N(p_N, p_S, M, m). \tag{4.24}$$

While the demand for alcohol bought at Systembolaget for a Norwegian consumer with income $M$ that lives $m$ minutes from a Systembolaget outlet will be:

$$D_S(p_N, p_S, M, m). \tag{4.25}$$

If the border closes and the consumer can no longer buy alcohol at Systembolaget this can be simulated as the Swedish price $p_S$ increasing to a high enough level, $\hat{p}_S$ so that the demand for alcohol bought at Systembolaget is equal to zero, $D_S = 0$. The Norwegian demand for alcohol purchased in Sweden will then be:

$$D_S^{closed}(p_N, p_S, M, m) = D_S(p_N, \hat{p}_S(p_N, M, m), M, m) = 0. \tag{4.26}$$

Here, $\hat{p}_S$ is a function dependent on $p_N$, $M$, and $m$. For individuals residing closer to the border, $\hat{p}_S$ will be higher compared to those living further away. This implies that $\hat{p}_S$ is inversely proportional to $m$. The rationale behind this is that individuals in proximity to the border will have lower transportation costs, necessitating a higher price for alcohol purchased in Sweden to offset the impact of the lower transportation cost compared to those residing at a greater distance.

The demand for alcohol bought in Norway with no cross-border shopping can then be defined as:

$$D_N^{closed}(p_N, p_S, M, m) = D_N(p_N, \hat{p}_S(p_N, M, m), M, m). \tag{4.27}$$

As previously noted, cross-border shopping will impact alcohol sales in Norway, leading to lower sales and, consequently, reduced income for Vinmonopolet and the government. Calculating the difference in demand for Norwegian alcohol when the border is open versus closed allows us to estimate the effect of cross-border shopping on Norwegian alcohol sales

$m$ minutes from the border:

$$\begin{aligned} & logD_N(p_N, p_S, M, m) - logD_N^{closed}(p_N, p_S, M, m) \\ & \qquad = logD_N(p_N, p_S, M, m) - logD_N(p_N, \hat{p}_S(p_N, M, m), M, m). \quad (4.28) \end{aligned}$$

In Equation (4.28), we observe that the impact of cross-border shopping is contingent on the Norwegian price for alcohol ($p_N$), the Swedish price for alcohol ($p_S$), income ($M$), distance to the border ($m$), and the Swedish price that mimicks a closed border ($\hat{p}_S$). The demand for Norwegian alcohol when the border is closed, $D_N^{closed}$, is larger than demand when the border is open, $D_N$, as the Norwegian consumer loses the option to purchase alcohol in Sweden. Consequently, the effect of cross-border shopping on Norwegian alcohol sales is negative.

Given that we lack the precise value of $\hat{p}_S$, we employ a first-order Taylor approximation around $p_S$ to estimate the demand when the border is closed, $D_N^{closed}$:

$$logD_N^{closed} \simeq logD_N(p_N, p_S, M, m) + \frac{\partial logD_N(p_N, p_S, M, m)}{\partial p_S}(\hat{p}_S - p_S). \qquad (4.29)$$

The right-hand side of Equation (4.29) provides an estimate of the demand for Norwegian alcohol when the price for Swedish alcohol, $\hat{p}_S$, is sufficiently high to eliminate the demand for Swedish alcohol (i.e., when the border is closed). This approximation indicates that the demand for Norwegian alcohol when the border is closed is equivalent to the demand when the border is open plus the increase in demand resulting from the rise in the Swedish price.

If we then substitute the Approximation (4.29) back into Equation (4.28) we get:

$$logD_N - logD_N^{closed} \simeq -\varepsilon_{NS}\frac{\hat{p}_S - p_S}{p_S}. \qquad (4.30)$$

From Equation (4.30), it is evident that the impact of cross-border shopping is determined by the cross-price elasticity between Norwegian and Swedish alcohol, denoted as $\varepsilon_{NS}$, and the relative increase in the Swedish price resulting from the border closure. The cross-price elasticity reflects how the demand for Norwegian alcohol responds to changes in the price of Swedish alcohol. An increase in the price in Sweden implies that Norwegian consumers find it relatively more expensive to buy alcohol in Sweden compared to Norway, leading to a higher demand for Norwegian alcohol —hence, $\varepsilon_{NS} > 0$. A substantial positive cross-price elasticity indicates that the goods are good or perfect substitutes.

Additionally, the variable $\hat{p}_s$ is higher for individuals residing closer to the border, implying that the relative price increase is inversely related to the distance from the border. However, this relative price increase remains positive as $\hat{p}_S > p_S$ for all values of $m$. From Equation 4.30, we can then see that there is an overall negative effect of cross-border shopping implying that an open border decreases the demand for alcohol purchased in Norway. The magnitude of this effect will be quantified in the analysis presented in Chapter 7.

The relative price increase is linked to the change in the Swedish price of alcohol. By construction, the demand for alcohol bought by Norwegians in Sweden becomes zero when the Swedish price changes from $p_S$ to $\hat{p}_S$. Employing a first-order Taylor approximation around $p_S$ for $D_S^{closed}$ enables us to express the relative price increase in terms of an inverse elasticity:

$$0 = D_S^{closed} \simeq D_S(p_N, p_S, M, m) + \frac{\partial D_S(p_N, p_S, M, m)}{\partial p_S}(\hat{p}_S - p_S), \tag{4.31}$$

$$\frac{\hat{p}_S - p_S}{p_S} = -\frac{1}{\varepsilon_{SS}}. \tag{4.32}$$

Equation (4.31) provides an estimation of the demand for Swedish alcohol by Norwegian consumers when the border is closed. The equation illustrates that the demand in this scenario is equivalent to the demand when the border is open plus the change in demand resulting from alterations in the Swedish price. A price increase in Sweden leads to a reduction in the demand for Swedish alcohol by Norwegian consumers, implying that $\frac{\partial D_S}{\partial p_S} < 0$.

Equation (4.32) demonstrates that the relative Swedish price increase, necessary to mimic a closed border, corresponds to the inverse price elasticity for Swedish alcohol. The price elasticity for Swedish alcohol, denoted as $\varepsilon_{SS}$, indicates that an increase in the price in Sweden results in a decrease in the Norwegian demand for Swedish alcohol. This occurs because it becomes more expensive for Norwegian consumers to buy alcohol in Sweden. Consequently, consumers have less of their budget available to spend on

Norwegian alcohol if they maintain their consumption of Swedish alcohol at the same level, leading to a reduction in utility. On the other hand, if consumers wish to keep their utility constant in the face of increased Swedish alcohol prices, they must purchase less alcohol in Sweden. This is known as the compensated demand elasticity, denoted as $\hat{\varepsilon}_{SS}$, and it is always negative. The elasticity $\varepsilon_{SS}$ is considered the uncompensated price elasticity since it depends on the consumer's income $M$, encompassing an income elasticity as well. Assuming an increase in the consumer's income to maintain constant purchasing power, the consumer could stay on the same indifference curve. However, as the price of Swedish alcohol rises, the consumer will still buy less of this good even with a higher income, indicating that $\varepsilon_{SS} < 0$.

Substituting Equation (4.32) into (4.30) we get:

$$logD_N - logD_N^{closed} \simeq \frac{\varepsilon_{NS}}{\varepsilon_{SS}}. \tag{4.33}$$

In Equation (4.33), the effect of cross-border shopping is represented as the ratio of the cross-price elasticity to the price elasticity for Swedish alcohol. This ratio is negative because the price elasticity for Swedish alcohol is negative, while the cross-price elasticity is positive. This aligns with our explanation for Equation (4.28), where we asserted that the log difference would be negative due to increased demand for Norwegian alcohol when the border is closed.

Further, $\varepsilon_{NS}$ and $\varepsilon_{SS}$ can be defined as:

$$\varepsilon_{NS} = \frac{\%\Delta D_N}{\%\Delta p_S}, \tag{4.34}$$

$$\varepsilon_{SS} = \frac{\%\Delta D_S}{\%\Delta p_S}. \tag{4.35}$$

By defining the elasticities in this way and substituting them into (4.33), the log difference can be written as:

$$logD_N - logD_N^{closed} \simeq \frac{\%\Delta D_N}{\%\Delta D_S}. \tag{4.36}$$

Here, we observe that the log difference is a ratio of the percentage change in demand for Norwegian alcohol to the percentage change in demand for Swedish alcohol when the price for Swedish alcohol changes. The change in demand for Swedish alcohol is expected to be negative when the Swedish price increases, while the change in demand for Norwegian alcohol will be positive. This implies that the changes in demand for Norwegian and Swedish alcohol have opposite effects. If Norwegian consumers increase their alcohol purchases in Sweden, they will likely decrease their purchases in Norway, and vice versa. This relationship is influenced by factors such as the change in the Swedish price for alcohol, the distance to the border, and the consumer's income. A change in the Norwegian price for alcohol will have the opposite effect of a change in the Swedish price for alcohol. An increase in the Norwegian price for alcohol, for example, would decrease the demand for Norwegian alcohol and increase the demand for Swedish alcohol. The income remains constant, so choosing to buy more alcohol in Sweden would mean having less to spend on alcohol in Norway. Additionally, the demand for Swedish alcohol decreases with distance, as mentioned earlier, due to transportation costs. In summary, consumers residing farther from the border would face higher transportation costs, reducing their available budget for alcohol if they opt for cross-border shopping, and resulting in a decreased likelihood of purchasing alcohol in Sweden.

# 5 Data

In quantifying the impact of cross-border shopping on tax revenue, we have constructed a panel data set by integrating weekly sales data from Vinmonopolet with travel distances and durations to Swedish Systembolaget, various municipality statistics, and COVID-19 related data, encompassing infection rates and border closure dates. The construction of this data set has relied on four primary sources: Vinmonopolet sales data, travel information from Google Maps, municipality statistics from Statistics Norway (SSB), and COVID-19 statistics from the Norwegian Institute of Public Health (NIPH).

The data used in the analysis adheres to the municipality structure implemented in 2020, which was part of a significant reform involving the merging of municipalities. This reform resulted in a reduction from 428 to 356 municipalities. The chosen structure enables the utilization of unbroken time series statistics that span both pre-reform and post-reform periods.

## 5.1 Data Sources

The data used for the analysis includes weekly sales data at the product-store level from Vinmonopolet, spanning the years 2018 to 2022. This data set provides information on the sales volume and revenue for eight main alcohol categories for each Vinmonopolet outlet throughout this time period. Additionally, we have access to two supplementary datasets: one detailing the total excise tax and environmental tax paid by Vinmonopolet from 2018 to 2022, and another providing the average alcohol percentage of items sold within each main alcohol category.[7] We have also utilized Vinmonopolet's API to retrieve store-specific information, including the address and postal code of each Vinmonopolet store. By merging these datasets, we establish municipality-level control variables and establish a connection between each store $s$ at time $t$ and the driving duration to the nearest Systembolaget.

For our analysis, we rely on information from the Norwegian Institute of Public Health (2022) to ascertain the weeks during which each Swedish bordering county was either open or closed for Norwegians. We adopt a definition where a week is considered "closed" if

[7]We are grateful to Anders Hauge at Vinmonopolet for assisting us in obtaining this data.

traveling to the Swedish county in question triggered a 10 or 14-day quarantine for four or more days within that specific week. A visual representation of the times when the border to different counties was closed is found in Figure 5.2 in Section 5.2.

We utilize Systembolaget's website to gather information about the addresses of the 15 Systembolaget stores in bordering Swedish counties that are closest to Norwegian Vinmonopolet outlets. Additionally, we obtain the addresses of three "ombud" locations, which are situated closer to some Vinmonopolet outlets than any regular Systembolaget outlet. It is important to note that Systembolaget "ombud" are post-office style pick-up points for online purchases, with around 480 "ombud" compared to 448 Systembolaget outlets. These "ombud" account for approximately 1 percent of Systembolaget revenue (Systembolaget, 2023). For this reason, we do not include "ombud" in our main analysis. Rather, we include them later as a robustness check.

To calculate travel distances and driving duration by car from each of the 345 Vinmonopolet outlets to the 15 Systembolaget outlets, we use the Google Maps API. Initially, we use this information to define pre-COVID driving bins, grouping Vinmonopolet outlets by the driving duration to the nearest Systembolaget outlet in increments of 45 minutes. Subsequently, we leverage the same data, along with information on travel restrictions, to determine the driving duration to the nearest Systembolaget outlet at time $t$. If there are no Systembolaget outlets in open counties, the driving duration is coded as $\infty$. This approach allows us to observe changes in the driving bin based on whether Swedish counties are open or closed for travel.

We employ data from Statistics Norway (SSB) to obtain municipality-level control variables. Although these variables are not utilized in the primary analysis, they serve as robustness checks. Our process involves linking postal codes to municipality codes valid from 2020. Subsequently, we collect quarterly data on the population for each municipality, yearly data on employment for each municipality, and the 2019 value for the number of holiday homes per square kilometer. Importantly, all three series allow for aggregated time series using the new municipality-structure following the reform in 2020. While higher frequency data would provide richer interactions, quarterly, yearly, and 2019-values, respectively, capture the most critical variations.

Finally, we obtain COVID-19 infection rate statistics by time and municipality from the Norwegian Institute of Public Health (2023). Daily observations are available from week 8 of 2020, which corresponds to 17th February 2020, while the primary data set for COVID-19 statistics begins on 4th May 2020. We retrieve both data sets and merge them. It is important to note a slight discrepancy in the method of reporting infection rates between the two data sets, specifically around the transition from week 18 to week 19 in 2020. We extract the week number for each daily observation, collapse the data set based on the week number, and sum the new cases to calculate weekly infection rates per 100,000 individuals in each municipality. Finally, we merge the data set containing COVID-19 statistics with the main data set using a unique week identifier.

## 5.2 Descriptive Statistics

The data from 2018 to 2021 reveals a consistent growth in Vinmonopolet sales, with a notable decline in 2022, as illustrated in Table 5.1. Despite the dip in 2022, both volume and revenue are considerably higher than the figures recorded in 2019. This trend may suggest increased alcohol purchases from retailers by Norwegians, potentially coupled with reduced cross-border shopping or altered shopping patterns. Notably, there was a substantial surge in sales from 2019 to 2020, with a roughly 40% increase across all Vinmonopolet outlets. The subsequent decline by approximately 18% in volume sold from 2021 to 2022 aligns with the pandemic timeline, suggesting that the closure of borders had an impact on alcohol sales in Norway.

**Table 5.1:** Vinmonopolet sales by year

| | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| *Yearly total* | | | | | |
| Volume (Total, mill. litres) | 82 | 83 | 116 | 118 | 97 |
| Revenue (Total, mill. NOK) | 13,858 | 14,300 | 20,563 | 21,696 | 18,435 |
| *Weekly store averages* | | | | | |
| Volume (Litres) | 572 | 576 | 790 | 825 | 678 |
| Revenue (‘000 NOK) | 97 | 100 | 141 | 151 | 128 |

Table 5.2 further emphasizes a significant rise in volume sold at Vinmonopolet outlets situated closer to Systembolaget outlets. However, it is noteworthy that there is also a considerable increase in volume sold for Vinmonopolet outlets located more than 180

minutes from a Systembolaget outlet. This suggests that the upswing in sales volume could potentially be attributed to changes in consumption and purchasing patterns, rather than solely being a consequence of unavailable cross-border shopping.

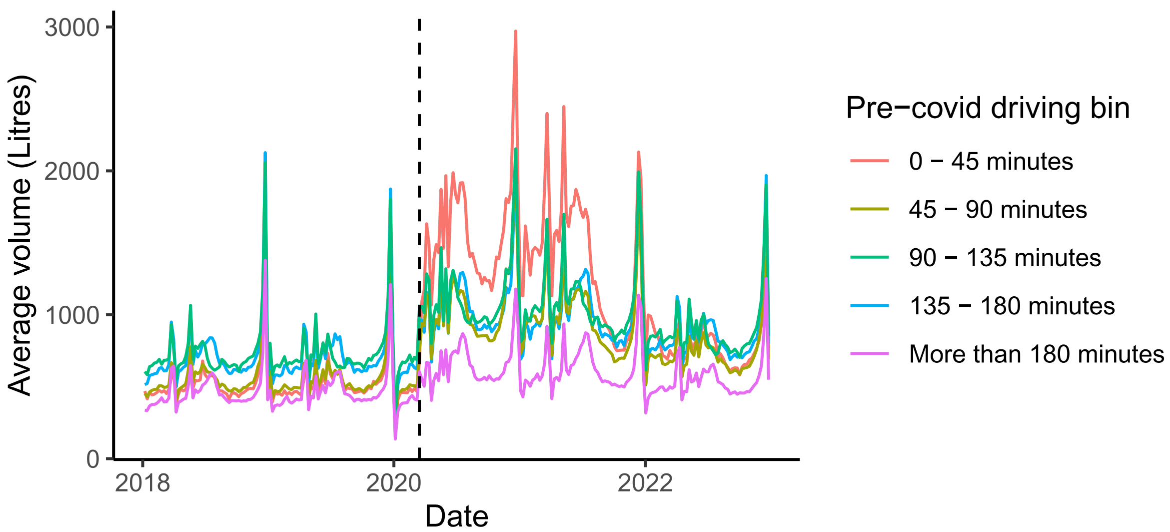
**Table 5.2:** Vinmonopolet sales by year and pre-covid driving bin

| | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| *0 - 45 minutes* | | | | | |
| *Total* | | | | | |
| Volume (Mill. litres) | 1.1 | 1.1 | 2.8 | 2.9 | 1.7 |
| Revenue (Mill. NOK) | 199 | 206 | 490 | 505 | 315 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 529 | 539 | 1,338 | 1,384 | 794 |
| Revenue ('000 NOK) | 96 | 99 | 231 | 243 | 151 |
| *45 - 90 minutes* | | | | | |
| *Total* | | | | | |
| Volume (Mill. litres) | 7.5 | 7.5 | 12.7 | 13.0 | 9.7 |
| Revenue (Mill. NOK) | 1,278 | 1,308 | 2,231 | 2,332 | 1,828 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 562 | 561 | 933 | 975 | 732 |
| Revenue ('000 NOK) | 96 | 98 | 164 | 175 | 137 |
| *90 - 135 minutes* | | | | | |
| *Total* | | | | | |
| Volume (Mill. litres) | 25.8 | 26.0 | 37.0 | 37.9 | 30.8 |
| Revenue (Mill. NOK) | 4,408 | 4,564 | 6,691 | 7,107 | 5,970 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 732 | 737 | 1,027 | 1,073 | 872 |
| Revenue ('000 NOK) | 125 | 129 | 186 | 201 | 169 |
| *135 - 180 minutes* | | | | | |
| *Total* | | | | | |
| Volume (Mill. litres) | 11.9 | 11.9 | 16.5 | 16.9 | 14.1 |
| Revenue (Mill. NOK) | 2,004 | 2,057 | 2,926 | 3,088 | 2,655 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 712 | 714 | 974 | 1,019 | 848 |
| Revenue ('000 NOK) | 120 | 124 | 173 | 186 | 160 |
| *More than 180 minutes* | | | | | |
| *Total* | | | | | |
| Volume (Mill. litres) | 35.7 | 36.1 | 46.6 | 47.7 | 41.0 |
| Revenue (Mill. NOK) | 5,969 | 6,165 | 8,226 | 8,664 | 7,667 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 469 | 474 | 600 | 627 | 539 |
| Revenue ('000 NOK) | 78 | 81 | 106 | 114 | 101 |

Figure 5.1 depicts the development of sales volume from 2018 to 2022 based on the

traveling duration to the nearest Systembolaget outlet. The vertical dashed line marks the week beginning Monday, 16th March 2020, which is three days after the initiation of a national lockdown and one day before the implementation of national travel restrictions. The figure reveals that sales volumes exhibit similar trends across different driving duration bins, following distinct seasonal variations like New Year's Eve and summer holidays. In the immediate aftermath of the onset of the COVID-19 pandemic, there is a noticeable surge in sales volume across all driving duration bins, with a particularly substantial increase for Vinmonopolet outlets situated closer to a Systembolaget outlet. In the subsequent year, the sales volume continues to follow similar trends, albeit at varying levels. Around the autumn of 2021, a pronounced decrease is observed across several bins, especially for Vinmonopolet outlets located within 45 minutes of a Systembolaget outlet. Starting in 2022, the sales volumes appear to revert to a trend and level more akin to pre-pandemic conditions. This visual analysis provides initial support for an assumption that the trend in Vinmonopolet outlet sales volume is independent of the driving duration to a Systembolaget. However, a more comprehensive examination and discussion of this assumption will be undertaken in Chapter 7.

