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An Empirical Investigation into the Impact of the Step-Price Model on the Norwegian Pharmacy Market

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Abstract

The pharmacy sector is a crucial part of any nation's healthcare system. The Norwegian pharmacy market is dominated by three key players, each integrated with their own wholesaler. The step-price model was introduced in 2005, and its core premise was to lower the prices of pharmaceuticals when patented medicines lose their patent and face competition from generic medicines. According to the preparatory works of the current pharmacy law, generic substitution of medicines in pharmacies was moreover implemented to stimulate the competition. This master's thesis presents an empirical analysis of the Norwegian pharmacy market, focusing on the impact of the step-price model on pharmaceutical prices and market concentration measured by the Herfindahl-Hirschman Index. This study aims to quantitatively measure the effect of the step-price model by comparing it to a control group not affected by the model using a difference-in-differences method. Furthermore, the study analyzes the increase in the number of pharmacies, where we compare the trend of new chain pharmacies versus independent pharmacies. Our study found that while the step-price model was successful in lowering the prices, no significant effect was found on the market concentration.

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We would also like to express our gratitude towards the great people at Apotekforeningen, Legemiddelverket and Helse- og Omsorgsdepartementet. The valuable discussions and unique insights provided by these institutions have helped shape our focus on the aspects of the Norwegian pharmacy market, thereby substantially enriching our research.

Finally, we want to thank all our professors and fellow students at BI. The stimulating environment, fostered by the collective intellect at BI, has made this thesis both a challenging and rewarding experience.

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1 Introduction

The pharmaceutical industry is a critical component of any healthcare system, and the regulation of the pharmacy market has profound implications for consumer welfare, market efficiency and competition. A key characteristic of the Norwegian pharmacy market is that the pharmacy chains primarily compete on location, service, and opening hours, and not on prices (NOU 2023:2, 2023). One reason for this is that about 80% of the pharmaceutical expenses are covered by the public sector, reducing the financial burden on consumers. The patients pay a deductible, which makes up a small amount of the price of the pharmaceutical. Furthermore, the customers do not choose which pharmaceutical to buy, but this is rather chosen by their doctor. This choice is to a small degree influenced by the pharmaceutical's price. However, it is in the public's interest that the price is as low as possible, and this goal is actively pursued (NOU 2023:2, 2023).

The prices of pharmaceuticals in Norway are heavily regulated. In 2005, the step-price model was introduced with the goal of reducing prices of generic medicines and thereby reducing the expenses of the Norwegian national insurance (Folketrygden) and patients (NOU 2023:2, 2023). The step-price model works by reducing the prices of pharmaceuticals when the patent runs out, and the pharmaceutical faces competition from generic manufacturers. When the patent runs out, the wholesalers usually get increased bargaining power when buying pharmaceuticals because of competition from generic medicines, and this allows the reduction of the prices (Legemiddelverket, 2016). Additionally, the generic substitution of pharmaceuticals was implemented into the current pharmacy law to stimulate competition (NOU 2023:2, 2023).

The Norwegian pharmacy market is characterized by a few, dominant players all vertically integrated with their respective wholesalers. There have been voiced concerns about the competition in the market and how the three large companies act as a barrier to entry for smaller, chain-independent pharmacies (NOU 2023:2, 2023). Since all three of the players are vertically integrated with their own wholesalers, independent companies have to buy their pharmaceuticals from a

competing pharmacy chain, which can be problematic for the independent pharmacies (Helsedepartementet, 2004). Another problem is that there have been signs of over-establishments of chain pharmacies in the larger cities, as there are no limits for pharmacy establishments (NOU 2023:2, 2023). Because of the company structure, the vertically integrated pharmacies are able to operate with a loss in the pharmacy sector, and still gain profits in the company as a whole (NOU 2023:2, 2023). This may act as a barrier to entry for independent pharmacies, which can't compete on these terms. In addition to the three players, the public sector runs hospital pharmacies (Sykehusapotekene), which primarily supplies the pharmacies and its patients with pharmaceuticals.

This thesis will quantitatively analyze the effects of the step-price model, both on prices and the competition measured by the Herfindahl-Hirschman Index (HHI), a measure of market concentration. Additionally, the thesis will qualitatively analyze the number of new pharmacies opened after 2003 and compare the number of chain pharmacies opened versus the number of independent pharmacies. The addition of this analysis is to get a deeper understanding of the market concentration and how the market has developed after the implementation of the current pharmacy act. Moreover, the pharmacies primarily compete on location and other factors, rather than competing on prices. This additional analysis will also look at the effects in recent times, and how the market changes.

1.1 Relevance and motivation

The importance of this study comes from its ability to offer a deeper understanding of the unique Norwegian pharmacy market and its rules. Because this market is mostly controlled by a few big players, we need to look closely at the goals of the current pharmacy law to see how it has influenced competition and the prices of pharmaceuticals.

The main reason for this study is the need to address concerns about the state of competition in the Norwegian pharmacy market. We're particularly interested in seeing how the step-price model (in Norwegian, "trinnprismodellen"), a system introduced in 2005, has affected the pharmacy market, specifically how it has

affected the prices of pharmaceuticals and the level of competition. While previous research has commented on the success of the step-price model, this study is set to provide a quantitative analysis of the effects of the model. This study is also important because the Norwegian government is in the process of making a new pharmacy law. The findings from this research could provide useful insights that might help shape these new rules. Our results could help lawmakers understand how the current rules are affecting competition and prices in the market, and what changes might be needed to improve competition. In other words, this study aims to offer valuable information that can lead to better decision-making for a more balanced and competitive Norwegian pharmacy market.

In the 2023 Norwegian Official Report (NOU), numerous independent pharmacies highlight an excessive increase of chain pharmacies in central regions, which significantly hinders their ability to compete. (NOU 2023:2, 2023). The NOU further unveils that integrated pharmacies can maintain their competitive edge by operating at a loss within the retail sector while compensating for the deficit through profits in the wholesale sector. This approach enables them to outperform newly established pharmacies lacking vertical integration. Observations indicate that the wholesaler with the smallest market share experiences a decline in market presence, pointing towards the significant influence of economies of scale for players in the market (NOU 2023:2, 2023).