**Figure 5.1:** Pretrend plot




**Note:** The figure plots the weekly volume sales by pre-covid driving bin. The dashed vertical line indicates the week society was shutdown.

Table 5.3 provides an overview of yearly sales for each main alcohol category, along with the average weekly store-average sales and the mean nominal selling price per litre within each category (excluded VAT). The data reveals considerable heterogeneity in sales increases across categories. For instance, wine sales witnessed an average increase of approximately 42% from 2019 to 2020, while fortified wine sales experienced a mere 20% increase over the same period. Despite these variations, all categories exhibit the same general trend, with rising sales until 2021 followed by a decline in 2022.

**Table 5.3:** Vinmonopolet sales by year and category, excluded VAT

| | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|
| *Spirits* | | | | | |
| Mean price (NOK, per litre) | 394.0 | 398.6 | 410.8 | 419.8 | 425.3 |
| *Total* | | | | | |
| Volume (Mill. litres) | 11 | 11 | 15 | 16 | 14 |
| Revenue (Mill. NOK) | 4,448 | 4,575 | 6,238 | 6,776 | 5,814 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 626 | 636 | 824 | 896 | 758 |
| Revenue (‘000 NOK) | 248 | 255 | 341 | 378 | 324 |
| *Beer* | | | | | |
| Mean price (NOK, per litre) | 105.0 | 105.6 | 109.2 | 108.7 | 108.4 |
| *Total* | | | | | |
| Volume (Mill. litres) | 3 | 3 | 4 | 4 | 3 |
| Revenue (Mill. NOK) | 312 | 337 | 462 | 491 | 409 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 154 | 164 | 212 | 232 | 193 |
| Revenue (‘000 NOK) | 17 | 19 | 25 | 27 | 23 |
| *Fortified Wine* | | | | | |
| Mean price (NOK, per litre) | 198.0 | 205.2 | 211.2 | 214.2 | 219.6 |
| *Total* | | | | | |
| Volume (Mill. litres) | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 |
| Revenue (Mill. NOK) | 97 | 101 | 139 | 141 | 119 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 27 | 26 | 35 | 36 | 29 |
| Revenue (‘000 NOK) | 5 | 6 | 8 | 8 | 7 |
| *Wine* | | | | | |
| Mean price (NOK, per litre) | 127.7 | 130.7 | 136.5 | 139.4 | 143.4 |
| *Total* | | | | | |
| Volume (Mill. litres) | 67 | 67 | 95 | 97 | 79 |
| Revenue (Mill. NOK) | 8,894 | 9,160 | 13,577 | 14,115 | 11,898 |
| *Weekly store-average* | | | | | |
| Volume (Litres) | 3,734 | 3,744 | 5,210 | 5,391 | 4,393 |
| Revenue (‘000 NOK) | 496 | 511 | 743 | 787 | 663 |

The table further highlights the substantial differences in sales volumes among categories. Wine stands out as the highest-selling category, followed by spirits, beer, and fortified wine. In terms of litres sold, wine outpaces fortified wine by nearly tenfold in 2022. The available data does not provide information at a more detailed product level than the broad alcohol categories presented in Table 5.3.

Adjusting the nominal mean sales prices to 2022-kroner using the CPI-calculator of SSB reveals a decline in real mean average selling prices in 2022 (Statistics Norway, 2023b),[8] after a period of steady increase until 2021, which raises intriguing possibilities. This trend might be indicative of two potential scenarios: either prices have been reduced by Vinmonopolet, or Norwegians are opting for more affordable alcohol on average in 2022. Since Vinmonopolet allows wholesalers to adjust prices three times a year,[9] and without detailed information on their own price adjustments, the use of CPI-adjustment serves as a reasonable method for controlling price changes. The implication from this observation is that, on average, Norwegians might be choosing less expensive alcohol from Vinmonopolet in 2022 compared to previous years.

Table 5.4 provides a breakdown of the distribution of all Vinmonopolet outlets active on 8th March 2020, the week preceding the effective shutdown of Norway due to the pandemic. Out of the 345 Vinmonopolet stores in our sample, five are situated within 45 minutes of a Systembolaget, while 162 are within 180 minutes of a Systembolaget. This implies that around 47 percent of Vinmonopolet outlets fall within the 180-minute drive time from a Systembolaget outlet, constituting our defined treatment group.

**Table 5.4:** Distribution of Vinmonopolet outlets within driving bins

| | Frequency | Percent |
|---|---|---|
| 0-45 minutes | 5 | 1.4 |
| 45-90 minutes | 32 | 9.3 |
| 90-135 minutes | 85 | 24.6 |
| 135-180 minutes | 40 | 11.6 |
| More than 180 minutes | 183 | 53.0 |
| Total | 345 | 100 |

[8]The mean sales prices adjusted to 2022-kroner can be found in Appendix A.3.
[9]The last price adjustment occurred 1st September 2023.

Starting from Tuesday, 17th March, until 25th July 2020, Norwegians essentially did not have access to cross-border shopping. During the summer of 2020, some Swedish counties were open for travel without triggering quarantine. However, all counties triggered quarantine from the autumn of 2020 until the summer of 2021, as described in Section 2.3. Figure 5.2 depicts which weeks which counties were open for travel. We keep track of driving times from all Vinmonopolet outlets to all Systembolaget outlets in counties that are open. This means that while the closest Systembolaget to a specific Vinmonopolet outlet $s$ could be in a closed county at time $t$, there could still be a Systembolaget outlet in an open county within 180 minutes drive time of Vinmonopolet outlet $s$, meaning that the status within the treatment group is maintained.

**Figure 5.2:** Accessibility of Swedish border counties

# 6 Methodology

In our thesis, we aim to estimate the causal effects of cross-border shopping for alcohol on tax revenue. The causal impact of a treatment can be defined as the difference between the outcome $Y_{it}(1)$ when a unit $i$ is treated at time $t = t$ and the outcome $Y_{it}(0)$ if the same unit $i$ was not treated at time $t$. This framework is known as the potential outcomes framework (Rubin, 1972). To determine the true causal impact of cross-border shopping for alcohol on tax revenue, it would be necessary to observe the world in two states —one where cross-border shopping is available and another where it is not. Unfortunately, this is not possible. Another alternative would be a randomized controlled trial in which the treatment, i.e., the availability of cross-border shopping, is randomly assigned. However, this approach is not feasible and may be unethical. Therefore, we turn to quasi-experimental methods. To identify the causal effect of cross-border shopping for alcohol on tax revenue, we follow Friberg et al. (2022) and leverage the natural experiment of COVID-19, during which the borders to neighboring Swedish counties essentially closed at different times and for varying durations due to the implementation of mandatory quarantine.

We employ a generalized Differences-in-Differences (DiD) methodology that leverages both the complete closure of the border to Sweden in early 2020 and the subsequent variations in the opening and closing times of different Swedish counties throughout the approximately two-year pandemic.

## 6.1 Generalized Differences in Differences

In its simplest form, a Differences-in-Differences (DiD) analysis involves two groups $(g = 1, 2)$ and two time periods $(t = 1, 2)$, represented in a $2 \times 2$ matrix. In one period, both groups are exposed to control conditions, i.e., no treatment is taking place. In the second period, one of the groups receives some treatment, while the other does not. Importantly, treatment need not be randomly assigned. Instead, under the assumption that in the absence of treatment the two groups would have followed parallel trends, the difference between the two groups in the different periods (hence, differences-in-differences) will identify the causal effect of the treatment. This entails a simple statistical model of treated and untreated potential outcomes of the form $Y_{it} = \beta_0 + \beta_1 T_i + \beta_2 P_t + \beta_3 (T_i \times P_t) + \epsilon_{it}$ (Wing et al., 2018, pp. 455–457). Here, $\beta_1$ captures the unit-fixed effects, $\beta_2$ captures the time-fixed effects, and $\beta_3$ captures the treatment effect. This case is easily generalized to a multiple-group × multiple-period setting and is commonly known as a two-way fixed effects estimator (TWFE). It takes the form $Y_{it} = \lambda_i + \gamma_t + \tau D_{it} + \epsilon_{it}$, where $\lambda_i$ is the group-fixed effect and $\gamma_t$ is the time-fixed effect (hence, two-way fixed effects), and $\tau$ is the treatment effect if assumptions hold. $D_{it}$ is a binary variable taking the value 1 if unit $i$ is treated at time $t$ and 0 otherwise.

A common extension of this method for estimating treatment effects involves an event study. However, most estimators, particularly those feasible for software implementation, typically assume an absorbing treatment state. In other words, every unit that will eventually be treated has a specific event date on which treatment starts and remains constant thereafter. This setup doesn't align with our scenario, where treatment is switching, turning on and off, and treatment effects are only present when treatment is active. The TWFE estimator accommodates the possibility of changing treatment states, offering attractive qualities for our objective of determining the causal effect.

However, recent research has highlighted several challenges in traditional TWFE estimation when there is heterogeneity in treatment timing and/or treatment effects. In severe cases, the estimated coefficients can even have the opposite sign of the true effect, as demonstrated by studies such as Borusyak et al. (2023), de Chaisemartin and D'haultfœuille (2022), Gardner (2022), and Roth et al. (2023). Gardner (2022) provides detailed insights, illustrating that under parallel trends but with varying treatment timing and/or effects, the TWFE estimator becomes misspecified. In such cases, the estimator incorrectly attributes some of the heterogeneous treatment effects to group- and/or time-fixed effects. Specifically, if a group is subject to treatment for an extended period, the treatment effects will be ascribed to group-fixed effects. Similarly, if a period has a higher likelihood of units being treated, the treatment effects will be absorbed by time-fixed effects. Using a static TWFE model, the estimated treatment effect remains a consistent estimate for the overall average treatment effect only in two cases: when treatment occurs simultaneously for all treated units or when treatment effects are constant across groups and time.

To address these challenges, both Gardner (2022) and Borusyak et al. (2023) propose a two-stage approach. Following the notation of Borusyak et al. (2023):

Group all $N$ observations, $it \in \Omega$, into treated $\Omega_1 = \{it \in \Omega : D_{it} = 1\}$ observations of size $N_1$, and untreated $\Omega_0 = \{it \in \Omega : D_{it} = 0\}$ observations of size $N_0$. Using only untreated observations, $\Omega_0$, estimate

$$Y_{it}(0) = \lambda_i + \gamma_t + \epsilon_{it}, \qquad it \in \Omega_0. \tag{6.1}$$

The estimated unit-fixed effect $\widehat{\lambda}_i$ and time-fixed effect $\widehat{\gamma}t$ constitute our estimate of the untreated potential outcome, $\widehat{Y}it(0)$. This estimate is then used to derive an estimate for the treatment effect.

$$\hat{\tau}_{it} = Y_{it}(1) - \widehat{Y}_{it}(0), \qquad it \in \Omega_1. \tag{6.2}$$

The treatment effects are averaged to find an estimate of the average treatment effect on the treated (ATT).

$$\widehat{\tau}_w = \sum_{it=\Omega_1} w_{it}\widehat{\tau}_{it}, \tag{6.3}$$

where $w_{it} = 1/N_1$. $\widehat{\tau}_{it} \neq \tau_{it}$ because $Y_{it}(0) = \widehat{Y}_{it}(0) + \widehat{\epsilon}_{it}$. However, since the first stage is unbiased and consistent, $E(\widehat{\epsilon}_{it}) = 0$, thus averaging over a big enough set of $i, t$ means that $E(\widehat{\tau}_w) = \tau_w$ (Butts & Gardner, 2022; Gardner, 2022).

Gardner's Two-Stage Differences-in-Differences (2SDiD) offers appealing properties in our context as it yields unbiased and consistent estimates of the treatment effect when treatment is switching and the adoption and average treatment effects vary across units and periods (Gardner, 2022). While it also allows for identifying heterogeneous treatment effects concerning periods within units within an event study setup, our situation does not align with this approach. Consequently, we rely on 2SDiD as our primary estimator, complemented by the static Two-Way Fixed Effects (TWFE) estimator for baseline estimates.

## 6.2 Regression Models

Our objective is to estimate the Average Treatment Effect on the Treated (ATT) across groups and periods. We undertake two model estimations: first, a basic model discerning the overall treatment effect of available cross-border alcohol shopping, irrespective of the distance to a Systembolaget outlet within the treatment group; second, a model accommodating heterogeneous treatment effects based on driving duration to the nearest Systembolaget outlet within the treatment group, considering the likely variation in treatment effects depending on driving distance. We aim to estimate the following two models:

$$Y_{st} = store_s + week_t + \tau_w D_{st} + \epsilon_{st}, \tag{6.4}$$

$$Y_{st} = store_s + week_t + \sum_j \tau_{w,j}(D_{st} \times driving\_bin_{st}) + \epsilon_{st}. \tag{6.5}$$

Here, $Y_{st}$ represents the natural logarithm of volume sold in Vinmonopolet store $s$ at time $t$. $store_s$ denotes store-level fixed effects, accounting for time-invariant store-specific factors, while $week_t$ captures store-invariant time-specific influences. For instance, time-invariant factors might encompass varying clientele sizes among Vinmonopolet stores, and time-specific influences might include periods with generally heightened sales, such as the lead-up to New Year's Eve. The binary variable $D_{st}$ takes the value 1 if Vinmonopolet outlet $s$ is treated at time $t$ and 0 otherwise. Treatment is defined as having a Systembolaget outlet in an open county within 180 minutes of driving time from a Vinmonopolet outlet.[10] Therefore, the treatment indicator varies depending on whether the border is open or closed. The categorical variable $driving\_bin_{st}$ measures the driving duration in $j$ bins with increments of 45 minutes from Vinmonopolet outlet $s$ to the nearest accessible Systembolaget outlet at time $t$. The control group, i.e., outlets more than 180 minutes from a Systembolaget outlet in an open county, falls into the $j^{\text{th}}$ bin.

To estimate the models, we employ both a static Two-Way Fixed Effects (TWFE) estimator and the imputation-based Two-Stage Differences-in-Differences (2SDiD) approach. For baseline estimates, we initiate the process by estimating two static TWFE models specified as Equation (6.4) and Equation (6.5). The TWFE specification fits $store_s$ and $week_t$ on the entire sample, a setup that could potentially attribute treatment effects to store-fixed effects and/or week-fixed effects. Consequently, we anticipate the TWFE estimator to be biased downward, leading to an underestimation of the true effect.

The imputation-based methods proposed by Borusyak et al. (2023) and Gardner (2022)

[10] As a robustness check, we also reestimate our model using a 270-minute drive-time threshold.

address this issue. Hence, we opt to use the Two-Stage Differences-in-Differences (2SDiD) estimator suggested by Gardner (2022) as our primary specification. The first stage is identical across both specifications, and we estimate:

$$Y_{st} = \widehat{store_s} + \widehat{week_t} + \epsilon_{st}, \qquad st \in \Omega_0. \tag{6.6}$$

We retain the estimated store-fixed effect $\widehat{store_s}$ and time-fixed effect $\widehat{week_t}$ to derive an estimate of the untreated potential outcome. Subsequently, we estimate two second-stage equations:

$$\widetilde{Y}_{st} = \tau_w D_{st} + u_{st}, \qquad st \in \Omega_1, \tag{6.7}$$

$$\widetilde{Y}_{st} = \sum_j \tau_{w,j}(D_{st} \times driving\_bin_{st}) + u_{st}, \qquad st \in \Omega_1, \tag{6.8}$$

where $\widetilde{Y}_{st} = Y_{st} - \widehat{store_s} - \widehat{week_t}$.

Subject to specific assumptions, the parameters $\tau_w$ and $\tau_{w,j}$ will identify the average causal impact of cross-border alcohol shopping on Norwegian tax revenue. We will now outline the key assumptions that facilitate causal interpretation within our context. Subsequently, we will delve into alternative specifications intended for robustness checks.

### 6.2.1 Identifying Assumptions

Firstly, the primary assumption is that the underlying trend in Vinmonopolet outlet sales is independent of the driving duration to a Swedish Systembolaget outlet. It's important to note that this assumption doesn't impose any restrictions on the levels of sales but asserts that the sales trend from one period to the next is consistent regardless of the distance to Sweden.

Secondly, we assume that there are no anticipation effects and no spillover effects. In essence, this assumption posits that treatment effects will exclusively manifest when treatment is applied, with no effects anticipated before or spilling over from previous treatment. In our context, this implies that a Vinmonopolet outlet should only experience treatment effects during the period when a Systembolaget outlet is in an open county within 180 minutes of drive time. If the county is closed in the preceding period, there should be no treatment effects during that time, and if the county is closed in the succeeding period, there should be no treatment effects during that time.

Finally, an assumption of homoscedastic errors can be imposed for efficient estimation. While this is a strong assumption that is unlikely to hold, it is a common practice when working with panel data. To address potential heteroscedasticity, standard errors are typically clustered at the fitting level. In our case, we cluster the standard errors at the store level.

## 6.3 Control Variables

One potential issue when fitting a regression model to mimic the true model is that of omitted variable bias (OVB). If there are variables omitted from our model that are correlated with both the independent variables and the dependent variable, we may experience OVB, leading to over- or underestimation of the effects of the independent variables. Although a properly specified generalized differences-in-differences study should not be prone to this issue, as we assume parallel trends, we conduct a robustness check by estimating our model with additional control variables that could potentially induce OVB.

In this analysis, we include quarterly population data for each municipality, weekly infection rates in each municipality, yearly employment rates at the municipality level, and 2019-levels of cabins per square kilometer. These control variables are chosen based on their potential correlation with the opening and closing of borders, as well as alcohol consumption and purchases, providing alternative explanations for any observed effects. Our hypothesis is centered around the idea that border closures impact sales volume, but including these controls allows us to explore alternative explanations. Changes in population within counties during the time period, surges in unemployment due to the pandemic, and variations in the number of cabins in municipalities are all factors that may influence the outcomes. If the observed variation can be explained by including these controls, it would weaken confidence in our hypothesis.

# 7 Empirical Analysis

In this chapter, we present the results from our empirical analysis and extrapolate the findings to estimate the total tax loss stemming from cross-border shopping of alcohol. Subsequently, we discuss these results in the context of economic theory. After presenting and discussing the results, we delve into the robustness and limitations of our findings.

In summary, our analysis reveals that the accessibility of cross-border shopping leads to a sales reduction of approximately 13 percent in treated Vinmonopolet outlets. This impact is more pronounced in proximity to the Swedish border, with a sales reduction of 48 percent within 45 minutes' driving time from a Systembolaget outlet. The effect gradually diminishes with increased distance, reaching a 5.6 percent reduction in sales for stores located 135–180 minutes away and economically insignificant more than 180 minutes away. The estimated tax loss in 2019 attributable to reduced Vinmonopolet sales due to cross-border shopping is approximately NOK 871 million.

## 7.1 The Effect of Cross-Border Shopping on Sales Volume

Table 7.1 provides the results of estimating the overall Average Treatment Effect on the Treated (ATT), equivalent to $logD_N - logD_N^{closed}$ from Equation (4.28) for the entire treated population. Column (1) presents the Two-Way Fixed Effects (TWFE) estimates, and Column (2) presents the Two-Stage Differences-in-Differences (2SDiD) estimates. The dependent variable in both columns is the natural logarithm of volume sold. As anticipated, the TWFE estimator exhibits a downward bias, likely attributing treatment effects to time-fixed effects due to the simultaneous treatment of many units. Nevertheless, the point estimates are highly similar to the 2SDiD estimate. The 2SDiD estimate provides the weighted average of ATT, with all observations being equally weighted, giving more importance to times when many units are treated. The overall ATT is estimated to be 13.2 percent $(100 \times (\exp(-0.1420) - 1))$. This implies that the accessibility of cross-border shopping reduces Vinmonopolet sales on average by approximately 13 percent. The results are statistically significant at the 1 percent level.

**Table 7.1:** Effect of available cross-border shopping on Vinmonopolet sales

| Dependent Variable: | log_vol | |
|---|---|---|
| Model: | (1) | (2) |
| | TWFE | 2SDiD |
| *Variables* | | |
| $D_{st} = 1$ | -0.1356*** | -0.1420*** |
| | (0.0145) | (0.0151) |
| *Control group* | | |
| Driving duration | $> 180$ | $> 180$ |
| *Fit statistics* | | |
| Observations | 87,422 | 87,384 |
| Stores | 345 | 345 |
| Weeks | 260 | 260 |

*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from the two specifications using TWFE and 2SDiD. In each column, the dependent variable is the natural logarithm of sales volume. Column (1) reports estimates using a static TWFE model. Column (2) reports estimates using a static 2SDiD model. Standard errors reported in parentheses are clustered at the store level.

While Table 7.1 provides the overall Average Treatment Effect on the Treated (ATT) as a weighted average of all treatment effects, it is also of interest to explore how treatment effects vary with the distance to a Systembolaget outlet. Table 7.2 presents the results from estimating the ATT across driving bins using both a Two-Way Fixed Effects (TWFE) and a Two-Stage Differences-in-Differences (2SDiD) specification. This is equivalent to $logD_N - logD_N^{closed}$ within driving bins from Equation (4.28). The dependent variable is the natural logarithm of volume sold. Once again, we observe that the TWFE estimates appear biased downwards, as expected, yet are nearly identical to the 2SDiD estimates. The results from Column (2) provide the average treatment effects on the treated within each bin, meaning that periods with more treated units are given more weight.

The results indicate that the treatment effect diminishes with the distance to a Systembolaget outlet. Within the nearest driving bin, alcohol sales are reduced by 48 percent as a result of available cross-border shopping, whereas within the farthest driving bin, alcohol sales are reduced by 5.6 percent. All results are statistically significant at the 1 percent level. The results reported in Column (2) are our main findings, and if assumptions hold, they represent the average treatment effect on the treated of available cross-border shopping on Vinmonopolet alcohol sales.

**Table 7.2:** Effect of cross-border shopping on Vinmonopolet sales by driving bin

| Dependent Variable: | log_vol | |
|---|---|---|
| Model: | (1) | (2) |
| | TWFE | 2SDiD |
| *Variables* | | |
| Duration < 45 $\times D_{st}$ | -0.6455*** | -0.6567*** |
| | (0.0448) | (0.0511) |
| 45 $\leq$ Duration < 90 $\times D_{st}$ | -0.2746*** | -0.2774*** |
| | (0.0169) | (0.0174) |
| 90 $\leq$ Duration < 135 $\times D_{st}$ | -0.1006*** | -0.1011*** |
| | (0.0178) | (0.0185) |
| 135 $\leq$ Duration < 180 $\times D_{st}$ | -0.0553*** | -0.0581*** |
| | (0.0148) | (0.0151) |
| *Control group* | | |
| Driving duration | > 180 | > 180 |
| *Fit statistics* | | |
| Observations | 87,422 | 87,384 |
| Stores | 345 | 345 |
| Weeks | 260 | 260 |

*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from the two specifications using TWFE and 2SDiD. In each column, the dependent variable is the natural logarithm of sales volume. Column (1) reports estimates using a static TWFE model. Column (2) reports estimates using a static 2SDiD model. Standard errors reported in parentheses are clustered at the store level.

In the subsequent analysis, our focus shifts exclusively to the 2SDiD estimator, and we cease to report TWFE estimates. As previously discussed, even if point estimates are highly similar, there is no justification for employing the TWFE estimator in our setting as it imposes assumptions that do not hold. This is evidenced by the downward bias observed in TWFE estimates in Table 7.1 and Table 7.2. The 2SDiD estimator does not encounter this issue, and consequently, we exclusively present estimates derived from the 2SDiD estimator henceforth.

## Treatment Effect Contingent on Alcohol Category

Table 7.3 presents the results from four regressions as specified in Equation (6.8), focusing on the four main categories of alcohol sold at Vinmonopolet. These regressions depict the contribution of each alcohol category to the main results in Table 7.2 and are equivalent to calculating $logD_N - logD_N^{closed}$ from Equation (4.28) for each alcohol category within each driving bin. Weighting the average within a driving bin by the volume sold for each category would yield the same estimate as the overall estimate for the corresponding driving bin in Table 7.2.

The analysis reveals significant heterogeneity in the effect of available cross-border shopping on different alcohol categories. For all main categories, cross-border shopping reduces Vinmonopolet sales within 135 minutes of driving distance of a Systembolaget outlet. Except for fortified wine, all categories also experience a reduction in sales volume up to 180 minutes from a Systembolaget outlet. Notably, wine shows the largest decrease in sales due to cross-border shopping for all driving durations, while fortified wine exhibits the smallest decrease. For driving durations above 135 minutes, the effects on fortified wine are statistically insignificant. Despite this, all effects are relatively large in magnitude.

**Table 7.3:** Effect of cross-border shopping on Vinmonopolet sales by alcohol category

| Dependent Variable: | log_vol | | | |
|---|---|---|---|---|
| Model: | (1) Wine | (2) Fortified wine | (3) Spirits | (4) Beer |
| *Variables* | | | | |
| Duration $< 45 \times D_{st}$ | -0.7112*** | -0.3791*** | -0.4671*** | -0.5038*** |
| | (0.0539) | (0.0460) | (0.0479) | (0.0625) |
| $45 \leq$ Duration $< 90 \times D_{st}$ | -0.2953*** | -0.1880*** | -0.2076*** | -0.2360*** |
| | (0.0195) | (0.0197) | (0.0153) | (0.0204) |
| $90 \leq$ Duration $< 135 \times D_{st}$ | -0.1046*** | -0.0681*** | -0.0867*** | -0.0892*** |
| | (0.0191) | (0.0176) | (0.0175) | (0.0191) |
| $135 \leq$ Duration $< 180 \times D_{st}$ | -0.0621*** | -0.0069 | -0.0418** | -0.0379** |
| | (0.0150) | (0.0199) | (0.0176) | (0.0174) |
| *Control group* | | | | |
| Driving duration | > 180 | > 180 | > 180 | > 180 |
| *Fit statistics* | | | | |
| Observations | 87,384 | 86,906 | 87,378 | 87,368 |
| Stores | 345 | 345 | 345 | 345 |
| Weeks | 260 | 260 | 260 | 260 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from estimation with 2SDiD. In Column (1) the dependent variable is the natural logarithm of sales volume of wine. In Column (2) the dependent variable is the natural logarithm of sales volume of fortified wine. In Column (3) the dependent variable is the natural logarithm of sales volume of spirits. In Column (4) the dependent variable is the natural logarithm of sales volume of beer. Standard errors reported in parentheses are clustered at the store level.

From the results, one would assume that wine has the largest price difference between Norway and Sweden and that fortified wine has the lowest. Surprisingly, as seen from Table 2.6 wine has the lowest price difference between Norway and Sweden in our constructed basket. This is followed by fortified wine, spirits, and beer, which has the highest price difference. We discuss this further in Section 7.3.

### Treatment Effect Contingent on Period

Our main estimates, as presented in Table 7.2 and Table 7.3, provide the average treatment effects on the treated across all periods. Consequently, these estimates do not allow us to explore whether the effect is constant across periods or if it varies over time. There is a possibility that treatment effects differ between the initial lockdown in March 2020 and the final opening in January 2022, given the change in quota regulations. It is reasonable to anticipate that treatment effects might be lower towards the end of the pandemic compared to the beginning, owing to the tightening of regulations implemented 1st January 2022.

To investigate this, we re-estimate the treatment effects using two indicator variables — one indicating whether the period is before or after 16th March 2020, and the other indicating whether the period is before or after 29th January 2022. On both dates, the availability of cross-border shopping changed status for all counties simultaneously, as shown in Figure 5.2. The results are presented in Table 7.4. The results from Column (1) and Column (2) indicate a difference in treatment effects contingent on periods. From Column (1), the estimated treatment effect of available cross-border shopping in early 2020 shows a reduction in sales volume by 14.7%. From Column (2), the estimated treatment effect at the end of the pandemic is 10.9%, suggesting a difference of approximately 4 percentage points. Column (3) and Column (4) indicate that this difference exists within all driving bins.

To formally examine if the true coefficients are different, we conduct a chi-squared test to assess if the coefficient estimates in Column (1) and Column (2) are statistically different.[11] The test statistic yields a p-value of 0.001, leading to the rejection of the hypothesis that the effects are identical in both periods. Subsequently, we perform chi-squared tests to

[11] Results from the test can be found in the Appendix, Table A.12.

**Table 7.4:** Regressions estimating whether treatment effects differ by period

| Dependent Variable: | log_vol | | | |
|---|---|---|---|---|
| Model: | (1) First Lockdown | (2) Final Opening | (3) First Lockdown | (4) Final Opening |
| *Variables* | | | | |
| $D_t$ | -0.1591*** | -0.1151*** | | |
| | (0.0197) | (0.0125) | | |
| Duration $< 45 \times D_t$ | | | -0.7385*** | -0.5389*** |
| | | | (0.0583) | (0.0562) |
| $45 \leq$ Duration $< 90 \times D_t$ | | | -0.3302*** | -0.2093*** |
| | | | (0.0232) | (0.0140) |
| $90 \leq$ Duration $< 135 \times D_t$ | | | -0.1020*** | -0.0845*** |
| | | | (0.0246) | (0.0146) |
| $135 \leq$ Duration $< 180 \times D_t$ | | | -0.0661*** | -0.0484*** |
| | | | (0.0221) | (0.0131) |
| *Control group* | | | | |
| Driving duration | $> 180$ | $> 180$ | $> 180$ | $> 180$ |
| *Fit statistics* | | | | |
| Observations | 87,384 | 87,384 | 87,384 | 87,384 |
| Stores | 345 | 345 | 345 | 345 |
| Weeks | 260 | 260 | 260 | 260 |
| $D_t = 1$ if Date | <2020-03-16 | >2022-01-29 | <2020-03-16 | >2022-01-29 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from estimation with 2SDiD. The dependent variable is the natural logarithm of sales volume. The independent variables are an indicator variable indicating whether the period is before or after the first lockdown and an indicator variable indicating whether the period is before or after the final opening. Column (1) and (2) estimates the regression from Equation (6.7). Column (3) and (4) estimates the regression from Equation (6.8). Standard errors reported in parentheses are clustered at the store level.

evaluate if the coefficients in Column (3) and Column (4) are statistically different. The results from these tests suggest that the true effect of cross-border shopping was different at the beginning and the end of the pandemic within the two nearest driving bins, i.e., within 90 minutes of a Systembolaget outlet. Both test statistics have corresponding p-values well below 0.001. However, more than 90 minutes of driving time from a Systembolaget outlet, the difference in coefficient estimates is not significantly different.

The results presented above introduce ambiguity regarding which treatment effects should be given weight when utilizing our findings. We could either use the results presented in

Table 7.3, the estimates in Column (3) in Table 7.4 or the estimates in Column (4) in Table 7.4. We have chosen to rely on the results presented in Table 7.3 rather than Table 7.4. The results in Table 7.3 essentially represent a breakdown of the results in Table 7.2, which, in turn, decompose the results in Table 7.1. On one hand, the estimated treatment effect at the beginning of the pandemic, Column (3), should capture the true treatment effect at a moment before the pandemic could alter behaviors. If we believe behaviors will revert to pre-pandemic patterns, we should have employed the effect measured at this moment. On the other hand, quota regulations were tightened in 2022, indicating that the results from the end of the pandemic are the most relevant ones. Furthermore, it could be the case that the pandemic permanently altered shopping behaviors. In this scenario, the effects estimated at the end of the pandemic, Column (4), should have been used.

We do not believe the pandemic itself permanently changed shopping behaviors and expect to see a convergence towards pre-pandemic levels. However, the tightening of quota regulations implies that true treatment effects should be lower than estimated in 2020. For these reasons, we proceed using the results presented in Table 7.3 —these estimates should err on the side of caution as they are a weighted average of all ATTs, being pulled down from 2020 levels by late treated observations.

## 7.2 Tax Loss due to Cross-Border Shopping

With the estimated effects of available cross-border shopping on Vinmonopolet sales volume in total, by pre-COVID driving bin, and by category, our next objective is to quantify the estimated Norwegian tax loss resulting from reduced Vinmonopolet sales. Sales of alcoholic beverages contribute to tax revenue through VAT, excise tax on alcohol, and the beverage packaging tax, as outlined in Section 2.2. Decreased sales consequently lead to a reduction in tax income. VAT is computed based on the selling price, the excise tax is determined by alcohol volume and litre[12], and the beverage packaging tax is derived from the type of beverage packaging per unit. Our data set contains revenue excluding VAT, enabling us to calculate VAT directly. Additionally, we know the average alcohol percentage of units sold within the four main alcohol categories, allowing us to estimate the excise tax on alcohol induced by Vinmonopolet sales. Lastly, we possess information

[12]Except for beer, where it is calculated per litre beverage.

on the paid environmental tax covering the years 2018–2022.

To compute the tax loss, we estimate the actual tax revenue by each main category from Vinmonopolet sales in 2019, the last full year before COVID-19.[13] We then use the estimated effects from Table 7.3 to construct the counterfactual tax income in a scenario where cross-border shopping is unavailable.

For example, consider the total volume of spirits sold by Vinmonopolet outlets located within 45 minutes of driving time from a Systembolaget outlet in 2019, which was 215,085 litres. The estimated effect of cross-border shopping on sales within this driving bin is $-0.7112$. By calculating $215,085/\exp(-0.7112) = 343,138$, we obtain the counterfactual sales volume. The average alcohol percentage of beverages sold within the category "spirits" in 2019 was 35.75%, resulting in an estimated actual excise tax of approximately NOK 59.1 million and an estimated counterfactual excise tax of approximately NOK 94.3 million. The difference between the actual and counterfactual values represents the estimated tax loss.

For the basic tax and environmental tax, we use the actual paid tax in 2019, distribute it based on the estimated actual volume sold, and multiply it by the estimated counterfactual volume to derive estimates of the tax loss. This assumes that the distribution of types of beverages sold (cardboard wine, glass bottles, metal cans, etc.) would be the same in the counterfactual state. The VAT is calculated by taking the actual revenue excluding VAT and multiplying it by 0.25, and the same calculation is performed for the counterfactual revenue.

Table 7.5 provides the total estimated tax loss from reduced Vinmonopolet sales, calculated by each main category within each pre-COVID driving bin, as described above. The overall estimated tax loss is NOK 871.1 million. The largest contributor to the tax loss is the excise tax loss, accounting for over 65 percent of the total. The loss of VAT is the second largest, constituting 33 percent of the total tax loss, while the remaining 2 percent comes from the beverage packaging tax.

The total revenue from the excise tax on alcohol in 2019 was NOK 14.4 billion (see Table 2.4), indicating that eliminating cross-border shopping could potentially increase the revenue from this tax by about 4 percent.

[13] Calculations for all main categories can be found in Appendix A.

**Table 7.5:** Estimated tax loss from Vinmonopolet sales 2019. Mill. NOK, by pre-COVID driving bin and total

| | $< 45$ | $[45 - 90)$ | $[90 - 135)$ | $[135 - 180)$ | $> 180$ | Total |
|---|---|---|---|---|---|---|
| *VAT* | | | | | | |
| Counterfactual | 93.6 | 422.1 | 1,248.4 | 538.2 | 1,528.1 | 3,830.4 |
| Actual | 50.9 | 323.9 | 1,130.6 | 509.9 | 1,528.1 | 3,543.5 |
| Loss | 42.6 | 98.2 | 117.8 | 28.3 | - | 286.9 |
| *Excise Tax* | | | | | | |
| Counterfactual | 202.8 | 876.0 | 2,425.0 | 1,153.5 | 3,289.2 | 7,946.6 |
| Actual | 112.8 | 677.7 | 2,199.7 | 1,094.6 | 3,289.2 | 7,374.0 |
| Loss | 90.0 | 198.4 | 225.3 | 59.0 | - | 572.6 |
| *Basic Tax* | | | | | | |
| Counterfactual | 2.7 | 12.4 | 36.2 | 15.9 | 45.4 | 112.7 |
| Actual | 1.4 | 9.4 | 32.7 | 15.0 | 45.4 | 104.0 |
| Loss | 1.3 | 3.0 | 3.5 | 0.9 | - | 8.8 |
| *Environmental Tax* | | | | | | |
| Counterfactual | 0.9 | 4.0 | 11.7 | 5.1 | 14.7 | 36.5 |
| Actual | 0.5 | 3.0 | 10.6 | 4.9 | 14.7 | 33.7 |
| Loss | 0.4 | 1.0 | 1.1 | 0.3 | - | 2.8 |
| *Total* | | | | | | |
| Total Tax Loss | 134.3 | 300.6 | 347.8 | 88.4 | - | 871.1 |

**Note:** This table shows the estimated actual tax revenue from Vinmonopolet sales, the estimated counterfactual revenue based on the results showed in Table 7.3 and the calculated tax loss defined as the difference between the two. Detailed calculations for each alcohol category can be found in Appendix A.