1.2 Framework

Chapter 2 serves as our gateway into the intricacies of the Norwegian pharmacy market. We will outline the market structure, pharmacy law, and the behavioral obligations of the market players under this law. In Chapter 3, we explain the process of our data accumulation, elaborate on the quantitative research methods employed, and examine the design of the difference-in-difference model. Chapter 4, the heart of our thesis, starts with an explanation of the dataset acquired from Farmastat, its constraints, and how data merging from Legemiddelverket and SSB augmented its informational value. We then elaborate on our analytical approach - the fixed effects difference-in-differences model that handles time constant

omitted variables, using it to analyze the effect of the step price system's implementation in 2005 on prices and the market concentration through the lens of the Herfindahl-Hirschman index (HHI). Chapter 5 presents the observed location-based competition and looks at the difference in openings of chain pharmacies versus independent pharmacies. Chapter 6 houses our discussion on the insights gleaned from our analysis, raising a deeper understanding of our findings. Lastly, Chapter 7 encapsulates our findings, providing a concise summation of our research.

2 Background

2.1 The structure of the Norwegian pharmacy market

2.1.1 Historical development

In 1957, Norsk Medisinaldepot AS was established, and served as a government-run monopoly wholesaler of pharmaceuticals until it was privatized in 1995. Due to requirements of the EEA agreement, this monopoly was terminated, and Tamro (now Apokjeden Distribusjon AS) and Holtung (now Alliance Healthcare Norway AS) were allowed to enter the market (NOU 2023:2, 2023). Twenty-eight years later, the same three pharmacy wholesalers are still the only ones operating within the country. Prior to the current pharmacy act of 2001, all pharmacies were owned by individual pharmacists, contrary to the majority of chain pharmacies today. When the current pharmacy act was implemented, there were 397 pharmacies in Norway. As of January 1st, 2023, there are now 1045 pharmacies in Norway (NOU 2023:2, 2023), and thus there has been tremendous growth in the number of pharmacies in Norway.

2.1.2 Current situation

Today, all three wholesalers are vertically integrated with their own pharmacy chains, and except Sykehusapotekene, which is government-owned and supplies the hospitals, pharmacies not controlled by one of the three wholesalers made up only 3% of the market in 2022 measured by sales (NOU 2023:2, 2023). The three vertically integrated pharmacy businesses are thought to have substantial market

power. There is also a fourth pharmacy chain, Ditt Apotek, which is franchise-driven, but is controlled by Norsk Medisinaldepot. Sykehusapotekene currently has an agreement with the wholesaler Alliance for the purchase of pharmaceuticals.

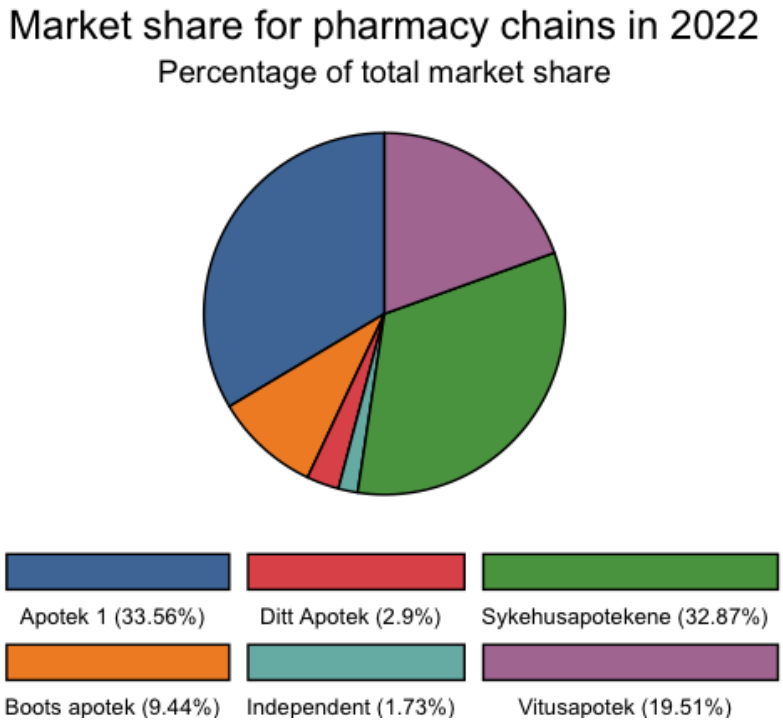

Figure 1: Market shares for pharmacy chains in 2022. Data from Farmastat.

Figure 1 shows the market shares of the different pharmacies in 2022, based on data we obtained from Farmastat. Note that while only accounting for 3% of the total pharmacies, Sykehusapotekene has around 33% of the market share (NOU 2023:2, 2023). This is partly due to Sykehusapotekene supplying the hospitals with pharmaceuticals, and their sales volume per pharmacy is substantially higher than the other pharmacy chains. In the period from 2012 to 2022, Apotek 1 and Vitusapotek gained 5 and 3 percent market shares respectively. In the same period, Boots Apotek and Ditt Apotek lost 6 and 2 respective percent market shares, while the number of independent pharmacies has stayed relatively constant (NOU 2023:2, 2023). There has been concerns that Boots Apotek is being driven out of the market by losing substantial market shares while the two largest chains are gaining market shares, indicating that economies of scale are important in the Norwegian pharmacy market (NOU 2023:2, 2023).

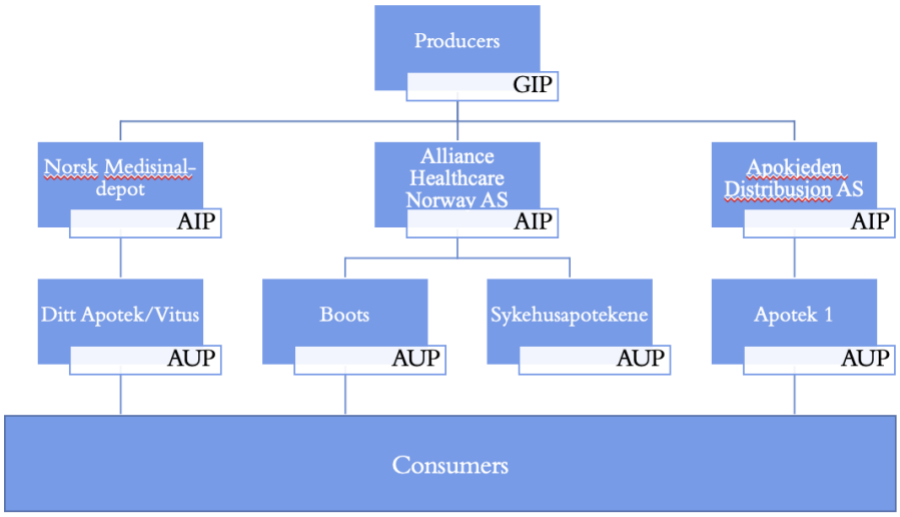

Figure 2: Supply chain structure of wholesalers and retailers as of January 1st, 2023.

Figure 2: Supply chain structure of wholesalers and retailers as of January 1st, 2023. shows the current structure of the Norwegian pharmacy market and the denominations of the prices. AIP (Apotekens innkjøpspris: the pharmacies' purchace prices), is the price at which the pharmacies buy pharmaceuticals from the wholesalers. This Norwegian Medicines Agency sets the maximal purchase price for prescription drugs, and updates this yearly. The prices are based on the three lowest prices the pharmaceuticals are sold for in selected EEA countries (Legemiddelverket, 2022). The Norwegian Medicines Agency also determines the maximum price in which the pharmacies can sell the prescription medicines for (maximum AUP). As of 2023, the maximum profit for pharmacies is 2% of the AIP, the pharmacies' purchase price, plus a flat rate addon of 29 NOK per package, with certain options to have higher profits if the pharmacies have to keep the products chilled or if they are narcotic. A 25% value added tax is also added. Conversely, the prices the wholesaler has to pay to the manufacturers (GIP) are not regulated, and is individually negotiated (Legemiddelverket, 2023).

In Norway, 22 years have passed since the last pharmacy law was implemented, with the preparatory work of the law stating that the goals included promoting a highly competitive market, and thus facilitating for lower prices, as well as accessible sales of prescription drugs for Norwegian citizens by equally distributing pharmacies throughout the country (Helsedepartementet, 1998). However, concerns have been raised about the state of the competition in this market (NOU 2023:2, 2023). One concern is about the possibility of oligopolistic competition and

unequal treatment of integrated and non-integrated agents in the pharmacy market. As a result, it is important to investigate these issues and consider ways to increase competition.

Pharmaceutical product markets and the distribution of pharmaceuticals, like many other healthcare services, have characteristics that do not easily fit the concepts of typical, well-functioning product markets. These characteristics include (Dranove, 2011).

- Information asymmetry: Consumers may not be in the best position to evaluate the suitability and quality of their medication, so the demand for (prescription) medicines is influenced more by prescribing doctors than by consumer preferences.
- Consumers not fully paying the costs: Pharmaceutical costs are often heavily subsidized by society to make them more affordable.
- Inelastic demand: The demand for pharmaceutical products is very inelastic because the medication is often a necessity for most consumers, who cannot easily adjust their usage in response to price changes. This can give actors in the pharmaceutical sector greater market power over consumers (Dranove, 2011).
- Externalities: There are positive externalities from proper medication use, but overuse should be avoided and may cause negative externalities.
- Selection of medication by doctor: The patient/consumer typically does not have the autonomy to select their pharmaceuticals. More often than not, it is the doctor who determines the appropriate medication for the patient's condition.

Together with the three vertically integrated actors' large market shares, and therefore large market power, and the laws against marketing pharmaceuticals, there is a market failure in the prescription medication market, where the conditions for normal price competition is not met (Gudbrandsen & Fellkjær, 2011).

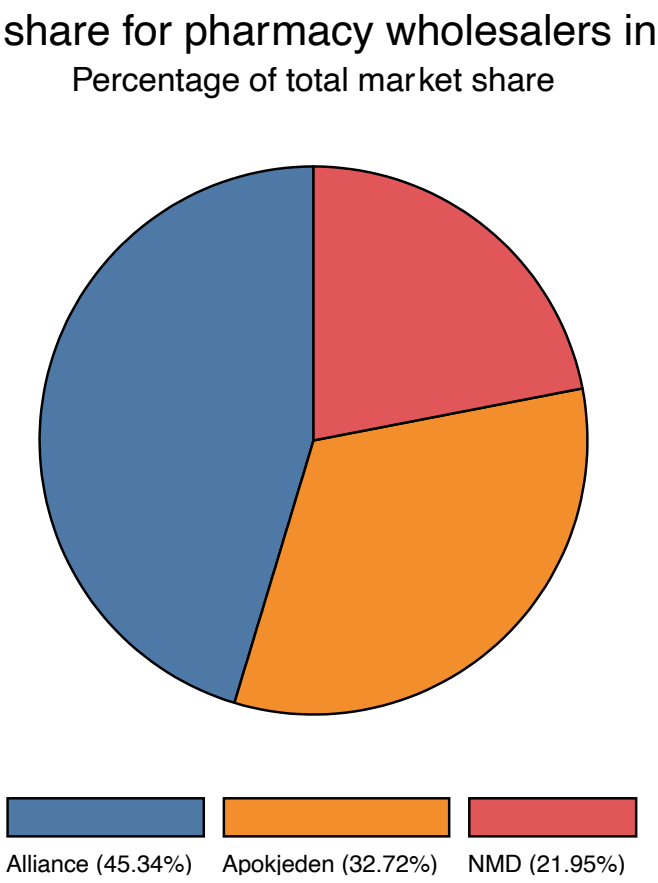

Figure 3: Market share for pharmacy wholesalers. Data from Farmastat

This market share was achieved through AIP Volume. Alliance is currently the biggest wholesaler, as they have the current deal for supplying Sykehusapotekene with pharmaceuticals.

2.1.3 Internet pharmacies

On the 1st of January 2016, the restrictions on pharmacies' ability to send prescription drugs by mail were lifted, which meant that pharmacies could also send prescription drugs to customers through the mail. Sales of pharmaceuticals over the internet are low compared to other retail sectors. The internet pharmacies have to follow the same rules as the physical ones, and all pharmacies are required to have at least one physical location (Apotekforskriften §42). All pharmacies in Norway must have the necessary permission to own and operate a pharmacy (pharmacy license and operating license). The market shares for internet pharmacies are lower in Norway than in many other European countries, and per 2021 only accounts for about 3% of the total market share (NOU 2023:2, 2023).