The decision to estimate the actual excise tax, despite having access to the actual paid excise tax by Vinmonopolet, is motivated by two main considerations. Firstly, Vinmonopolet pays the excise tax to wholesalers, who, in turn, remit the tax to the Tax Administration. Vinmonopolet has indicated that their creditor payment period is typically 25 days. This suggests a potential discrepancy between the numbers received and the estimated numbers, possibly arising from unsold inventory at the end of the year for which Vinmonopolet has already paid the excise tax. Secondly, maintaining consistency in the estimation approach is essential since we need to calculate counterfactual estimates as described. Therefore, estimating the actual excise tax in the same manner ensures methodological coherence.[14]

[14]The actual paid excise tax and the estimated actual paid excise tax can be found in Table A.9.

## 7.3 Discussion of Results

The theoretical model presented in Chapter 4 suggests that consumers engage in cross-border shopping when the price difference between Norway and Sweden is sufficient to cover transportation costs. Additionally, the model, supported by the literature reviewed in Chapter 3, implies that cross-border shopping should decrease as transportation costs increase, which, in turn, is associated with greater distance. Our empirical results align with the theoretical framework and existing literature. However, an interesting observation is the larger impact on wine sales compared to spirits and beer sales, despite the relative price difference favoring spirits. This discrepancy warrants further explanation, and in the following section, we will discuss our findings and propose additional insights.

### Overall Sales and Driving Bins

Our estimation reveals a significant and expected negative impact of cross-border shopping on Vinmonopolet's sales, leading to an overall reduction of approximately 13 percent within 180 minutes of a Systembolaget outlet. This aligns with our initial expectations and is consistent with the background described in Chapter 2. As highlighted, a considerable portion of the Norwegian population engages in cross-border shopping to Sweden, and a significant share of the transaction amount is used on highly taxed items, including alcohol.

The primary motivation for individuals to participate in cross-border shopping is likely the notable price difference between Norway and Sweden, where we estimated an average price difference for alcohol of approximately 30% in Table 2.6. In Chapter 4, we presented a theoretical model suggesting that rational consumers would opt to purchase alcohol in Sweden if the price difference is substantial enough to compensate for transportation costs. The results in Table 7.1 support this premise. Our main contribution lies in the precision of estimating the magnitude of this effect.

Comparing the magnitude of our findings with those of Friberg et al. (2022), who estimated a 3 percent overall reduction in grocery store sales, our results indicate a more than fourfold impact. This difference can be attributed to the different types of commodities considered. While Friberg et al. (2022) examined goods suitable and unsuitable for cross-border shopping, our focus is solely on alcohol, a category highly conducive to cross-border shopping, which likely contributes to the heightened effect.

In Table 7.2, we show a diminishing treatment effect with increasing driving time to the nearest Systembolaget outlet, aligning with our expectations. The rationale behind this pattern lies in the anticipated increase in transportation costs as the distance grows. Our theoretical model, outlined in Chapter 4, predicts that a larger share of the alcohol budget will be allocated to cross-border shopping when transportation costs are lower. This finding is consistent with the results of Statistics Norway (2022), who reported that individuals in Eastern Norway engage in more cross-border shopping compared to those in Western Norway. Similarly, Friberg et al. (2022) found that grocery store sales decrease by 25% within 30 minutes of the border and 6.1% within 180 minutes due to available cross-border shopping.

In our context, we estimate a substantial 48% reduction in Vinmonopolet sales volume within 45 minutes of a Systembolaget outlet. This effect diminishes to 5.6% up to 180 minutes away. Notably, our estimates indicate a significantly larger impact close to the border compared to the findings of Friberg et al. (2022), while the effects 180 minutes away are highly similar.

The difference in estimates closest to the border between our study and Friberg et al. (2022) may be attributed to several factors. One potential explanation is the difference in bin increments, as we use 45-minute increments while Friberg et al. (2022) uses 30-minute increments. However, if this was the primary factor, we might expect our estimate to be smaller in magnitude due to including a sample with larger transportation costs (since transportation costs increase with driving time, and our bins cover longer driving times). A more plausible explanation is again that our study focuses specifically on alcohol, a product well-suited for cross-border shopping. In contrast, Friberg et al. (2022) considers a broader range of products, including those not suitable for cross-border shopping.

In their study, Friberg et al. (2022) estimate a 10% to 20% reduction in sales for stores within 30 minutes of a Swedish grocery store for products not suited for cross-border shopping. For stores more than one hour away, they find no significant effect. Thus, we would expect our results to align more closely with theirs for distances exceeding one hour, with our estimated effects being substantially larger in magnitude for outlets closer to the border. This reasoning stems from the fact that, beyond one hour of driving time, Friberg et al. (2022)'s overall effect is not influenced by commodities unsuitable for cross-border shopping, making it more comparable to our estimates. For distances less than one hour, the average overall effect they measure is influenced by both commodities suited and unsuited for cross-border shopping.

## Alcohol Category

Our study reveals significant heterogeneity in treatment effects across alcohol categories, as detailed in Table 7.3. To our knowledge, we are the first to estimate the impact of cross-border shopping on the sales volume of specific alcohol categories in Norway. While Friberg et al. (2022) investigates the effect on beer, which is sold in Norwegian grocery stores, the comparison may not be entirely direct. Beer sold at Vinmonopolet mainly consists of specialty beers, differing from the predominantly industrial types of lager found in grocery stores. Despite these differences, beer is the most comparable category examined in their study to our results.

Friberg et al. (2022) find that within 30 minutes of a Swedish grocery store, Norwegian beer sales decrease by 40 percent. The nearly identical estimate for the effect on beer in our analysis, where Vinmonopolet's beer sales within 45 minutes of a Systembolaget are reduced by 40 percent ($100*(exp(-0.5038) - 1) = 39.6$), provides confidence in the precision of our beer estimate. Further, Friberg et al. (2022) find an economically significant effect for beer sales up to 150 minutes driving time, while we find an effect up to 180 minutes driving time (later in Section 7.4, we show that treatment effects are economically insignificant beyond 180 minutes driving time). For further comparison, Asplund et al. (2006) find an economically significant effect for wine sales that becomes negligible at a distance of 200 km. Our own findings align with this observation when we consider an assumed average driving speed of approximately 65 km/h for the consumer. In 180 minutes, the consumer would cover a distance of 195 km, a value nearly equivalent to the 200 km threshold.

As indicated in Table 7.3, wine sales experience a reduction of approximately 51 percent, and since wine constitutes the most sold category, this increases our overall estimated effect. The notable impact of cross-border shopping on wine sales compared to other alcohol categories prompts the question: Why is wine more heavily affected? In our estimates, wine experiences the most substantial reduction in sales volume due to cross-border shopping, followed by beer, spirits, and fortified wine. Contrary to expectations based on our theoretical model from Chapter 4, the largest price differences between Norway and Sweden, as shown in Table 2.6, do not align with this order. Wine has the lowest price difference, followed by fortified wine, spirits, and beer, which has the largest price difference. Therefore, there must be an alternative explanation beyond what was presented in Chapter 4. We propose two potential explanations before delving into an examination of these theories using data.

One potential explanation for the observed differences in the impact of cross-border shopping on various alcohol categories is related to differences in consumer preferences. If individuals engaging in cross-border shopping have distinct preferences compared to those who do not, it could influence the observed effects. For instance, if higher-income groups generally prefer premium products like fortified wine and specialty beers, while lower-income individuals who engage in cross-border shopping are more price-sensitive and prefer cheaper wine, spirits, and standard lagers available in grocery stores, this could explain the relatively lower estimated effect on fortified wine and specialty beer and the higher estimated effect on wine.

Unfortunately, we lack individual-level data that would allow for a comprehensive examination of this hypothesis. However, anecdotal evidence, such as reports indicating that low-income groups engage in cross-border shopping more frequently (Institute of Transport Economics, 2006), seems to support this idea. This aligns with findings in previous research on sodas, where more price-sensitive consumers tend to stock up on larger volumes, affecting lower-priced products more than premium ones (Friberg et al., 2022). It is important to note that this explanation could coexist with the validity of the parallel trends assumption, as long as the distribution of these preferences is independent of driving time to Systembolaget. The concern would arise if individuals with access to cross-border shopping were fundamentally different from those without access, meaning these preferences are not independent of driving time. However, we address this concern later in Section 7.4 and provide additional evidence supporting the assumption.

Another potential explanation for the observed differences in the impact of cross-border shopping on various alcohol categories relates to the specific regulations governing alcohol quotas. The quota regulations, as outlined in Section 2.2, play a crucial role in determining the amounts and different types of alcoholic beverages that individuals can purchase during cross-border shopping. To thoroughly explore this hypothesis and establish whether it contributes to the larger measured effect for wine compared to spirits, individual-level data would be essential.

Nevertheless, even without individual-level data, we can leverage the clear variation introduced by the tightening of quota regulations to support our hypothesis. This regulatory change offers a natural experiment setting, allowing us to explore whether the observed treatment effects are influenced by changes in these regulations.

**Testing Hypothesis with Data**

To empirically examine the impact of quota regulations on treatment effects for wine and spirits, let's consider the adaptations of three hypothetical consumers.

For Consumer A, who uses tobacco, the initial adaptation is 0 litres of spirits and 3 litres of wine and the maximum tobacco allowance. After the tightening of regulations, Consumer A's adaptation remains unchanged, continuing to bring 0 litres of spirits and 3 litres of wine.

Consumer B has an initial adaptation of 1 litre of spirits, 3 litres of wine, and 0 tobacco, and faces a choice after the regulations are tightened. They can opt to reduce spirits to zero while maintaining the amount of wine, or reduce wine while maintaining the amount of spirits.

Consumer C, with initial quotas of 0 litres of spirits, 4.5 litres of wine, and 0 tobacco, encounters a constraint after the tightening. Unable to maintain the same volume of wine, Consumer C adapts by bringing 0 litres of spirits and 3 litres of wine.

The key insight here is that, after the tightening of quota regulations, Consumer B has the flexibility to adjust its allocation between spirits and wine, while Consumer C is constrained and forced to reduce the volume of wine.

This thought experiment illustrates how changes in quota regulations can influence the choices consumers make regarding the types and quantities of alcoholic beverages they acquire through cross-border shopping. By examining these adaptations, we can gain insights into whether observed differences in treatment effects for wine and spirits are influenced by regulatory changes.

The example suggests that if the disparity between the first lockdown and the final opening is solely due to quota regulations, we would anticipate lower treatment effects for both wine and spirits during the final opening compared to the first lockdown. Based on consumers A, B, and C, we would expect treatment effects for wine to decrease by 0–50%. Assuming a uniform distribution of consumers like A, B, and C, the expected reduction in treatment effects for wine would be approximately 28% ($\sum \frac{\Delta_A+\Delta_B+\Delta_C}{3} \approx 0.28$), while for spirits, the reduction would be approximately 0–33% (0% if all consumer B-types prefer spirits, 33% if all consumer B-types prefer wine). Our data set and the natural experiment offer an opportunity to test this hypothesis empirically. If we find empirical support for the hypothesis, it would strengthen the argument that quota regulations contribute to the observed variation in treatment effects based on alcohol categories.

From Figure 5.2, it is evident that all bordering Swedish counties were closed from Christmas 2021 until late January 2022. Comparing the treatment effects between the first lockdown in March 2020 and the final opening in January 2022 should reveal a smaller treatment effect due to the tightening of quota regulations, with the reduction more pronounced for wine and spirits purchases. Table 7.4 confirms smaller treatment effects in 2022 compared to the beginning of the pandemic, aligning with our expectations. Subsequently, we investigate whether the diminishing treatment effects can be attributed to wine and spirits. We conduct four regressions, one for each main alcohol category, and incorporate two indicator variables as shown in Table 7.4.

Table 7.6 presents the results from the regressions on the sales volume of wine and spirits. For beer and fortified wine, coefficient estimates from the first lockdown and the final opening are not statistically different, as indicated by the results of a chi-squared test.[15] This aligns with expectations if we consider our explanation that high-income individuals generally prefer fortified wine and special beer while engaging in less cross-border shopping. However, for wine and spirits, there is a distinct and statistically significant reduction in treatment effects across all driving bins. This corresponds with expectations if people

[15]Regression output for all four main categories can be found in Table A.10 and Table A.11 in the Appendix. Output from Chi squared tests can be found in Table A.13.

**Table 7.6:** Regressions estimating whether treatment effects differ by period and alcohol category

| Dependent Variable: | log_vol | | | |
|---|---|---|---|---|
| Model: | (1) | (2) | (3) | (4) |
| | Wine | Fortified Wine | Spirits | Beer |
| *Variables* | | | | |
| pre_lockdown × b = 1 | -0.1682*** | -0.0834*** | -0.1296*** | -0.1243*** |
| | (0.0209) | (0.0211) | (0.0171) | (0.0208) |
| post_opening × b = 1 | -0.1198*** | -0.0951*** | -0.0888*** | -0.1061*** |
| | (0.0130) | (0.0154) | (0.0120) | (0.0148) |
| *Control group* | | | | |
| Driving duration | > 180 | > 180 | > 180 | > 180 |
| *Fit statistics* | | | | |
| Observations | 87,384 | 86,906 | 87,378 | 87,368 |
| Stores | 345 | 345 | 345 | 345 |
| Weeks | 260 | 260 | 260 | 260 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from estimation with 2SDiD. The independent variables are an indicator variable indicating whether the period is before or after the first lockdown and an indicator variable indicating whether the period is before or after the final opening. In Column (1) the dependent variable is the natural logarithm of sales volume of wine. In Column (2) the dependent variable is the natural logarithm of sales volume of fortified wine. In Column (3) the dependent variable is the natural logarithm of sales volume of spirits. In Column (4) the dependent variable is the natural logarithm of sales volume of beer. Standard errors reported in parentheses are clustered at the store level.

are indeed responding to changes in quota regulations. The treatment effect on wine has been reduced by approximately 27% $(1-(1-exp(-0.1198))/(1-exp(-0.1682)))$, and the treatment effect on spirits has been reduced by approximately 30% $(1-(1-exp(-0.0888))/(1-exp(-0.1296)))$. These results closely match our ex-ante expectations, enhancing confidence in our explanation that quota regulations contribute to unexpected differences in treatment effects for various alcohol categories.

The findings also align with those reported by Bygvrå (2009), consistent with the discussion in Chapter 3. Bygvrå (2009) observed that an augmentation in allowances led to a concurrent rise in cross-border shopping. In our study, we discovered that a reduction in allowances correlates with a decline in cross-border shopping. These consistent outcomes suggest that alterations in policies, particularly allowances, exert an influence on cross-border shopping.

## Tax Loss

As observed in Table 7.5, we estimated a tax loss of approximately NOK 871 million due to reduced Vinmonopolet sales, stemming from cross-border shopping in Sweden. Notably, the total tax loss increases in the first three driving bins before it decreases in the fourth bin, with no loss in the fifth bin which serves as the control group.[16] The total loss in the second bin is more than twice the size of the loss in the first bin. This discrepancy can be attributed to the fact that there are only 5 outlets located within the first bin, while there are 32 outlets located within the second bin. Calculating the average loss per outlet within each driving bin provides a more informative perspective on the loss within each bin.[17] The average within the first bin is NOK 26.86 million ($134.2/5 = 26.86$), while for the second bin, it is NOK 9.39 million. This analysis unsurprisingly reveals that the total tax loss within the first two bins aligns with the same pattern as the estimated effect of cross-border shopping found in Section 7.1.

Furthermore, we can assess how much the tax loss decreases when transitioning from bin 1 to bin 2, providing insight into how distance to the border affects the average tax loss. This is calculated by determining the difference in averages between the first two bins and then dividing it by the average for the first bin. The result indicates that the average tax loss per outlet decreases by 65% ($(9.39 - 26.86)/26.86 = -65\%$) when moving from bin 1 to bin 2.

Given that there are only 5 Vinmonopolet outlets within 45 minutes of the nearest Systembolaget outlet, it suggests that people living closer to the border might have a longer driving distance to their nearest Vinmonopolet outlet compared to those living further away. Additionally, with 32 Vinmonopolet outlets located between 45–90 minutes of the nearest Systembolaget outlet, individuals within this bin have more outlets to choose from, coupled with a shorter driving distance. This could contribute to the observed decrease in tax loss when moving further away from the border, along with the increasing transportation cost explained earlier.

To determine the optimal tax level and minimize the tax loss, we could use the Ramsey

[16] Duty-free shopping and cross border shopping from other countries, such as ferries to Denmark, imply that there will probably be a tax loss in the fifth bin as well. However, for this thesis, we examine the reduction in Vinmonopolet sales as a result of cross-border shopping in Sweden exclusively.

[17] The calculations for all bins can be found in Table A.8.

rule, which allows for cross-price effects between commodities (Hindriks & Myles, 2013). To apply the Ramsey rule we need information about the marginal cost of public funds (MCF) and the uncompensated price elasticity of the demand for alcohol in Norway, $\varepsilon_{NN}$.

The MCF reflects the societal cost when the government raises revenues through higher taxation and is typically estimated to be between 1.2 and 1.3. This value indicates that if the government increases revenues by 1, the societal cost will be 20–30% higher than the revenue increase. The Norwegian Ministry of Finance operates with a 20 percent MCF as a standard (Ministry of Finance, 2021b).

However, to acquire the uncompensated demand elasticity $\varepsilon_{NN}$, we would either need to make some strict assumptions unlikely to hold, or we would need some further information.

The Norwegian price elasticity ($\varepsilon_{NN}$) represents the sensitivity of the demand for alcohol to changes in its price. Although the model in Section 4.2 suggests that the effect of cross-border shopping can be decomposed into a cross-price elasticity and the price elasticity for Swedish alcohol, it doesn't directly provide the value for the Norwegian demand elasticity for alcohol. However, it indicates the direction of the effect. Since $\varepsilon_{SS}$ is negative (an increase in the Swedish price decreases the Norwegian demand for alcohol bought in Sweden), we can infer that $\varepsilon_{NN}$ is also negative. This means that an increase in the Norwegian price decreases the Norwegian demand for alcohol bought in Norway.