2.2 Regulatory environment and Norwegian legislation

2.2.1 The Norwegian pharmacy act

In Norway, opening and operating a pharmacy comes with its unique set of requirements that ensure the right environment for the storage, handling, and distribution of pharmaceuticals. First and foremost, the space in which the pharmacy operates needs to be perfectly suited for both storage and handling of pharmaceutical products. This means the premises need to be equipped and designed in a way that maintains the intactness of the pharmaceuticals. Secondly, the pharmacy must establish and stick to a thorough quality management system. Such a system helps in standardizing procedures, ensuring quality and safety, and boosting overall operational efficiency. The third criterion emphasizes the importance of having correct personnel and resources. The business should be well-equipped with the required resources and staffed with competent professionals to deliver adequate services (NOU 2023:2, 2023). Moreover, full compliance with all applicable laws and regulations is required. This includes legislation concerning not only the handling of pharmaceuticals but also the protection of customers' personal data. It's essential to remember that these prerequisites can fluctuate depending on the specific nature of the pharmacy business being set up and its geographical location, as prescribed under the Norwegian Pharmacy Act (Apotekloven). In essence, navigating the pharmacy sector in Norway requires careful consideration and adherence to these requirements.

The Norwegian government regulates the pharmacy market, and there are strict rules for how pharmacies can operate and cooperate with other market players. For example, according to Apotekloven §2-3 the owner of a pharmacy cannot also be a manufacturer of pharmaceuticals or have a connection to a manufacturer of pharmaceuticals. This ensures that all pharmacies have equal opportunities to compete for customers and that consumers can be sure they have access to the same medications regardless of which pharmacy they choose to shop at. Furthermore, all wholesalers are required to deliver to all parts of the country within 24 hours as a main rule, or 48 hours if the area is hard to get to. This helps ensure that the pharmaceutical products get transported to where they are needed in a quick manner. This rule make the barrier to entry for both the pharmacy and wholesaler

markets higher, because of the high entry and operating costs associated with such networks (Gudbrandsen & Fellkjær, 2011).
On January 1st, 2015, the rule mandating wholesalers to carry a complete range of products was repealed. The aim of this change was to foster competition and lower prices for consumers by enabling wholesalers to carry a restricted range of goods, with the goal of attracting new niche wholesalers to enter the market. However, this has not happened, and no new wholesalers have entered the market (NOU 2023:2, 2023). Before the new pharmacy act of 2001, it was forbidden for wholesalers and pharmacies to have the same owner, making the pharmacies often privately owned by individual pharmacists. After the changes in the pharmacy law that made it possible for wholesalers to own the pharmacies, the pharmacies and wholesalers became extensively vertically integrated. After the deregulation, the number of inhabitants per pharmacy went from just over 800 in 2001 to just under 450 in 2019 (Joint Nordic Report, 2021). In 2010, 82% of all Norwegian pharmacies were owned by one of the three wholesalers. Since all of the wholesalers are vertically integrated with their respective pharmacy chains, this means that all competing actors have to buy pharmaceuticals via their competitors' integrated wholesalers.

In Norway, both prescription and non-prescription medicine could only be bought in physical pharmacy stores before 2003. In 2003, consumers were allowed to buy certain non-prescription medicines in grocery stores, gas stations and kiosks. In 2010, the law opened up for online sales of non-prescription medicine and in 2016 for online sales of prescription medicines. Additionally, the online pharmacies must also buy their products from one of the three vertically integrated actors. These factors contribute to a high barrier to entry, and also makes it harder to grow (Gudbrandsen & Fellkjær, 2011).

Government regulation is often implemented in the pharmaceutical and healthcare industries to address various concerns, such as ensuring the quality of products, promoting transparency, regulating access to pharmacies, and controlling public spending on medical reimbursements and medications. The question of whether some regulation is necessary for these objectives and, if so, how much regulation is optimal remains a topic of debate (Dranove, 2011). A lot of these points are also mentioned in The Economics of Healthcare (Mankiw, 2017).

A 2004 report by ECON commissioned by the Norwegian Department of Health (Helsedepartementet) found that the goals set forth by the 2001 law were largely achieved. The law aimed to improve pharmacy accessibility for the public, enhance competition among pharmaceutical products, and increase efficiency within the pharmacy sector (Helsedepartementet, 2004). However, the new law did not reduce the prices of pharmaceutical goods significantly, even though the pharmacies' costs decreased after the vertical integration. However, this report is from before the introduction of the step-price model.

2.2.2 The step-price model (trinnprismodellen)

The step-price model (trinnprismodellen), introduced in 2005, has significantly influenced the pharmacy market by promoting competition and reducing pharmaceutical costs for both patients and the government (Håkonsen & Horn, 2009). The primary objective of this system is to encourage pharmacies to lower their prices through a systematic and transparent framework for price reductions. Upon the expiration of a patented medication's patent protection, the market opens for competition from generic manufacturers and biosimilar producers. To gain approval for a generic medication in Norway, the manufacturer is required to submit a marketing authorization application to the Norwegian Medicines Agency. This is for inclusion to the exchange list, which serves as an official endorsement that the generic product can be an appropriate replacement for the original medication (Ali, 2019). This introduction of competition often leads to price reductions, as new market entrants aim to gain market share (Dalen et al., 2011). Wholesalers and producers then engage in price negotiations for the newly available generic and biosimilar products, with the goal of achieving lower prices for consumers. Medicines affected by the step-price system comprises about 60% of all medicines sold in the primary healthcare service measured in defined daily doses (DDD), and patients and the Norwegian national insurance (folketrygden) save an estimated 2 billion NOK every year because of the step-price model (Apotekforeningen, 2021).

The step-price model works by reducing the prices of the pharmaceuticals in a stepwise manner. The pharmacies purchase prices (AIP) are reduced in two or three steps, dependent on the type of medicine. The first cut comes immediately after the

pharmaceutical is included to the exchange list (byttelisten). The exchange list is a list of pharmaceuticals sold in Norway which are so similar to each other that they can be substituted in pharmacies with no potential side effects. For biological medicines, the second cut in prices comes after 6 months, and the third cut comes 12 months after the second cut at the earliest. For synthetic medicines, the second cut comes after 18 months at the earliest (Legemiddelverket, 2016). The cuts in prices, or "steps", varies in size, and are generally between 25 and 96%. The size of the steps is determined based on the turnover of the medicine. The more the medicine sells for per year, the higher the cuts in prices are. However, if the cuts in prices gives an unreasonably low price, the Norwegian Medicines Agency determines the step price at its discretion (NOU 2023:2, 2023). The Norwegian Medicines Agency (NoMA, in Norwegian Legemiddelverket) is the regulatory body determining the step-price for off-patent pharmaceuticals. This step-price is calculated based on the lowest price of generic or biosimilar products available in the market and is generally expressed as a percentage reduction from the reference price, i.e., the original patented product's price (Håkonsen & Horn, 2009). The step-price system undergoes a revision every quarter to account for market fluctuations and the introduction of new products. The model results in an overall decrease in the price level of the medication in question, benefiting consumers and the healthcare system (Dalen et al., 2011).

The success of the step-price system in Norway can be attributed to its promotion of competition and the establishment of a clear, transparent pricing structure. This system has enabled patients to access more affordable medications, consequently reducing the financial burden on the healthcare system. Furthermore, it encourages innovation and efficiency in the pharmaceutical industry, as manufacturers continuously strive to develop cost-effective solutions in order to stay competitive in the market. This can enable increased price competition in the manufacturing sector. Moreover, the step-price model can incentivize the negotiation of lower pharmaceutical prices, thus also giving an incentive for making the wholesalers and pharmacies more cost efficient because of the lower profits. According to Apotekforeningen (2021), medicines in the step-price system are subject to shortages less frequent than those not in the system. All things considered, there is a broad consensus that the step-price model has been successful in reducing the prices of pharmaceuticals in Norway.

3 Research Method

3.1 Methodological approach

The objective of our research is to establish whether or not the regulation for the pharmacy market has significantly influenced the market dynamics and/or prices for pharmaceuticals. Our thesis contains a quasi-experimental design, mainly by using a difference-in-differences model. Our main analysis is to examine whether or not the prices have been significantly reduced because of the step-price model introduced in 2005, as well as examining whether the Herfindahl-Hirschman Index has changed because of the policy change.

We also analyze the market structure by charting changes in the number of pharmacies across Norwegian counties from 2003 to 2023. This includes a focus on chain versus independent pharmacies to understand different growth trends. Additionally, we consider spatial competition principles (Hotelling model) to comprehend location-based competition. Lastly, we study the market shares of major pharmacy chains over time, providing insights into the competitive landscape.

3.2 Data collection and sample

We have gathered data from four different companies: Farmastat, Farmalogg/Apotekforeningen, Legemiddelverket and SSB.

From Farmastat, we obtained a dataset with all pharmaceuticals sold each year in Norway from 2001 to 2022. The dataset contains the value of the pharmaceuticals sold, which is the total AIP (pharmacies' purchase price for pharmaceuticals). This is the variable we use when defining the prices of pharmaceuticals. The dataset contains the number sold, article number, as well as which pharmacy that sold it. The dataset also contains a dummy variable indicating whether the product requires a prescription or not.

From Farmalogg, a subsidiary of Apotekforeningen, we obtained information on all closures, takeovers, and openings of pharmacies per county per month in Norway.

From Legemiddelverket, we obtained the exchange lists (bytteliste). The exchange lists show the pharmaceuticals that are so similar that they can be exchanged in pharmacies. Products enter the exchange list after the patent has expired, and they get competition from generic pharmaceuticals. We needed the exchange lists to identify whether a pharmaceutical is affected by the step-price model or not.

From SSB, we obtained the yearly population of each county in Norway from 2003 to 2023. This was used to examine the closures, takeovers, and openings of pharmacies per capita, which enabled us to do a more thorough analysis on the change of the number of pharmacies in Norway.

3.3 Design

3.3.1 Fixed effects difference-in-differences method

Difference-in-Differences (DiD) is a research design used to discern causal relationships in observational data, frequently employed in economics, social sciences, and other fields to measure the effect of a specific intervention or treatment at a specific point in time (Angrist & Pischke, 2015). Furthermore, Angrist and Pischke explain that the DiD method operates by comparing the average change over time in the outcome variable for a 'treatment group' to the average change over time for a 'control group'. This comparison aims to emulate the counterfactual outcome, presuming that changes in the untreated group over time represent what would have happened in the treated group if the treatment had not been administered.

The DiD framework consists of four primary components: the treatment group, the control group, the pre-treatment period, and the post-treatment period. Angrist and Pischke (2015) describe the average treatment effect calculation as follows: (Average outcome of the treatment group post-treatment - Average outcome of the treatment group pre-treatment) - (Average outcome of the control group post-

treatment - Average outcome of the control group pre-treatment). The parallel trends assumption is a fundamental premise of the DiD method, and assumes that in the absence of treatment, the average outcomes for the treatment and control groups would have traced the same trend over time (Angrist & Pischke, 2015). In essence, this assumption allows us to attribute any difference between the treatment and control groups' changes over time to the treatment itself.

In a DiD regression, the coefficient derived from the interaction term between the post-treatment dummy variable and the treatment group dummy variable is interpreted as the average effect of the treatment on the treated group relative to the control group. Nonetheless, it may face limitations associated with potential violations of the parallel trends assumption and the presence of time-constant unobserved confounders, also called fixed effects (Imbens & Wooldridge, 2009).

Specifically, we use a fixed effects model, which helps mitigate the problems that can arise when we have time-constant unobserved confounders in our data (Wooldridge, 2020). The model used is a fixed effects transformation, also called a within transformation. This model captures effects that are specific to each individual and do not change over time. These effects can include inherent characteristics of the individuals in the analysis. By controlling for these time-constant characteristics, the fixed effects model helps us to isolate the impact of our treatment variable by focusing on the within-individual variation over time.