If we assume zero income effects, then the uncompensated elasticities would equal the compensated ones. In this case, we could acquire $\varepsilon_{NN}$ through the following $\varepsilon_{NN} \times M_N = \hat{\varepsilon}_{NN} \times M_N = -\hat{\varepsilon_{NS}} \times M_S$, where $M_N$ and $M_S$ is the wealth in Norway and Sweden, respectively. This would assume that the Norwegian uncompensated demand elasticity is equal to the compensated one, and also assume that it would be equal to the negative of the compensated cross-price elasticity between Norwegian and Swedish-bought alcohol. We are not comfortable in making these assumptions, as they are unlikely to hold because there are undoubtedly income effects. Furthermore, the model presented in Section 4.2 models a situation in which only alcohol matters. This is a strong assumption as in reality, other goods will also influence the adaptation of the consumer. Thus, we would need further information to derive $\varepsilon_{NN}$.

To empirically derive the Norwegian price elasticity ($\varepsilon_{NN}$), we would either need individual-level data for Norwegian alcohol demand, an exogenous shock to the Norwegian price, or a valid instrument for the Norwegian price of alcohol. We do not have access to individual-level data on Norwegian alcohol demand, rendering it unfeasible. Although border closings were theoretically considered as an exogenous price shock in Section 4.2, they did not directly impact the *Norwegian* price. Another alternative is the price adjustments that occurred 1st September 2023, when wholesalers adjusted prices as described in Section 5.2. On average, prices increased 1.6 percent and for products that changed price, the average increase was 5.2 percent (Strømsnes & Halvorsen, 2023). Utilizing the price directly in a regression estimating demand is invalid as price is determined in equilibrium of supply and demand, making it endogenous in nature. The excise tax rate was considered as a potential instrument, but its annual variation, indistinguishable from yearly fixed effects, hinders the empirical determination of $\varepsilon_{NN}$. The price change 1st September could potentially be a fitting setup for a Regression Discontinuity Design (if consumers are unable to sort their purchases to before the price change) and would be an intriguing topic for further research.

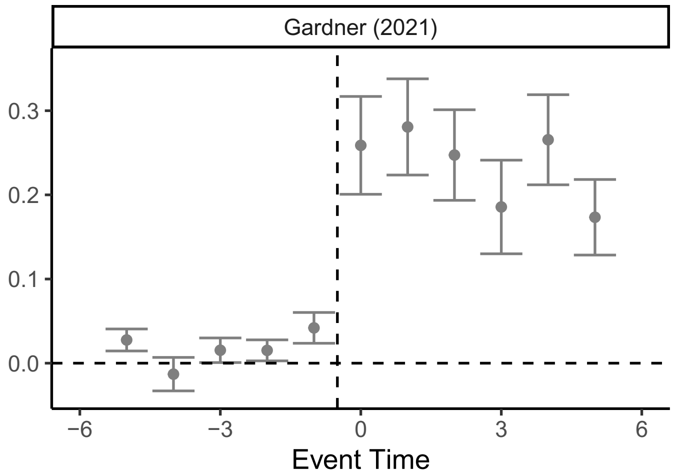
## 7.4 Robustness Checks

To ensure the causal interpretation of our results, it's crucial to address the potential influence of confounders or outliers. Additionally, we must validate the assumption that the trend in Vinmonopolet outlet sales is independent of the driving duration to a Systembolaget outlet. In this section, we will introduce and discuss robustness checks aimed at bolstering the credibility and causal interpretation of our findings.

### 7.4.1 Parallel Trends

The parallel trend assumption is not testable as we would need to observe the world in two states. Instead, a common approach is to present a plot of trends and formally test pre-trends to substantiate the assumption's validity. In Section 5.2, we depicted the sales volume's development by pre-COVID driving bin in Figure 5.1. Importantly, the assumption posits that the groups would follow parallel trends in the absence of treatment. Therefore, parallel trends need to be observed in periods when the border is closed to support this assumption. It is reasonable to believe that treatment switching on decreases the levels of volume sold instantly, followed by an identical trend at different levels. Upon visual inspection, it seems that the treatment group and control group exhibit similar trends as described, following the same trajectory when the border is closed and also when the border is open, albeit at different levels. This lends credibility to the parallel trend assumption. To further validate this assumption, we present a plot where we formally test the pre-trends using the methodology proposed by Gardner (2022), following the simple specification from Equation (6.7). The interpretation of the plots is the opposite of our main analysis: they investigate trends in the pre-periods when treatment is "on" and then in the post-periods when treatment is "off". Positive coefficients in the plots should be interpreted as an increase in volume sales because cross-border shopping becomes unavailable, aligning with the main analysis.

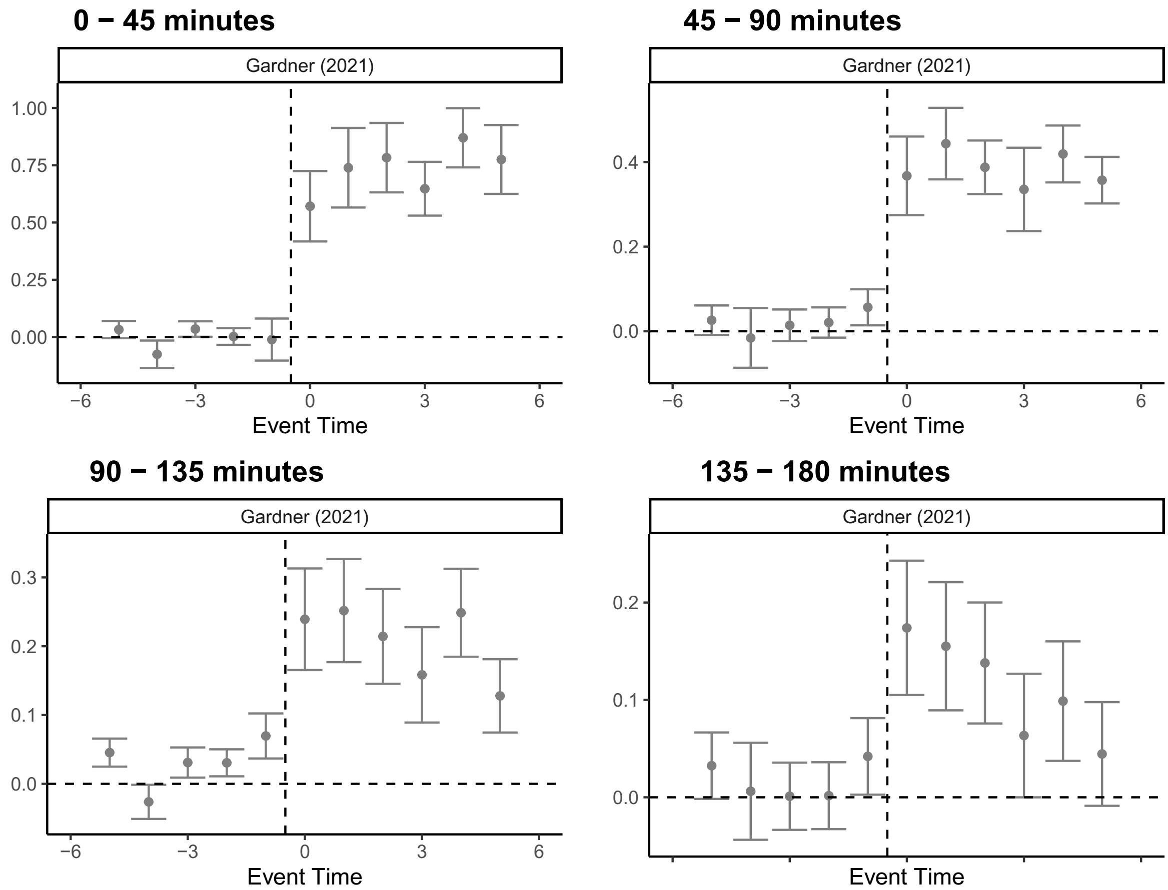
**Figure 7.1:** Test of pretrends from simple specification




**Note:** The figure plots a test of pre-trends using Gardner (2022) following the simple specification in Equation (6.7). Event time = 0 indicates the week beginning Monday, 16$^{\text{th}}$ March 2020.

Figure 7.1 displays an event-study graph illustrating the estimates of the difference between the control and treatment groups in relation to a base period. The chosen base period is the week commencing Monday, 9$^{\text{th}}$ March 2020. In a scenario where the two groups follow parallel trends and the treatment merely alters the levels, the coefficient estimates should hover around zero during each pre-period and subsequently rise and maintain relatively consistent estimates in the post-periods. As observed in the figure, this pattern is largely evident —estimates in the pre-periods are in close proximity to zero, and in the post-periods, there is a notable increase followed by a stabilization at similar levels.

**Figure 7.2:** Test of pretrends by pre-COVID driving bin




**Note:** The figure plots a test of pretrends using Gardner (2022) by pre-COVID driving bin from Equation (6.8). Event time = 0 indicates the week beginning Monday, $16^{\text{th}}$ March.

As discussed in Chapter 6, there is no reason to assume that the levels and effects are uniform across all driving durations. Figure 7.2 presents a test of the pre-trends using the methodology proposed by Gardner (2022) by pre-COVID driving bin, as per Equation (6.8). The figure indicates that all distinct driving bins roughly follow the same trend, with pre-period estimates close to zero and post-period estimates showing a significant increase. The pre-trends align closely with expectations, both overall and by pre-COVID driving bin. For driving bins 2, 3, and 4, there appears to be some potential anticipation effects. This is likely because we have defined the event-time as the week beginning Monday, $16^{\text{th}}$ March 2020, meaning the week before the event-time corresponds to the week when society shut down (though people were still permitted to travel). Additionally, there seems to be a possible event at $t = -4$, which is likely related to the winter holiday. The winter holiday occurred in different weeks across various parts of the country in

2020, either in week number 8 or 9.[18] We are therefore not overly concerned with this discrepancy.

In conclusion, the plots depicted in Figure 5.1 and the estimates presented in Figure 7.1 and Figure 7.2 provide support for the parallel trend assumption. These visualizations demonstrate nearly zero effects in the pre-periods, an immediate increase in the post-period, followed by coefficients at similar levels, aligning precisely with our expectations. Despite potential anticipation effects at $t = -1$ and winter holidays at $t = -4$, we consider the evidence satisfactory to uphold the parallel trend assumption and maintain confidence in our results. Consequently, we have further substantiated the necessary assumption for the causal interpretation of our findings.

### 7.4.2 Alternative Specifications

We need to assess whether our results are influenced by confounders, outliers, or other extreme observations. Table 7.7 presents the estimates from five distinct regressions. These regressions involve variations such as including "ombud" and covariates, excluding outliers and extreme observations, and changing the control group.

Column (1) displays the outcomes of a regression incorporating three "ombud", as explained in Section 5.2. The outcomes for the nearest driving bin undergo substantial changes, while the other driving bins remain largely consistent with our original estimates in Table 7.2. The inclusion of "ombud" in our analysis results in more Vinmonopolet outlets being categorized with a shorter driving time. If the proximity to an "ombud" is indeed equivalent to the proximity to a Systembolaget outlet, then including "ombud" in our analysis would be appropriate. However, the results in Column (1), coupled with the fact that less than 1 percent of Systembolaget's revenue is derived from "ombud", suggest that they should be excluded. Additionally, "ombud" only permit pickups from virtual orders, making the concept slightly different from Vinmonopolet and Systembolaget outlets. Typically, orders are ready for pick-up within a day or two, requiring additional planning compared to visiting an outlet. Finally, it is unclear whether individuals living closer to an "ombud" are aware of their existence, as they offer few benefits other than

[18] The counties of Oslo, Agder, Møre og Romsdal, Vestfold og Telemark, Trøndelag, Vestland (except for former Hordaland) and Viken (except for former Buskerud) had winter holidays week number 8. The rest of the country had winter holidays week number 9.

picking up pre-ordered items. The reduction in treatment effects for the nearest driving bin strongly supports the arguments — the change in treatment effects aligns precisely with what would be expected if observations were included in the nearest driving bin when they should not be.

Column (2) presents the outcomes of a regression that includes the employment rate, infection rate, number of cabins per $km^2$, and population, as detailed in Section 5. Our hypothesis is that the observed increase in Vinmonopolet sales in outlets close to a Systembolaget outlet is due to cross-border shopping becoming unavailable. Alternatively, it could be posited that Vinmonopolet sales in border regions were influenced differently by COVID-19 than Vinmonopolet sales in the rest of Norway. To address this alternative, we incorporate the potential covariates mentioned. Encouragingly, the inclusion of covariates has minimal impact on the point estimates. Furthermore, the signs of all covariates align with our expectations.

Column (3) displays the outcomes after trimming the sample of outliers. We exclude volume and revenue observations larger than the $99^{th}$ percentile or smaller than the $1^{st}$ percentile. This step aims to investigate whether extreme observations might be driving the results and obscuring the true effect of cross-border shopping. The point estimates remain nearly identical after the exclusion of outliers. Moving to Column (4), we exclude all negative volume and revenue observations, as well as observations from Vinmonopolet outlets in municipalities with fewer than 5000 inhabitants. Given that our data is derived from Vinmonopolet's accounting system, negative sales are recorded for returned items. For instance, if a large purchase, such as one for a wedding, is returned in a different week than the original purchase, a negative sales figure within a main category for a given week at a Vinmonopolet outlet *could* be registered. If this coincides with openings and closings of the border, it has the potential to bias the results. Once again, the point estimates of coefficients show minimal change from the main specification, further reinforcing the credibility of our results.

Column (5) presents the results from a regression where we expand the treatment group to include all Vinmonopolet outlets located within 270 minutes of a Systembolaget outlet. The estimates remain significant up until the 180-minute driving bin, becoming insignificant for outlets located further away from a Systembolaget than our original control group.

The point estimates are highly similar, albeit slightly higher than the original estimates. This could potentially indicate that effects are noticed a little bit further than 180 minutes from a Systembolaget outlet. However, the estimates are similar enough for us to be content with our original results.

**Table 7.7:** Regressions with changing sample or changing control groups

| Dependent Variable: | log_vol | | | | |
|---|---|---|---|---|---|
| Model: | (1) | (2) | (3) | (4) | (5) |
| *Variables* | | | | | |
| Duration $< 45 \times D_{st}$ | -0.5545*** | -0.6513*** | -0.6584*** | -0.6530*** | -0.6845*** |
| | (0.1021) | (0.0520) | (0.0512) | (0.0513) | (0.0489) |
| $45 \leq$ Duration $< 90 \times D_{st}$ | -0.2546*** | -0.2693*** | -0.2692*** | -0.2687*** | -0.2921*** |
| | (0.0206) | (0.0180) | (0.0189) | (0.0176) | (0.0177) |
| $90 \leq$ Duration $< 135 \times D_{st}$ | -0.0879*** | -0.1035*** | -0.1014*** | -0.0958*** | -0.1064*** |
| | (0.0168) | (0.0181) | (0.0185) | (0.0199) | (0.0196) |
| $135 \leq$ Duration $< 180 \times D_{st}$ | -0.0546*** | -0.0541*** | -0.0564*** | -0.0574*** | -0.0654*** |
| | (0.0154) | (0.0153) | (0.0152) | (0.0159) | (0.0155) |
| $180 \leq$ Duration $< 225 \times D_{st}$ | | | | | -0.0119 |
| | | | | | (0.0141) |
| $225 \leq$ Duration $< 270 \times D_{st}$ | | | | | -0.0150 |
| | | | | | (0.0150) |
| Employment rate | | -0.0068 | | | |
| | | (0.0046) | | | |
| Infection rate | | $1.77 \times 10^{-5}$*** | | | |
| | | $(2.97 \times 10^{-6})$ | | | |
| Cabins per km$^2$ | | -0.0009 | | | |
| | | (0.0006) | | | |
| Population | | $8.91 \times 10^{-8}$*** | | | |
| | | $(3.28 \times 10^{-8})$ | | | |
| *Control group* | | | | | |
| Driving duration | > 180 | > 180 | > 180 | > 180 | > 270 |
| *Fit statistics* | | | | | |
| Observations | 87,384 | 86,968 | 86,336 | 72,075 | 87,344 |
| Stores | 345 | 345 | 345 | 285 | 345 |
| Weeks | 260 | 260 | 260 | 260 | 260 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from estimation with 2SDiD. The dependent variable in all columns is the natural logarithm of sales volume. Column (1) is the main model revisited for comparison. Column (2) is the main specification including potential covariates, as described in Section 5. Column (3) excludes outliers defined as the 99 percentile and 1 percentile. In Column (4), observations with negative values and observations from municipalities with less than 5000 citizens are removed. In Column (5), the control group is defined as being more than 270 minutes away from a Systembolaget outlet. Standard errors reported in parentheses are clustered at the store level.

In summary, our results appear robust to various sensitivity analyses, including the incorporation of covariates, different sample restrictions, and alterations to the definition of the control group.

## 7.5 Limitations

Our data set consists of weekly sales observations, and consequently, the entire panel data set is structured based on week numbers. The first lockdown was enforced on Thursday, $12^{\text{th}}$ March 2020, during week number 11. Therefore, we designate all of week 11 as the week when the first lockdown occurred, despite the first three days not being subject to lockdown measures. Similar challenges arise in defining when the border was open and closed, as explained in Section 5. Due to potential difficulties in establishing a precise cutoff for some treatment date switches, the estimated treatment effects may be either over- or underestimated. In our assessment, they are more likely to be underestimated, as untreated outcomes could be absorbed into the first week of treatment switching on or the last week before treatment switches off, making the estimated treatment effects appear smaller than the actual effects.

Another limitation is the small number of Vinmonopolet outlets in the nearest driving bin, along with an incomplete understanding of the nature of "ombud". To the best of our knowledge, "ombud" cannot be considered equivalent to a Systembolaget outlet. However, there is circumstantial evidence suggesting that the use of "ombud" could be prevalent in the Trondheim area. The exclusion of "ombud" leaves five Vinmonopolet outlets in the nearest driving bin, while their inclusion increases the count to six. A larger sample size within the nearest driving bin would enhance confidence in these estimates. Nonetheless, it's worth noting that the other robustness checks showed minimal changes in point estimates within the nearest driving bin.

To gain a comprehensive understanding of consumer preferences, adaptations to cross-border shopping, and the impact of taxes and prices, individual-level data would be essential. While our current data set enables an examination of overall effects, determining the Norwegian price elasticity of demand requires either individual-level data or an exogenous shock to the Norwegian price, distinct from the "simulated" Swedish price used to inhibit cross-border shopping, as demonstrated in Chapter 4. Additionally, individual-level data could help elucidate whether variations in preferences and income contribute to the observed differences in treatment effects across alcohol categories. Although we are confident in our explanation of quota regulations regarding spirits and wine-specific treatment effects, and we have supporting estimates, individual-level data could further solidify this explanation.

Serial correlation, where observations are correlated with past observations, poses a concern when dealing with panel data. This concern is relevant in our panel data set, as the sales for a Vinmonopolet outlet show a high correlation with its sales in the preceding period. The presence of serial correlation can undermine the validity of calculated standard errors, impacting inference. To address this issue, we have chosen to cluster the standard errors at the Vinmonopolet outlet level, following standard practice. While clustering at the municipality level could have been an alternative, variations in driving bins within a municipality could change differently, suggesting that the outlet level is likely to exhibit the most significant variation.

## External Validity

The external validity of our study is contingent on the absence of plausible explanations that would invalidate a generalization of our results. One such potential factor is the unique setting of our investigation: the sales volume analysis of a Norwegian government-owned liquor monopoly. Several reasons may limit the applicability of our findings beyond this context. Firstly, Norwegians might exhibit distinctive reactions to treatment due to factors such as purchasing power, consumption patterns, and cultural nuances. Secondly, the absence of a liquor monopoly akin to Vinmonopolet in most countries could yield different effects for retail alcohol. Thirdly, the geography of Norway and Sweden, featuring the longest land border in Europe, along with free travel, shared language, culture, and history, could contribute to unique dynamics not present in other settings. Therefore, caution should be exercised in assuming the generalizability of our results to contexts outside our specific study parameters.

However, the key findings of our study likely have broader applicability to settings beyond our specific investigation. The observed decrease in sales volume in response to available cross-border shopping and price differences is a phenomenon that can reasonably be expected to occur in other contexts where similar conditions exist. Additionally, the intuitive notion that the effects diminish as the distance to the border increases aligns with the expectation that transportation costs generally rise with greater distance. This generalization may be particularly relevant within a Nordic context, where countries like Sweden and Finland, both featuring state-owned liquor monopolies, have neighboring countries with comparatively lower prices (Denmark and Russia, respectively).

## 7.6 Summary of Results

The study reveals a substantial and statistically significant negative impact of accessible cross-border shopping on Vinmonopolet sales. Overall, there is a 13 percent sales reduction for treated Vinmonopolet outlets. Within a 45-minute driving distance of a Systembolaget outlet, the sales decrease significantly by 48 percent. This effect diminishes in driving duration, but remains statistically significant up to a 180-minute driving distance. When examining alcohol categories, wine demonstrates the most significant treatment effect, experiencing a sales reduction of around 51 percent within 45 minutes of a Systembolaget outlet. Following wine, beer and spirits exhibit the second and third largest effects, while fortified wine has the lowest estimated impact.

The study posits two primary explanations for the variations in estimated effects. First, individuals engaged in cross-border shopping are typically from lower-income groups, characterized by higher price sensitivity. This helps elucidate why sales of fortified wine and specialty beers exhibit a relatively modest estimated effect. Second, the impact of quota regulations is considered. The study delves into the disparity in treatment effects at the onset of the pandemic and its conclusion, taking into account changes in quota regulations. The observed alterations in treatment effects align with the anticipated outcomes, providing support for the assertion that differences in treatment effects stem from quota regulations.

The study employs its findings to estimate the tax revenue forgone by Vinmonopolet due to cross-border shopping in 2019. The calculated total tax loss for that year is approximately NOK 871 million. This loss is further delineated, with lost excise tax constituting 65 percent of the foregone revenue, VAT accounting for 33 percent, and the remaining 2 percent attributed to lost environmental tax. Notably, the study indicates that excise tax revenue from alcohol would have been 4 percent higher in 2019 in the absence of cross-border shopping. It's important to highlight that the study doesn't determine an optimal tax level as per the Ramsey rule due to the unavailability of data to calculate the Norwegian price elasticity of demand for alcohol.

The study's results demonstrate consistency across various robustness checks, providing compelling evidence for the crucial assumption of parallel trends, essential for causal interpretation. The inclusion of "ombud" in the analysis affects estimates for the nearest driving bin, indicating a potential mis-specification due to the incomparability of "ombud" to a Systembolaget outlet. However, given the small sample size in the nearest driving bin, caution is advised in interpreting these results. Despite the study's high internal validity and robustness, its external validity is considered low due to the unique geography, culture, and history specific to Norway and Sweden. Nevertheless, the findings may have some relevance for similar settings within Nordic countries.

## Implications

This thesis demonstrates that extensive cross-border shopping of alcohol by Norwegians results in substantial losses of tax revenue, estimated at NOK 871 million in 2019 alone. These findings reveal a policy dilemma —high alcohol taxes intended to discourage consumption and mitigate public health issues also incentivize cross-border shopping and reduce revenues. Lowering alcohol taxes could potentially curb cross-border purchasing and recapture some lost revenue, especially for consumers near the Swedish border who engage heavily in such shopping. However, for consumers residing farther from Sweden, lower alcohol taxes may simply increase consumption rather than reducing cross-border trips. This could undermine public health objectives by increasing alcohol consumption, especially among heavy drinkers. Alternatively, further tightening import quotas could limit individual-level tax avoidance without reducing tax rates. However, it could be costly to enforce obedience to the thightened quotas. Furthermore, this could displace cross-border shopping through organized smuggling.

Ultimately, policymakers must weigh multiple factors in designing alcohol tax policy, including public health impacts, revenue objectives, individual behaviors, and enforcement challenges. This thesis provides robust evidence regarding cross-border shopping effects and distance implications to inform these complex policy decisions and optimize along the different dimensions of this trade-off.

# 8 Conclusion

This thesis demonstrates that the accessibility of cross-border alcohol shopping in Sweden leads to substantial reductions in Vinmonopolet sales and tax revenues for the Norwegian government. Leveraging an exogenous shock from COVID-19 border closures, we find a 13% overall decrease in Vinmonopolet sales when cross-border shopping is available. The effect reaches 48% for stores within 45 minutes of the Sweden border but diminishes progressively farther away, consistent with rising transportation costs.

Significant heterogeneity is uncovered across beverage categories, with wine sales exhibiting the largest sensitivity. Two primary explanations are proposed and tested. First, cross-border shoppers likely have distinct preferences skewed towards value offerings, disproportionately reducing wine and fortified wine sales, respectively. Second, alcohol import quota regulations have asymmetric effects, advantaging wine over spirits.

Estimated tax losses of NOK 871 million in 2019 highlight the fiscal implications, equivalent to approximately 4% of total alcohol excise tax receipts. This underscores the trade-offs policymakers face between public health goals served by high alcohol taxes and the revenue leakage induced by cross-border shopping responses.

Our analysis makes several contributions. To our knowledge, it is the first to rigorously estimate the causal impact of cross-border alcohol shopping on Norwegian sales and tax revenues. The findings are robust to various specifications and align with economic theory. Additionally, by uncovering heterogeneity across beverage categories, the study provides novel evidence on factors shaping cross-border shopping behavior.

However, some limitations warrant mention. The small sample of stores very near the border could reduce the precision of estimates for that subgroup, especially if the use of "ombud" is more prevalent than our understanding. Individual-level data would enable deeper investigation of consumer decision-making mechanisms, especially related to heterogeneous effects with respect to alcohol categories. The unique context of Norway and Sweden may restrict external validity. Future research could build on these findings by addressing such limitations and extending the analysis to other goods and country-pairs.

In conclusion, this thesis enhances academic and policy-oriented understanding of cross-border shopping dynamics, employing an innovative methodology and generating compelling results. The insights should inform ongoing taxation and regulatory decisions balancing public health objectives with mitigating cross-border economic leakage.

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# Appendices

## A Figures and Tables

**Table A.1:** Basket Price, NOK

| | Price Norway | Price Sweden | Difference | Difference % |
|---|---|---|---|---|
| *Wine* | | | | |
| Falling Feather Ruby Cabernet | kr 135.90 | kr 100.02 | kr 35.88 | 33.00 % |
| Tommasi Graticcio Appassionato | kr 162.90 | kr 116.19 | kr 46.71 | 35.85 % |
| Laroche Chardonnay L | kr 139.90 | kr 110.12 | kr 29.78 | 26.61 % |
| Wongraven Morgenstern Riesling | kr 182.90 | kr 160.64 | kr 22.26 | 15.21 % |
| Abbazia Prosecco Extra Dry | kr 131.90 | kr 110.12 | kr 21.78 | 20.64 % |
| Pizzolato Spumante d'Italia Extra Dry | kr 149.90 | kr 79.81 | kr 70.09 | 58.44 % |
| *Spirits* | | | | |
| The Famous Grouse | kr 409.90 | kr 287.94 | kr 121.96 | 37.19 |
| Jameson | kr 419.90 | kr 312.18 | kr 107.72 | 32.07 % |
| Gammel Opland | kr 494.90 | kr 403.11 | kr 91.79 | 23.18 % |
| Akevitt Spesial | kr 347.00 | kr 241.46 | kr 105.54 | 38.02 % |
| Bombay Sapphire London Dry | kr 419.90 | kr 302.08 | kr 117.82 | 35.07 % |
| Tanqueray London Dry Gin | kr 419.90 | kr 302.08 | kr 117.82 | 35.07 % |
| Absolut Vodka | kr 359.90 | kr 249.55 | kr 110.35 | 38.33 % |
| Dworek Vodka | kr 325.00 | kr 211.15 | kr 113.85 | 43.79 % |
| *Fortified Wine* | | | | |
| Graham's Late Bottled Vintage | kr 229.90 | kr 180.84 | kr 49.06 | 26.67 % |
| Taylor's Late Bottled Vintage | kr 203.90 | kr 190.95 | kr 12.95 | 7.94 % |
| Bristol Cream | kr 259.90 | kr 126.29 | kr 133.61 | 64.26 % |
| Dry Sack | kr 192.90 | kr 126.29 | kr 66.61 | 43.16 % |
| *Beer* | | | | |
| Hoegaarden Wit | kr 46.90 | kr 19.09 | kr 27.81 | 74.11 % |
| Erdinger Kristallklar Weissbier | kr 63.90 | kr 25.66 | kr 38.24 | 74.80 % |
| Amundsen Ink & Dagger Modern Day IPA | kr 48.90 | kr 33.24 | kr 15.66 | 40.03 % |
| BrewDog Punk IPA | kr 45.90 | kr 21.12 | kr 24.78 | 67.50 % |

**Table A.2:** Basket Excise Tax, NOK

| | Excise Tax Norway | Excise Tax Sweden | Difference | Difference % |
|---|---|---|---|---|
| *Wine* | | | | |
| Falling Feather Ruby Cabernet | kr 44.55 | kr 20.41 | kr 24.14 | 54.19 % |
| Tommasi Graticcio Appassionato | kr 46.41 | kr 20.41 | kr 26.00 | 56.02 % |
| Laroche Chardonnay L | kr 44.55 | kr 20.41 | kr 24.14 | 54.19 % |
| Wongraven Morgenstern Riesling | kr 44.55 | kr 20.41 | kr 24.14 | 54.19 % |
| Abbazia Prosecco Extra Dry | kr 40.84 | kr 20.41 | kr 20.43 | 50.03 % |
| Pizzolato Spumante d'Italia Extra Dry | kr 40.84 | kr 20.41 | kr 20.43 | 50.03 % |
| *Spirits* | | | | |
| The Famous Grouse | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| Jameson | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| Gammel Opland | kr 245.47 | kr 150.03 | kr 95.45 | 38.88 % |
| Akevitt Spesial | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| Bombay Sapphire London Dry | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| Tanqueray London Dry Gin | kr 257.30 | kr 157.26 | kr 100.05 | 38.88 % |
| Absolut Vodka | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| Dworek Vodka | kr 236.60 | kr 144.60 | kr 92.00 | 38.88 % |
| *Fortified Wine* | | | | |
| Graham's Late Bottled Vintage | kr 74.25 | kr 42.56 | kr 31.69 | 42.68 % |
| Taylor's Late Bottled Vintage | kr 74.25 | kr 42.56 | kr 31.69 | 42.68 % |
| Bristol Cream | kr 64.97 | kr 42.71 | kr 22.26 | 34.26 % |
| Dry Sack | kr 55.69 | kr 20.41 | kr 35.28 | 63.35 % |
| *Beer* | | | | |
| Hoegaarden Wit | kr 8.00 | kr 0.03 | kr 7.97 | 99.58 % |
| Erdinger Kristallklar Weissbier | kr 13.12 | kr 0.06 | kr 13.06 | 99.58 % |
| Amundsen Ink & Dagger Modern Day IPA | kr 10.62 | kr 0.05 | kr 10.57 | 99.58 % |
| BrewDog Punk IPA | kr 8.82 | kr 0.04 | kr 8.78 | 99.58 % |

**Table A.3:** Adjusted mean sales price, excluded VAT. 2022-NOK

| | Alcohol category | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|
| 1 | Spirits | 446.3 | 441.7 | 449.6 | 444.0 | 425.3 |
| 2 | Beer | 119.0 | 117.1 | 119.5 | 114.9 | 108.4 |
| 3 | Fortified Wine | 224.3 | 227.5 | 231.2 | 226.6 | 219.6 |
| 4 | Wine | 144.6 | 144.9 | 149.4 | 147.4 | 143.4 |

**Table A.4:** Estimated tax loss wine 2019 in Mill. NOK, by pre-COVID driving bin and total

| **Wine** | $< 45$ | $[45 - 90)$ | $[90 - 135)$ | $[135 - 180)$ | $> 180$ | Total |
|---|---|---|---|---|---|---|
| *VAT* | | | | | | |
| Counterfactual | 56.9 | 277.5 | 875.5 | 335.0 | 952.2 | 2,497.1 |
| Actual | 27.9 | 206.5 | 788.6 | 314.8 | 952.2 | 2,290.1 |
| Loss | 29.0 | 70.9 | 87.0 | 20.2 | - | 207.0 |
| *Excise Tax* | | | | | | |
| Counterfactual | 105.5 | 499.6 | 1,483.3 | 624.6 | 1,784.5 | 4,497.4 |
| Actual | 51.8 | 371.8 | 1,336.0 | 587.0 | 1,784.5 | 4,131.1 |
| Loss | 53.7 | 127.7 | 147.3 | 37.6 | - | 366.3 |
| *Beverage Packing Tax* | | | | | | |
| Counterfactual | 2.2 | 10.3 | 30.6 | 12.9 | 36.8 | 92.7 |
| Actual | 1.1 | 7.7 | 27.5 | 12.1 | 36.8 | 85.2 |
| Loss | 1.1 | 2.6 | 3.0 | 0.8 | - | 7.6 |
| *Environmental Tax* | | | | | | |
| Counterfactual | 0.7 | 3.3 | 9.9 | 4.2 | 11.9 | 30.0 |
| Actual | 0.3 | 2.5 | 8.9 | 3.9 | 11.9 | 27.6 |
| Loss | 0.4 | 0.9 | 1.0 | 0.3 | - | 2.4 |
| *Total* | | | | | | |
| Total tax loss | 84.1 | 202.2 | 238.3 | 58.8 | - | 583.4 |

**Table A.5:** Estimated tax loss fortified wine 2019 in Mill. NOK, by pre-COVID driving bin and total

| **Fortified Wine** | $< 45$ | $[45-90)$ | $[90-135)$ | $[135-180)$ | $> 180$ | Total |
|---|---|---|---|---|---|---|
| *VAT* | | | | | | |
| Counterfactual | 0.7 | 3.1 | 10.1 | 4.0 | 8.9 | 26.8 |
| Actual | 0.5 | 2.6 | 9.4 | 4.0 | 8.9 | 25.4 |
| Loss | 0.2 | 0.5 | 0.7 | - | - | 1.4 |
| *Excise Tax* | | | | | | |
| Counterfactual | 1.3 | 5.0 | 15.5 | 6.7 | 14.4 | 42.8 |
| Actual | 0.9 | 4.2 | 14.5 | 6.7 | 14.4 | 40.5 |
| Loss | 0.4 | 0.9 | 1.0 | - | - | 2.3 |
| *Basic Tax* | | | | | | |
| Counterfactual | - | 0.1 | 0.2 | 0.1 | 0.2 | 0.6 |
| Actual | - | 0.1 | 0.2 | 0.1 | 0.2 | 0.6 |
| Loss | - | - | - | - | - | - |
| *Environmental Tax* | | | | | | |
| Counterfactual | - | - | 0.1 | - | 0.1 | 0.2 |
| Actual | - | - | 0.1 | - | 0.1 | 0.2 |
| Loss | - | - | - | - | - | - |
| *Total* | | | | | | |
| Total tax loss | 0.6 | 1.4 | 1.7 | - | - | 3.7 |

**Table A.6:** Estimated tax loss spirits 2019 in Mill. NOK, by pre-COVID driving bin and total

| **Spirits** | < 45 | [45 – 90) | [90 – 135) | [135 – 180) | > 180 | Total |
|---|---|---|---|---|---|---|
| *VAT* | | | | | | |
| Counterfactual | 33.9 | 133.1 | 333.7 | 187.3 | 528.7 | 1,216.6 |
| Actual | 21.2 | 108.2 | 306.0 | 179.6 | 528.7 | 1,143.7 |
| Loss | 12.6 | 25.0 | 27.7 | 7.7 | - | 73.0 |
| *Excise Tax* | | | | | | |
| Counterfactual | 94.3 | 364.6 | 903.9 | 512.9 | 1,460.3 | 3,336.0 |
| Actual | 59.1 | 296.3 | 828.8 | 491.9 | 1,460.3 | 3,136.3 |
| Loss | 35.2 | 68.4 | 75.1 | 21.0 | - | 199.6 |
| *Basic Tax* | | | | | | |
| Counterfactual | 0.4 | 1.7 | 4.2 | 2.4 | 6.7 | 15.4 |
| Actual | 0.3 | 1.4 | 3.8 | 2.3 | 6.7 | 14.5 |
| Loss | 0.2 | 0.3 | 0.3 | 0.1 | - | 0.9 |
| *Environmental Tax* | | | | | | |
| Counterfactual | 0.1 | 0.5 | 1.4 | 0.8 | 2.2 | 5.0 |
| Actual | 0.1 | 0.4 | 1.2 | 0.7 | 2.2 | 4.7 |
| Loss | 0.1 | 0.1 | 0.1 | - | - | 0.3 |
| *Total* | | | | | | |
| Total tax loss | 48.1 | 93.7 | 103.2 | 28.8 | - | 273.8 |