4 Empirical Analysis

4.1 Introduction

In 2005, the step-price model (trinnprismodellen) was introduced in order to make pharmaceuticals with generic competition cheaper. The pharmaceuticals affected by this policy change, and thus are in our treatment group, are prescription drugs which get included on the "exchange list" (byttelisten). The exchange list shows all original and generic pharmaceuticals which are so similar to each other that they can be exchanged without adverse effects. To investigate the effect of the prices, and subsidiary the order in which the prices were reduced, we conducted a difference-in-differences analysis of the prices before and after the step-price-model was introduced in 2005. Lastly, we conducted a difference-in-differences analysis on the effect the policy change had on the Herfindahl-Hirschman Index (HHI). By using a difference-in-differences model, we can capture the difference that the policy change made compared to a group of similar pharmaceuticals not affected by the treatment.

4.2 Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (HHI) is a measure of market concentration. The value ranges between 0 and 10 000, where 0 indicates perfect competition with equal market share for each entity, and 10 000 indicates a complete market concentration and a pure monopoly. In general, a HHI above 2500 indicates a highly concentrated market, which means that there are only a few large companies dominating the market, and competition is limited. The higher the HHI, the more concentrated the market, and the less competition there is. (Pepall et. al., 2014). The HHI is calculated by taking the sum of the market shares squared:

$$HHI = \sum_{i=1}^{N} (S_i)^2$$

For all pharmaceuticals, the HHI for the Norwegian pharmacy market has followed this course:

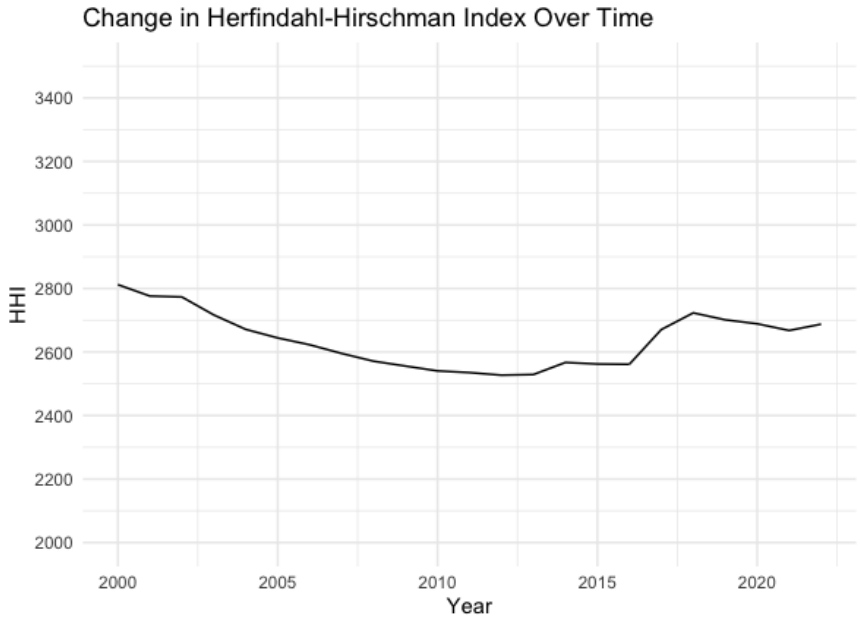

Figure 4: Herfindahl-Hirschman Index over time in terms of purchasing volumes for pharmacies. Data from Farmastat

By visually inspecting Figure 4: Herfindahl-Hirschman Index over time in terms of purchasing volumes for pharmacies. Data from Farmastat, the HHI has been moving between 2500 to 2800 between the years 2000 and 2022, indicating a highly concentrated market. There seems to be a decline in the HHI in the years before and following the step-price model's implementation. Our further analysis will establish whether there could be any causation involved in this development.

4.3 Data

We were fortunate to acquire the data for this analysis from a private company called Farmastat. The dataset is aggregated to sales of pharmaceuticals per pharmacy on an annual basis. For example, we can see what Apotek 1 bought of Viagra from the year 2000 up until 2022. This is data for the volumes the pharmacies bought and their purchasing price (AIP).

However, the dataset from Farmastat did not include the information we required to carry out a difference-in-differences analysis, as we didn't have a dummy variable indicating whether the pharmaceutical is on the exchange list or not. Because of this, we couldn't analyze the effects of the step-price model with a

difference-in-differences analysis. Ideally, by executing a difference-in-differences analysis around the 2005 step-price system, we could have compared prescription and non-prescription products. However, this presented a problem because there is a significant difference between prescription and non-prescription products - the latter has marketing authorization, something prescription drugs do not possess. Furthermore, many non-prescription drugs can be sold at other locations such as gas stations and grocery stores.

Furthermore, we did not have data specifying whether the prescription product was original or generic, or whether the products were on the exchange list at the given time. This lack of data could have led us to include variables in our treatment group that were not actually affected by the step-price, e.g., original drugs that entered the market in 2010 and were thus unaffected by the step-price model. These would have been incorrectly labeled as 'treated' simply because we only had a dummy variable indicating whether the drug was prescription-based or not.

We therefore had to gather information as to whether the product was affected by the step-price model or not. We obtained two exchange lists from the Medicine Agency (Legemiddelverket), which documented the types of products on the exchange list. One list was from 2023 with historical data tracing back to 2008, and the other list we obtained was from 2005 when the stepped pricing system was implemented. The exchange list of 2005 includes all pharmaceuticals on the that are substitutable as of 2005, even though they entered the list earlier. This gave us the opportunity to analyze all products that were on the exchange list from the start of the treatment period. With this information, we managed to capture data on all products from 2005 to the present date, except for those that entered the exchange list in 2006 and 2007. The products that made it onto the exchange list between 2006 and 2007 will still be incorporated in our data, but only as of 2008.

4.4 Difference in Difference analysis of HHI and Prices (AIP)

4.4.1 Our difference-in-differences model

Our analysis employs a fixed effects difference-in-differences model, represented by the following equation:

$$y_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

The equation is identical for both of our difference-in-differences analyses. y_{it} is the outcome of interest. In the case where we analyze the prices, y_{it} represents the logarithmic price per package, where i denotes the article number of the pharmaceutical, we have 997 unique article numbers. t denotes the year from 2001 to 2010. Since the prices are logarithmic, the results approximately yield the percentage change in prices. The incorporation of i in our regression allows for an effect centering on each article number, enabling the regression to differentiate between lower-cost and higher-cost pharmaceutical products. ε_{it} is the error term, which represents random, unexplained variations.