**Table A.7:** Estimated tax loss beer 2019 in Mill. NOK, by pre-COVID driving bin and total

| **Beer** | $< 45$ | $[45-90)$ | $[90-135)$ | $[135-180)$ | $> 180$ | Total |
|---|---|---|---|---|---|---|
| *VAT* | | | | | | |
| Counterfactual | 2.1 | 8.4 | 29.1 | 11.9 | 38.4 | 89.9 |
| Actual | 1.2 | 6.6 | 26.6 | 11.5 | 38.4 | 84.4 |
| Loss | 0.8 | 1.8 | 2.5 | 0.4 | - | 5.5 |
| *Excise Tax* | | | | | | |
| Counterfactual | 1.7 | 6.8 | 22.4 | 9.4 | 30.1 | 70.4 |
| Actual | 1.0 | 5.4 | 20.5 | 9.0 | 30.1 | 66.0 |
| Loss | 0.7 | 1.4 | 1.9 | 0.3 | - | 4.4 |
| *Basic Tax* | | | | | | |
| Counterfactual | 0.1 | 0.4 | 1.3 | 0.5 | 1.7 | 4.0 |
| Actual | 0.1 | 0.3 | 1.2 | 0.5 | 1.7 | 3.7 |
| Loss | - | 0.1 | 0.1 | - | - | 0.2 |
| *Environmental Tax* | | | | | | |
| Counterfactual | - | 0.1 | 0.4 | 0.2 | 0.6 | 1.3 |
| Actual | - | 0.1 | 0.4 | 0.2 | 0.6 | 1.2 |
| Loss | - | - | - | - | - | 0.1 |
| *Total* | | | | | | |
| Total tax loss | 1.5 | 3.3 | 4.5 | 0.8 | - | 10.2 |

**Table A.8:** Average estimated tax loss in 2019 in NOK Mill. within each bin

| | $< 45$ | $[45-90)$ | $[90-135)$ | $[135-180)$ | $> 180$ | Total |
|---|---|---|---|---|---|---|
| *Number of stores* | | | | | | |
| | 5 | 32 | 85 | 40 | 183 | 345 |
| *Wine* | | | | | | |
| Average Loss | 16.82 | 6.32 | 2.8 | 1.47 | - | 1.69 |
| *Spirits* | | | | | | |
| Average Loss | 9.62 | 2.93 | 1.21 | 0.72 | - | 0.79 |
| *Beer* | | | | | | |
| Average Loss | 0.3 | 0.1 | 0.053 | 0.02 | - | 0.03 |
| *Fortified Wine* | | | | | | |
| Average Loss | 0.12 | 0.044 | 0.02 | - | - | 0.011 |
| *Total* | | | | | | |
| Average Loss | 26.86 | 9.39 | 7.62 | 2.21 | - | 2.52 |

**Table A.9:** Difference between actual and estimated actual tax payed by Vinmonopolet NOK Mill., 2019

| | Actual | Estimated actual | Difference |
|---|---|---|---|
| Excise Tax | 7,418 | 7,374 | 44 |
| Basic Tax | 104 | 104 | 0 |
| Environmental Tax | 33.7 | 33.7 | 0 |

**Table A.10:** Regressions estimating whether treatment effects differ by period and alcohol category

| Dependent Variable: | log_vol | | | |
|---|---|---|---|---|
| Model: | (Wine) First Lockdown | (Fortified wine) First Lockdown | (Spirits) First Lockdown | (Beer) First Lockdown |
| *Variables* | | | | |
| Duration $< 45 \times D_t$ | -0.8040*** | -0.3877*** | -0.5169*** | -0.5333*** |
| | (0.0591) | (0.0629) | (0.0592) | (0.0895) |
| $45 \leq$ Duration $< 90 \times D_t$ | -0.3525*** | -0.2132*** | -0.2445*** | -0.2761*** |
| | (0.0260) | (0.0285) | (0.0195) | (0.0273) |
| $90 \leq$ Duration $< 135 \times D_t$ | -0.1046*** | -0.0579** | -0.0993*** | -0.0831*** |
| | (0.0257) | (0.0261) | (0.0227) | (0.0261) |
| $135 \leq$ Duration $< 180 \times D_t$ | -0.0707*** | 0.0081 | -0.0495** | -0.0348 |
| | (0.0222) | (0.0290) | (0.0241) | (0.0271) |
| *Control group* | | | | |
| Driving duration | $> 180$ | $> 180$ | $> 180$ | $> 180$ |
| *Fit statistics* | | | | |
| Observations | 87,384 | 86,906 | 87,378 | 87,368 |
| Stores | 345 | 345 | 345 | 345 |
| Weeks | 260 | 260 | 260 | 260 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:** This table reports results from estimation with 2SDiD. The independent variables are a dummy variable indicating whether the period is before or after the first lockdown and a dummy variable indicating whether the period is before or after the final opening. In Column (1) the dependent variable is the natural logarithm of sales volume of wine. In Column (2) the dependent variable is the natural logarithm of sales volume of fortified wine. In Column (3) the dependent variable is the natural logarithm of sales volume of spirits. In Column (4) the dependent variable is the natural logarithm of sales volume of beer. Standard errors reported in parentheses are clustered at the store level.

**Table A.11:** Regressions estimating whether treatment effects differ by period and alcohol category

| Dependent Variable: | log_vol | | | |
|---|---|---|---|---|
| Model: | (Wine) Final Opening | (Fortified wine) Final Opening | (Spirits) Final Opening | (Beer) Final Opening |
| *Variables* | | | | |
| Duration $< 45 \times D_t$ | -0.5756*** | -0.3936*** | -0.3987*** | -0.4718*** |
| | (0.0617) | (0.0560) | (0.0475) | (0.0335) |
| $45 \leq$ Duration $< 90 \times D_t$ | -0.2202*** | -0.1698*** | -0.1627*** | -0.1875*** |
| | (0.0154) | (0.0231) | (0.0132) | (0.0207) |
| $90 \leq$ Duration $< 135 \times D_t$ | -0.0867*** | -0.0784*** | -0.0646*** | -0.0805*** |
| | (0.0148) | (0.0169) | (0.0153) | (0.0181) |
| $135 \leq$ Duration $< 180 \times D_t$ | -0.0492*** | -0.0301 | -0.0399** | -0.0465*** |
| | (0.0132) | (0.0215) | (0.0178) | (0.0144) |
| *Control group* | | | | |
| Driving duration | $> 180$ | $> 180$ | $> 180$ | $> 180$ |
| *Fit statistics* | | | | |
| Observations | 87,384 | 86,906 | 87,378 | 87,368 |
| Stores | 345 | 345 | 345 | 345 |
| Weeks | 260 | 260 | 260 | 260 |

*Custom standard-errors in parentheses*
*Signif. Levels: ***: 0.01, **: 0.05, *: 0.1*

**Note:**This table reports results from estimation with 2SDiD. The independent variables are a dummy variable indicating whether the period is before or after the first lockdown and a dummy variable indicating whether the period is before or after the final opening. In Column (1) the dependent variable is the natural logarithm of sales volume of wine. In Column (2) the dependent variable is the natural logarithm of sales volume of fortified wine. In Column (3) the dependent variable is the natural logarithm of sales volume of spirits. In Column (4) the dependent variable is the natural logarithm of sales volume of beer. Standard errors reported in parentheses are clustered at the store level.

**Table A.12:** Chi squared tests First Lockdown vs Final Opening

| Specification | Chisq | Pr(>Chisq) |
|---|---|---|
| $D_t$ | 10.610 | 0.001 |
| Duration $< 45 \times D_t$ | 25.307 | 0.00000 |
| $45 \leq$ Duration $< 90 \times D_t$ | 45.023 | 0 |
| $90 \leq$ Duration $< 135 \times D_t$ | 0.979 | 0.323 |
| $135 \leq$ Duration $< 180 \times D_t$ | 0.667 | 0.414 |

**Table A.13:** Chi squared tests First Lockdown vs Final Opening alcohol categories

| Alcohol Category | Chisq | Pr(>Chisq) |
|---|---|---|
| Wine | 11.797 | 0.001 |
| Fortified Wine | 0.274 | 0.602 |
| Spirits | 9.501 | 0.002 |
| Beer | 0.88 | 0.348 |

# B Calculations for Models Used in Chapter 4

Here, we will go through all the calculations used in finding the main results for the models described in Chapter 4.

## B.1 Utility Maximization

**Step 2**

First, we calculate the optimal demand and the utility the consumers receive from alcohol. To do this we start off with the same utility function as in Equation 4.2, shown below.

$$u = \left((x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{4.2}$$

$$s.t.\ p_N x_N + p_S x_S = m_X - T \tag{4.3}$$

To find the optimal demand we here use Lagrange:

$$\begin{aligned}
L &= \left((x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} + \lambda(m_X - T - p_N x_N - p_S x_S) \\
\frac{\partial L}{\partial x_N} &= \frac{\sigma}{\sigma-1}\left((x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}-1} \frac{\sigma-1}{\sigma}(x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}-1} - \lambda p_N = 0 \\
\frac{\partial L}{\partial x_S} &= \frac{\sigma}{\sigma-1}\left((x_N + \gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}-1} \frac{\sigma-1}{\sigma}(x_S + \gamma_S)^{\frac{\sigma-1}{\sigma}-1} - \lambda p_S = 0 \\
\frac{\partial L}{\partial \lambda} &= m_X - T - p_N x_N - p_S x_S = 0
\end{aligned}$$

We solve with respect to $\lambda p_N$ and $\lambda p_S$ to find the relative price ratio, and then solve for

$x_N$ and $x_S$.

$$\lambda p_N = \left((x_N+\gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S+\gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}(x_N+\gamma_N)^{-\frac{1}{\sigma}}$$
$$\lambda p_S = \left((x_N+\gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S+\gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}(x_S+\gamma_S)^{-\frac{1}{\sigma}}$$
$$\frac{\lambda p_N}{\lambda p_S} = \frac{\left((x_N+\gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S+\gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}(x_N+\gamma_N)^{-\frac{1}{\sigma}}}{\left((x_N+\gamma_N)^{\frac{\sigma-1}{\sigma}} + (x_S+\gamma_S)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}(x_S+\gamma_S)^{-\frac{1}{\sigma}}}$$
$$\frac{p_N}{p_S} = \left(\frac{x_S+\gamma_S}{x_N+\gamma_N}\right)^{\frac{1}{\sigma}} = MRS$$

For simplicity we further assume that $\gamma_N = 0$ and $\gamma_S = 0$.

$$x_S^{\frac{1}{\sigma}} = \frac{p_N}{p_S} x_N^{\frac{1}{\sigma}}$$
$$x_S = x_N \left(\frac{p_N}{p_S}\right)^{\sigma}$$
$$x_N = x_S \left(\frac{p_S}{p_N}\right)^{\sigma}$$

We then substitute $x_S$ into the budget constraint, Equation 4.3, to find the optimal demand, $p_N x_N$ and $p_S x_S$:

$$\begin{aligned} m_X - T &= p_N x_N + p_S x_S \qquad (4.3)\\ &= p_N x_N + p_S x_N \left(\frac{p_N}{p_S}\right)^{\sigma} \\ &= p_N x_N + p_N^{\sigma} x_N p_S^{1-\sigma} \\ &= p_N x_N + p_N^{\sigma+1-1} x_N p_S^{1-\sigma} \\ &= p_N x_N + p_N x_N \left(\frac{p_S}{p_N}\right)^{1-\sigma} \\ p_N^{1-\sigma}(m_X - T) &= p_N x_N \left(p_N^{1-\sigma} + p_S^{1-\sigma}\right) \\ p_N x_N &= \frac{p_N^{1-\sigma}}{p_N^{1-\sigma} + p_S^{1-\sigma}}(m_X - T) \\ p_N x_N &= \left(\frac{p_N}{(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}}\right)^{1-\sigma}(m_X - T) \end{aligned}$$

We now set $P_X$ equal to a price index for alcohol:

$$P_X = P(p_N, p_S) = (p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}$$

Then we substitute the price index into the optimal demand. Since $x_N$ and $x_S$ are symmetrical this means that so are $p_N x_N$ and $p_S x_S$:

$$p_N x_N = \left(\frac{p_N}{P_X}\right)^{1-\sigma}(m_X - T) \tag{4.4}$$

$$x_N = \frac{1}{P_X^{1-\sigma} p_N^{\sigma}}(m_X - T)$$

$$p_S x_S = \left(\frac{p_S}{P_X}\right)^{1-\sigma}(m_X - T) \tag{4.5}$$

$$x_S = \frac{1}{P_X^{1-\sigma} p_S^{\sigma}}(m_X - T)$$

By substituting the optimal demand back into the utility function 4.2 we find the indirect utility:

$$u = \left(x_N^{\frac{\sigma-1}{\sigma}} + x_S^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{4.2}$$

$$\begin{aligned}
v &= \left(\left(\frac{1}{P_X^{1-\sigma} p_N^{\sigma}}(m_X - T)\right)^{\frac{\sigma-1}{\sigma}} + \left(\frac{1}{P_X^{1-\sigma} p_S^{\sigma}}(m_X - T)\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \\
&= \left(\frac{1}{(P_X^{1-\sigma} p_N^{\sigma})^{\frac{\sigma-1}{\sigma}}}(m_X - T)^{\frac{\sigma-1}{\sigma}} + \frac{1}{(P_X^{1-\sigma} p_S^{\sigma})^{\frac{\sigma-1}{\sigma}}}(m_X - T)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \\
&= \left(\frac{(m_X - T)^{\frac{\sigma-1}{\sigma}} p_N^{1-\sigma}}{P_X^{(1-\sigma)(\frac{\sigma-1}{\sigma})}} + \frac{(m_X - T)^{\frac{\sigma-1}{\sigma}} p_S^{1-\sigma}}{P_X^{(1-\sigma)(\frac{\sigma-1}{\sigma})}}\right)^{\frac{\sigma}{\sigma-1}} \\
&= \left(\frac{(m_X - T)^{\frac{\sigma-1}{\sigma}} (p_N^{1-\sigma} + p_S^{1-\sigma})}{P_X^{(1-\sigma)(\frac{\sigma-1}{\sigma})}}\right)^{\frac{\sigma}{\sigma-1}} \\
&= \frac{(m_X - T)(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{\sigma}{\sigma-1}}}{P_X^{1-\sigma}} \\
&= \frac{(m_X - T)(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{\sigma}{\sigma-1}}}{p_N^{1-\sigma} + p_S^{1-\sigma}} \\
&= (m_X - T)(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{\sigma}{\sigma-1} - (\frac{\sigma-1}{\sigma-1})} \\
&= (m_X - T)(p_N^{1-\sigma} + p_S^{1-\sigma})^{-\frac{1}{1-\sigma}}
\end{aligned}$$

$$v = \frac{(m_X - T)}{P_X} \tag{4.6}$$

If the consumer does not go cross-border shopping the utility will be $u = x_N$ as we will only get utility for alcohol purchases in Norway, and the budget constraint will change some as we will no longer have any transportation costs and we will no longer have any purchases in Sweden:

$$u = x_N$$
$$m_X = p_N x_N$$

We use the equation for $m_X$ and solve for $x_N$, and substitute this back into the "new" utility function:

$$\begin{aligned} m_X &= p_N x_N \\ x_N &= \frac{m_X}{p_N} \\ u &= x_N \\ &= \frac{m_X}{p_N} \end{aligned}$$

This is only possible if there is a possibility for the consumer to have zero consumption of alcohol purchased in Sweden. Under the CES preferences, we therefore exclude all possibilities where $\sigma \leq 1$, when $\gamma_N = 0$ and $\gamma_S = 0$.

If we now assume that $\sigma = 1$ then the utility function (4.2) becomes a Cobb-Douglas utility function. We arrive at this by first finding the MRS for the CES utility function (4.2).

$$\begin{aligned} MRS_{CES} &= \left(\frac{x_S + \gamma_S}{x_N + \gamma_N}\right)^{\frac{1}{\sigma}} \\ &= \left(\frac{x_S}{x_N}\right)^{\frac{1}{\sigma}} \\ &= \frac{x_S}{x_N} \end{aligned}$$

We now find the MRS for the Cobb-Douglas utility function.

$$
\begin{aligned}
u_{CD} &= x_N^{\beta} x_S^{1-\beta} \\
\frac{\partial u_{CD}}{\partial x_N} &= \beta x_N^{\beta-1} \\
\frac{\partial u_{CD}}{\partial x_S} &= (1-\beta) x_S^{1-\beta-1} \\
MRS_{CD} &= \frac{\beta x_N^{\beta-1}}{(1-\beta) x_S^{1-\beta-1}} \\
&= \frac{\beta x_N^{\beta-1}}{(1-\beta) x_S^{-\beta}} \\
&= \frac{\beta x_S^{\beta}}{(1-\beta) x_N^{1-\beta}}
\end{aligned}
$$

If we now set $\beta = \frac{1}{2}$ we get:

$$
\begin{aligned}
MRS_{CD} &= \frac{\beta x_S^{\beta}}{(1-\beta) x_N^{1-\beta}} \\
&= \frac{\frac{1}{2} x_S^{\frac{1}{2}}}{(1-\frac{1}{2}) x_N^{1-\frac{1}{2}}} \\
&= \frac{\frac{1}{2} x_S^{\frac{1}{2}}}{\frac{1}{2} x_N^{\frac{1}{2}}} \\
&= \frac{x_S}{x_N}
\end{aligned}
$$

As we can see $MRS_{CES} = MRS_{CD}$, this means that when $\sigma = 1$ and $\beta = \frac{1}{2}$ the utility function (4.2) can be written as a Cobb-Douglas utility function and will look like:

$$
u = x_N^{\frac{1}{2}} x_S^{1-\frac{1}{2}} \tag{4.8}
$$

**Step 1**

Secondly, we calculate the optimal alcohol budget with and without cross-border shopping and the total utility the consumers receive from alcohol and other goods. To do this, we start with the same utility function as in Equation 4.1, in addition to the budget constraint when the consumer does not go cross-border shopping, Equation 4.10.

$$U = \left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \tag{4.1}$$

$$s.t.\ M = P_X X + Y \tag{4.10}$$

To find the optimal demand we here use Lagrange:

$$\begin{aligned}
L &= \left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} + \lambda(M - P_X X - Y) \\
\frac{\partial L}{\partial X} &= \frac{\epsilon-1}{\epsilon}\alpha X^{\frac{\epsilon-1}{\epsilon}-1}\frac{\epsilon}{\epsilon-1}\left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}-1} - \lambda P_X = 0 \\
\frac{\partial L}{\partial Y} &= \frac{\epsilon-1}{\epsilon}(1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}-1}\frac{\epsilon}{\epsilon-1}\left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}-1} - \lambda = 0 \\
\frac{\partial L}{\partial \lambda} &= M - P_X X - Y = 0
\end{aligned}$$

We solve with respect to $\lambda P_X$ and $\lambda$ to find the relative price ratio, and then solve for $Y$.

$$\begin{aligned}
\lambda P_X &= \frac{\epsilon-1}{\epsilon}\alpha X^{\frac{\epsilon-1}{\epsilon}-1}\frac{\epsilon}{\epsilon-1}\left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}-1} \\
\lambda &= \frac{\epsilon-1}{\epsilon}(1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}-1}\frac{\epsilon}{\epsilon-1}\left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}-1} \\
\frac{\lambda P_X}{\lambda} &= \frac{\alpha X^{\frac{\epsilon-1}{\epsilon}-1}}{(1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}-1}} \\
P_X &= \frac{\alpha}{1-\alpha}\left(\frac{Y}{X}\right)^{\frac{1}{\epsilon}} \\
Y &= \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon} X
\end{aligned}$$