In the case where we analyze the HHI, y_{it} represents the yearly HHI, and the subscript i denotes the article number for pharmaceuticals. In other words, we're analyzing the HHI for each product included in our data, and we're defining each unique product as its own market in which we calculate the HHI for. In this analysis, we have 2102 unique article numbers. We calculate the HHI for each of the article numbers in our dataset. As with the analysis of the prices, t denotes the year from 2001 to 2010.

In our model, we use a fixed effects approach where each unique article number is treated as its own individual, denoted by the intercept α_i. By using a fixed effects model, we are able to control for all time constant omitted variables. With a relatively large number of products, different unobserved characteristics of the different products, such as brand reputation and number of years in the market before our data begins, may otherwise affect the price and HHI. These unobserved characteristics do not necessarily change in time, but can be different pricing factors that differ from product to product. By using a product fixed effects model, each product has its own unique baseline price, and therefore these unobserved

characteristics are controlled for. α_i can thus be seen as the intercept for every product i. (Wooldridge, 2020). We're using a fixed effects transformation, or commonly called a within transformation. By using this model, the differences in prices and HHI are more likely to be due to the treatment and no unobserved, time-constant factors.

With a fixed effects model, you often need to adjust the standard errors to account for the fact that observations within a group may not be fully independent (Wooldridge, 2020). In our analysis, we chose to cluster the standard errors by their unique article number, because there might be some systematic variation within each article number that is not captured by the model. The reasoning behind this is that one observation of the log prices for product i is not independent from another observation of the log prices or the HHI of the same product at a later time. For example, if a product's price is high in period 1, it is likely to also be high in period 2, and so forth. The same applies to the HHI, as different product characteristics may vary systematically. For example, some pharmaceuticals are only sold at the hospital pharmacies, "Sykehusapotekene", and thus the HHI will have a value of 10,000 for these pharmaceuticals every year. Clustering the standard errors at the product level means that correlation within the same products over time is allowed, and we're recognizing that the data points from the same product are not completely independent. In principle, clustering standard errors can remove a potential dependence problem that we could have in our data (Angrist & Pischke, 2015). Clustering the standard errors by product can help improve the accuracy of the standard errors and therefore also the significance of the coefficients. Clustered standard errors can help improve the robustness of our results if our model is affected by heteroscedasticity or autocorrelation (Wooldridge, 2020). The results of all of our tests of the prices and the HHI shown in the next pages are results using cluster-robust standard errors, although the results are not significantly different from the results without using cluster-robust standard errors.

Our difference-in-differences model has three main ingredients:

I. α_i represents the product (product i) fixed effects, which capture the average effect of all unobserved time-invariant characteristics for each product by using a within estimation.

II. $post_t$ is a binary dummy variable. The subscript t defines the time and tells us if the observation is before or after the treatment in 2005. The coefficient β_1 tells us about the change in the logarithm of the prices or the HHI for the control group from pre-2005 to post-2005.

III. The term $(treatment_i * post_t)$ is an interaction term that captures the differential effect of being in the treatment group in the post-2005 period. $treatment_i$ is a binary dummy variable, with the value 1 if it is in the treated group and 0 if it is in the control group. The subscript i defines the article number of the pharmaceutical. The coefficient β_2 is the difference-in-differences causal effect.

Subsidiary model for analysis of prices (AIP):

In our analysis of prices, we later want to test for whether there are any time trends in prices and control for them by using this difference-in-differences model:

$$logprices_{it} = \alpha_i + \beta_1 * t + \beta_2 * (\Delta_t * treatment_i * post_t) + \varepsilon_{it}$$

Similar to the previous model, this model is also a fixed effects model, and the parameter α_i is the same. This model differs in the parameters t and Δ_t which are related to time. The parameter t starts at 0 in 2001 and increases with 1 each year after this. By using this parameter, we can find out whether the prices follow a time trend, i.e., if the prices decrease or increase over time. The parameter Δ_t is a differential time trend and allows us to capture whether the treatment effect changes over time by analyzing the coefficient β_2 for the interaction term $(\Delta_t * treatment_i * post_t)$. Δ_t shows us how many years it is since the treatment happened, where it starts at 0 in 2005, and increases with 1 point every year after this. If the β_2 coefficient for this interaction term is negative, it suggests that the prices decrease more over time, and thus that the treatment effect increases. Because of the nature of the step-price model, where the prices are decreased stepwise over a longer period of time, this is expected to happen. A value of 0 would indicate that the treatment stays constant. This model is also going to provide a coefficient for the interaction term $(treatment_i * post_t)$ in order to compare it to the previous model used.

Tertiary model for analysis of prices and HHI:

To later control for a possible violation of the parallel trends assumption, we adjust our dependent variable to incorporate the annual change in the prices and HHI.

$$\Delta y_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

The model is otherwise exactly the same as the first model. The dependent variable Δy_{it} will show the average annual change in prices or HHI. By using this model, we're estimating the annual percentage change in prices and the total change in HHI due to the introduction of the step-price model. The model is accounting for overall trends in prices and HHI, and this approach is intended to be more robust to violations of the parallel trends assumption, by focusing on changes rather than levels. Δy_{it} is calculated by this equation: $\Delta y_{it} = y_{it} - y_{it-1}$.

Subsidiary model for analysis of HHI:

$$HHI_{it} = \alpha_i + \beta_1 * laggedHHI_{it-1} + \beta_2 * posttreatment_t + \beta_3(treatment_i \times post_t) + \varepsilon_{it}$$

This model is the same as the fixed effects difference-in-differences model, except we are including a lag in the HHI.