We then substitute $Y$ into the budget constraint, Equation 4.10, to find $X$:

$$\begin{aligned}
M &= P_X X + Y \\
&= P_X X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon} X \\
&= X\left(P_X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}\right) \\
X &= \frac{M}{P_X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}} \\
&= \left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}}
\end{aligned}$$

We then substitute $X$ into the budget constraint for alcohol without cross-border shopping, where $P_X = p_N$ and $X = x_N$:

$$\begin{aligned} m_X &= p_N x_N \\ &= P_X X \\ &= P_X\left(\left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right) \\ &= P_X^{1-\epsilon}\alpha^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}} \end{aligned}$$

We now set $P_T$ equal to the general price index for alcohol and other goods:

$$P_T = P(P_X, 1) = \left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}$$

Then we substitute the price index into the budget constraint:

$$\begin{aligned} m_X &= \alpha^{\epsilon}\left(\frac{P_X}{P_T}\right)^{1-\epsilon}M \\ m_X &= \alpha^{\epsilon}\left(\frac{p_N}{P_T}\right)^{1-\epsilon}M \end{aligned} \tag{4.11}$$

If we substitute the equation for $X$ into the equation for $Y$, we find the optimal $Y$:

$$\begin{aligned} X &= \left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}} \\ Y &= \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}X \\ &= \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}\left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}} \\ &= (1-\alpha)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}} \end{aligned}$$

By substituting the equations for $X$ and $Y$ back into the utility function 4.1 we find the indirect utility:

$$U = \left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \tag{4.1}$$

$$\begin{aligned}
V^{NC-BS} &= \left(\alpha\left(\left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)}\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)\left(\left(1-\alpha\right)^{\epsilon}\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \\
&= \left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}}\left(\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)^{\epsilon}\left(\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \\
&= \left(\left(\frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}}\left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}} + (1-\alpha)^{\epsilon}\right)\right)^{\frac{\epsilon}{\epsilon-1}} \\
&= \frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}} + (1-\alpha)^{\epsilon}\right)^{\frac{\epsilon}{\epsilon-1}} \\
&= \frac{M}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\left(\alpha^{\epsilon}P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{\epsilon}{\epsilon-1}} \\
&= M\left(\alpha^{\epsilon}P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{\epsilon-1}} \\
&= \frac{M}{\left(\alpha^{\epsilon}P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}} \\
V^{NC-BS} &= \frac{M}{P_T} \qquad (4.12)
\end{aligned}$$

Where $P_X = p_N$

In the case where the consumer goes cross-border shopping, $Y$ will remain the same, but the budget constraint will change as the consumer now will have a transportation cost associated with the border crossing. We substitute $Y$ into the "new" budget constraint to find $X$:

$$\begin{aligned}
Y &= \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}X \\
M-T &= P_X X + Y \\
&= P_X X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}X \\
&= X\left(P_X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}\right) \\
X &= \frac{M-T}{P_X + \left(P_X\frac{1-\alpha}{\alpha}\right)^{\epsilon}} \\
&= \left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}
\end{aligned}$$

We then substitute $X$ into the budget constraint for alcohol with cross-border shopping, where $P_X = P(p_N, p_S)$ and $P_X X = p_N x_N + p_S x_S$:

$$\begin{aligned} m_X - T &= P_X X \\ &= P_X \left( \left( \frac{\alpha}{P_X} \right)^{\epsilon} \frac{M - T}{\alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}} \right) \\ &= P_X^{1-\epsilon} \alpha^{\epsilon} \frac{M - T}{\alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}} \end{aligned}$$

We now set $P_T$ equal to the general price index for alcohol and other goods, same as above but $P_X$ is now defined as $P_X = P(p_N, p_S)$:

$$P_T = P(P_X, 1) = \left( \alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon} \right)^{\frac{1}{1-\epsilon}}$$

We then substitute the price index into the budget constraint and solve for $m_X$:

$$\begin{aligned} m_X - T &= \alpha^{\epsilon} \left( \frac{P_X}{P_T} \right)^{1-\epsilon} (M - T) \\ m_X &= T + \alpha^{\epsilon} \left( \frac{P_X}{P_T} \right)^{1-\epsilon} (M - T) \\ m_X &= T + \alpha^{\epsilon} \left( \frac{P(p_N, p_S)}{P_T} \right)^{1-\epsilon} (M - T) \end{aligned} \tag{4.13}$$

If we substitute the equation for $X$ into the equation for $Y$, we find the optimal $Y$:

$$\begin{aligned} X &= \left( \frac{\alpha}{P_X} \right)^{\epsilon} \frac{M - T}{\alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}} \\ Y &= \left( P_X \frac{1-\alpha}{\alpha} \right)^{\epsilon} X \\ &= \left( P_X \frac{1-\alpha}{\alpha} \right)^{\epsilon} \left( \frac{\alpha}{P_X} \right)^{\epsilon} \frac{M - T}{\alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}} \\ &= (1-\alpha)^{\epsilon} \frac{M - T}{\alpha^{\epsilon} P_X^{1-\epsilon} + (1-\alpha)^{\epsilon}} \end{aligned}$$

By substituting the equations for $X$ and $Y$ back into the utility function 4.1 we find the indirect utility:

$$
\begin{aligned}
U &= \left(\alpha X^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)Y^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} && (4.1)\\
V^{C-BS} &= \left(\alpha\left(\left(\frac{\alpha}{P_X}\right)^{\epsilon}\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)}\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)\left(\left(1-\alpha\right)^{\epsilon}\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}\\
&= \left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}}\left(\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}} + (1-\alpha)^{\epsilon}\left(\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}\\
&= \left(\left(\frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\right)^{\frac{\epsilon-1}{\epsilon}}\left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}}+(1-\alpha)^{\epsilon}\right)\right)^{\frac{\epsilon}{\epsilon-1}}\\
&= \frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\left(\frac{\alpha^{\epsilon}}{P_X^{\epsilon-1}}+(1-\alpha)^{\epsilon}\right)^{\frac{\epsilon}{\epsilon-1}}\\
&= \frac{M-T}{\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}}\left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{\epsilon}{\epsilon-1}}\\
&= (M-T)\left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{\epsilon-1}}\\
&= \frac{M-T}{\left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}\\
V^{C-BS} &= \frac{M-T}{P_T} && (4.14)
\end{aligned}
$$

Where $P_X = P(p_N, p_S)$

To find when the consumer will go cross-border shopping we compare the indirect utilities:

$$
\begin{aligned}
V^{C-BS} &> V^{NC-BS} && (4.15)\\
\frac{M-T}{\left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}} &> \frac{M}{\left(\alpha^{\epsilon}P_X^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}\\
\frac{M-T}{\left(\alpha^{\epsilon}P(p_N,p_S)^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}} &> \frac{M}{\left(\alpha^{\epsilon}p_N^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}\\
\frac{M-T}{M} &> \frac{\left(\alpha^{\epsilon}P(p_N,p_S)^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^{\epsilon}p_N^{1-\epsilon}+(1-\alpha)^{\epsilon}\right)^{\frac{1}{1-\epsilon}}}
\end{aligned}
$$

**Two cases**

We now look at a special case where $\alpha \to 1$:

$$m_X = T + \alpha^{\epsilon}\Big(\frac{P(p_N, p_S)}{P_T}\Big)^{1-\epsilon}(M - T) \tag{4.13}$$

$$m_X = T + \alpha^{\epsilon}\frac{P(p_N, p_S)^{1-\epsilon}}{\alpha^{\epsilon}P(p_N, p_s)^{1-\epsilon} + (1-\alpha)^{\epsilon}}(M - T)$$

$$m_X = T + M - T$$

$$m_X = M$$

This means that the alcohol budget is equal to the entire budget and therefore:

$$\frac{M - T}{M} = \frac{m_X - T}{m_X}$$

We then look at when the consumer will go cross-border shopping when $\alpha \to 1$:

$$V^{C-BS} > V^{NC-BS} \tag{4.15}$$

$$\frac{M - T}{M} > \frac{\big(\alpha^{\epsilon}P(p_N, p_S)^{1-\epsilon} + (1-\alpha)^{\epsilon}\big)^{\frac{1}{1-\epsilon}}}{\big(\alpha^{\epsilon}p_N^{1-\epsilon} + (1-\alpha)^{\epsilon}\big)^{\frac{1}{1-\epsilon}}}$$

$$\frac{M - T}{M} > \frac{P(p_N, p_S)}{p_N}$$

$$\frac{M}{M} - \frac{P(p_N, p_S)}{p_N} > \frac{T}{M}$$

$$1 - \frac{P(p_N, p_S)}{p_N} > \frac{T}{M} \tag{4.18}$$

We then set $p_N = (1+t_N)p_S$. The left-hand side of the inequality will be:

$$\begin{aligned}
1 - \frac{P(p_N, p_S)}{p_N} &= 1 - \frac{(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}}{p_N} \\
&= \frac{p_N - \left(p_N^{1-\sigma} + \left(\frac{p_N}{1+t_N}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}}{p_N} \\
&= \frac{p_N - \left(p_N^{1-\sigma}\left(1 + \frac{1}{(1+t_N)^{1-\sigma}}\right)\right)^{\frac{1}{1-\sigma}}}{p_N} \\
&= \frac{p_N - p_N\left(1 + \frac{1}{(1+t_N)^{1-\sigma}}\right)^{\frac{1}{1-\sigma}}}{p_N} \\
&= 1 - \left(1 + \frac{1}{(1+t_N)^{1-\sigma}}\right)^{\frac{1}{1-\sigma}} \\
&= 1 - (1 + (1+t_N)^{\sigma-1})^{\frac{1}{1-\sigma}} \qquad (4.19)
\end{aligned}$$

If we assume that alcohol in Norway and Sweden are perfect substitutes then $\sigma \to \infty$:

$$\lim_{\sigma\to\infty} 1 - \frac{P(p_N, p_S)}{p_N}$$
$$\lim_{\sigma\to\infty} 1 - \frac{(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}}{p_N}$$

To calculate this we look at a more general case where we have the utility function $(x^{\frac{s-1}{s}} + y^{\frac{s-1}{s}})^{\frac{s}{s-1}}$, where $s$ is the substitution elasticity. If $s \to 0$, then the utility function will be equal to the Leontief function $\min\{x, y\}$. Our "utility function" $(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}$ then has the substitution elasticity $\frac{1}{\sigma}$. How we arrived at this is shown below.

$$\begin{aligned}
\frac{s-1}{s} &= 1 - \sigma \\
s - 1 &= s(1-\sigma) \\
s - 1 &= s - s\sigma \\
1 &= s - s + s\sigma \\
s &= \frac{1}{\sigma}
\end{aligned}$$

This means that when $\sigma \to \infty$ then the substitution elasticity $\frac{1}{\sigma} \to 0$. This means that our utility function will be equal to the Leontief function when $\sigma \to \infty$.

$$\lim_{\sigma\to\infty}(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}} = \min\{p_N, p_S\} = p_S$$

If we set $p_S = 1$ we then get:

$$\begin{aligned}
\lim_{\sigma\to\infty} 1 - \frac{(p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}}}{p_N} &= 1 - \frac{p_S}{p_N} \\
&= 1 - \frac{p_S}{(1+t_N)p_S} \\
&= 1 - \frac{1}{1+t_N} \\
&= \frac{1+t_N-1}{1+t_N} \\
&= \frac{t_N}{1+t_N}
\end{aligned} \tag{4.21}$$

And the comparison can be written as:

$$\frac{t_N}{1+t_N} > \frac{T}{M} \tag{4.22}$$

If we now assume that $\alpha \to 1$, $\sigma = 30$, and $t_N = 0.2$.

$$\begin{aligned}
\frac{t_N}{1+t_N} &= \frac{T}{M} \\
\frac{0.2}{1+0.2} &= \frac{T}{M} \\
0.167 &= \frac{T}{M}
\end{aligned}$$

We next look at the more general case where $0 < \alpha < 1$

$$\begin{aligned}
\frac{M-T}{M} &> \frac{\left(\alpha^\epsilon P(p_N,p_S)^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^\epsilon p_N^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}} \\
1 - \frac{T}{M} &> \frac{\left(\alpha^\epsilon P(p_N,p_S)^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^\epsilon p_N^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}} \\
1 - \frac{\left(\alpha^\epsilon P(p_N,p_S)^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^\epsilon p_N^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}} &> \frac{T}{M}
\end{aligned} \tag{4.23}$$

If we now assume that $p_S = 2$, $\epsilon = 0.5$, $\alpha = 0.3$, $\sigma = 30$, and $t_N = 0.2$.

$$\begin{aligned} p_N &= (1 + t_N)p_S \\ &= (1 + 0.2)2 \\ &= 2.4 \end{aligned}$$

$$\begin{aligned} P(p_N, p_S) &= (p_N^{1-\sigma} + p_S^{1-\sigma})^{\frac{1}{1-\sigma}} \\ &= (2.4^{1-30} + 2^{1-30})^{\frac{1}{1-30}} \\ &= (2.4^{-29} + 2^{-29})^{-\frac{1}{29}} \\ &= 1.99 \end{aligned}$$

$$\begin{aligned} 1 - \frac{\left(\alpha^\epsilon P(p_N, p_S)^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}}{\left(\alpha^\epsilon p_N^{1-\epsilon} + (1-\alpha)^\epsilon\right)^{\frac{1}{1-\epsilon}}} &= \frac{T}{M} \\ 1 - \frac{\left(0.3^{0.5} 1.99^{0.5} + (0.7)^{0.5}\right)^{\frac{1}{0.5}}}{\left(0.3^{0.5} 2.4^{0.5} + (0.7)^{0.5}\right)^{\frac{1}{0.5}}} &= \frac{T}{M} \\ 0.088 &= \frac{T}{M} \end{aligned}$$

## B.2 Effect of Cross-Border Shopping

Demand, when the consumer goes cross-border shopping, is defined as:

$$D_N(p_N, p_S, M, m) \tag{4.24}$$

$$D_S(p_N, p_S, M, m) \tag{4.25}$$

Demand, when the consumer does not go cross-border shopping, is defined as:

$$D_N^{closed}(p_N, p_S, M, m) = D_N(p_N, \hat{p}_S(p_N, M, m), M, m) \tag{4.27}$$

$$D_S^{closed}(p_N, p_S, M, m) = D_S(p_N, \hat{p}_S(p_N, M, m), M, m) = 0 \tag{4.26}$$

The effect of border closing can be defined as:

$$\begin{aligned} &logD_N(p_N, p_S, M, m) - logD_N^{closed}(p_N, p_S, M, m) \\ &\qquad = logD_N(p_N, p_S, M, m) - logD_N(p_N, \hat{p}_S(p_N, M, m), M, m). \quad (4.28) \end{aligned}$$

We can estimate the demand for Norwegian alcohol when the border is closed by taking the first order Taylor approximation around $p_S$ for $D_N^{closed}$:

$$\begin{aligned} logD_N^{closed} &\simeq logD_N + \frac{\partial logD_N}{\partial p_S}(\hat{p}_S - p_S) \quad (4.29) \\ &\simeq logD_N + \frac{\partial logD_N}{\partial p_S}(\hat{p}_S - p_S)\frac{p_S}{p_S} \\ &\simeq logD_N + \frac{\partial logD_N}{\partial logp_S}\frac{(\hat{p}_S - p_S)}{p_S} \end{aligned}$$

Substituting the approximation back into (4.28), the effect will then be:

$$\begin{aligned} logD_N - logD_N^{closed} &\simeq logD_N - \big(logD_N + \frac{\partial logD_N}{\partial logp_S}\frac{(\hat{p}_S - p_S)}{p_S}\big) \\ &\simeq -\frac{\partial logD_N}{\partial logp_S}\frac{\hat{p}_S - p_S}{p_S} \end{aligned}$$

An elasticity can be defined as:

$$\varepsilon = \frac{\partial logf(x)}{\partial logx}$$

Substituting the definition for elasticity back into the effect:

$$\begin{aligned} logD_N - logD_N^{closed} &\simeq -\frac{\partial logD_N}{\partial logp_S}\frac{\hat{p}_S - p_S}{p_S} \\ &\simeq -\varepsilon_{NS}\frac{\hat{p}_S - p_S}{p_S} \quad (4.30) \end{aligned}$$

By taking the first order Taylor approximation around $p_S$ for $D_S^{closed}$ we can rewrite the relative price increase as an inverse elasticity:

$$
\begin{aligned}
0 = D_S^{closed} &\simeq D_S + \frac{\partial D_S}{\partial p_S}(\hat{p}_S - p_S) \qquad (4.31)\\
0\frac{1}{D_S} &= \frac{D_S}{D_S} + \frac{\partial D_S}{\partial p_S}(\hat{p}_S - p_S)\frac{p_S}{p_S}\frac{1}{D_S}\\
0 &= 1 + \frac{\partial logD_S}{\partial logp_S}\frac{\hat{p}_S - p_S}{p_S}\\
\frac{\partial logD_S}{\partial logp_S}\frac{\hat{p}_S - p_S}{p_S} &= -1\\
\frac{\hat{p}_S - p_S}{p_S} &= -\frac{\partial logp_S}{\partial logD_S}\\
&= -\frac{1}{\frac{\partial logD_S}{\partial logp_S}}\\
&= -\frac{1}{\varepsilon_{SS}} \qquad (4.32)
\end{aligned}
$$

Substitution Equation (4.32) into (4.30) we get:

$$
\begin{aligned}
logD_N - logD_N^{closed} &\simeq -\varepsilon_{NS}\frac{\hat{p}_S - p_S}{p_S}\\
logD_N - logD_N^{closed} &\simeq -\varepsilon_{NS}\frac{1}{\varepsilon_{SS}}\\
logD_N - logD_N^{closed} &\simeq \frac{\varepsilon_{NS}}{\varepsilon_{SS}} \qquad (4.33)
\end{aligned}
$$

$\varepsilon_{NS}$ and $\varepsilon_{SS}$ can be defined as:

$$
\begin{aligned}
\varepsilon_{NS} &= \frac{\%\Delta D_N}{\%\Delta p_S} \qquad (4.34)\\
\varepsilon_{SS} &= \frac{\%\Delta D_S}{\%\Delta p_S} \qquad (4.35)
\end{aligned}
$$

Substituting these into (4.33) gives:

$$
\begin{aligned}
logD_N - logD_N^{closed} &\simeq \frac{\frac{\%\Delta D_N}{\%\Delta p_S}}{\frac{\%\Delta D_S}{\%\Delta p_S}}\\
&\simeq \frac{\%\Delta D_N}{\%\Delta D_S} \qquad (4.36)
\end{aligned}
$$