α_i is the fixed effect for unit i. In this model, this effect is differenced out (or "removed") by focusing on changes within each unit over time, so you will not see an estimated value for this in the output of a fixed-effects model. β_1 is the coefficient of the $laggedHHI$. This shows how a one-unit change in lagged HHI (HHI from the previous period) affects HHI in the current period, holding everything else constant. β_2 is the coefficient of the $posttreatment$ variable. It represents the change in average HHI for the control group before and after the introduction of the law, without considering the treatment. β_3 is the coefficient of the interaction term between the treatment and post-treatment indicators. This coefficient is of primary interest in our difference-in-differences analysis. It

represents the average differential effect of the treatment on the treatment group compared to the control group from before to after the treatment (i.e., it represents the effect of the step-price model).

4.4.2 Difference-in-differences analysis of prices

Hypothesis for our analysis with prices:

The reason for the implementation of the step-price model was to reduce the prices for pharmaceuticals which had competition from other generic pharmaceuticals. Our hypothesis is that the prices in these pharmaceuticals have been reduced significantly. The null hypothesis is that the prices did not change significantly because of the treatment in 2005, while the alternative hypothesis is that the prices were significantly decreased because of the treatment. We therefore hypothesize that the introduction of the step-price model has led to a substantial decrease in prices for pharmaceuticals which are in competitive markets with generic drugs.

The difference-in-differences model with prices:

Our model can be represented with the following equation:

$$logprices_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

We're analyzing the logarithm of the prices of pharmaceuticals. By including all unique article numbers, an increase in the sales of less expensive pharmaceuticals versus more expensive pharmaceuticals will not be included as an effect of the treatment, and we're more likely to only see the effects of the step-price model.

In order to ensure that the drugs in the treatment group and control group were as similar and comparable as possible, we wanted to restrict which pharmaceuticals we would include in the dataset. Because of the vastly different pharmaceuticals entering and exiting the market, we restricted the data to only include the pharmaceuticals which were sold each year in the entirety of the period from 2001 to 2010, and look at the effect of only these pharmaceuticals. By doing this, we capture the most commonly sold pharmaceuticals, and we won't get skewed results

from pharmaceuticals entering or exiting the market in the period we're analyzing. The pre-treatment period starts at 2001, the year the current pharmacy law was implemented, and stops at 2004. We incorporate all prescription and non-prescription drugs listed on the "exchange list". For instance, "Aerius" is a product that is both prescription-based and non-prescription based. In this manner, the price of the over-the-counter Aerius will also be influenced by the negotiations surrounding the step-price model. On January 1st, 2005 the step-price-system was introduced, and our post-treatment period runs until 2010. Because of the nature of the step-price-system, where the prices of all products included on the exchange list, both generic and original products, are reduced in multiple steps at multiple points of time, we wanted to have a longer post-treatment period. Secondly, to pick our treatment group, we restricted the data to only include pharmaceuticals included on the exchange list at any time between 2005 and 2010. This means that the patent for the pharmaceutical could have expired at any time before it entered the exchange list, as the requirement for inclusion to the exchange list is that the pharmaceutical has competition from generic manufacturers, and thus the patent must have expired. In other words, pharmaceuticals where the patent expired several years before the step-price model was introduced can still be in our treated group, where the prices already were decreased due to bargaining power at the wholesaler. However, the step-price model still affects these pharmaceuticals, and provides a set discount the pharmacies must adhere to. Lastly, our control group were all other pharmaceuticals, and to make sure these were similar products as our treatment group, we decided to only include those which would be included to the exchange list at a later time, i.e., between 2011 and 2023. This way, the pharmaceuticals are similar to the ones in our treatment group but does not receive any treatment in the period we are analyzing. All in all, we got a sample size of 997 unique article numbers of pharmaceuticals, of which 788 is in the treatment group and 209 is in the control group.

Treated group: All pharmaceuticals that entered the exchange list, both prescription-based and non-prescription-based, and therefore were affected by the step-price model in the period from 2005 to 2010.

Control group: Other pharmaceuticals, prescription-based or not, that will enter the exchange list at a later point in time, i.e., between 2011 and 2023.

However, one must also take selection bias into consideration. With our data selection, we didn't include new pharmaceuticals introduced after 2001, and we likewise excluded pharmaceuticals that exited the market before 2010. The problem might be that some pharmaceuticals are less likely to be included to our analysis, and thus the sample is not random. If the drugs we excluded from our analysis have substantially different pricing strategies than the ones we included, the possibility of us overestimating the effect of the step-price model must be taken into consideration. However, our argument is that this ensures that the data is consistent over time. Also, our argument is that capturing established products and not capturing new products with a high starting price removes both noise and unnecessary market fluctuations that might affect our possibility to see the true effects of the step-price model.

After running the product fixed effects difference-in-differences analysis with cluster-robust standard errors, we obtained the following results:

	Estimate	**Std. Error**	**t-value**	**P-value**
Post_Treatment (β_1)	-0.019711	0.013418	-1.469	0.1419
Treatment:Post_Treatment (β_2)	-0.242090	0.018406	-13.153	$< 2e-16^{***}$

*Table 1: n = 997, T = 10, NT = 9970. β_1 = Difference in prices for control group before and after 2005. β_2 = Difference-in-differences estimate. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.*

Model Statistics	
R-squared	0.21436
Adjusted R-squared	0.12696
F-statistic	1223.83
F-test p-value	$< 2.22e-16^{***}$

Table 2 : Model statistics for product fixed effects difference-in-differences model.

Because of the use of a fixed effects model, there is no distinct intercept α calculated by the model. The coefficient for the post treatment variable, β_1, indicates that the log prices in the control group decreased with 0.01971 log points after the treatment. Since the prices are at a logarithmic form, this can be approximated to a 1.97% decrease in prices. However, this result is not statistically significant with a p-value of 0.1419 and it indicates that the prices for the control group did not significantly change from pre- to post-treatment.

Our results show that the logarithmic prices in our treated group had a decrease of -0.24209 compared to the control group, as shown by the difference-in-differences estimate with the coefficient β_2. Since the prices are at a logarithmic form, the coefficient approximately gives the decrease in prices in percentage form, and the prices of our treatment group decreased approximately 24.2% compared to the control group. This is a strongly statistically significant decrease, with a p-value of less than 2e-16. This indicates that the step-price model significantly lowered the prices of the treatment group.

Our results yielded a reasonable multiple R-squared value of 21.436% and an adjusted R-squared value of 12.696%, meaning that our model explains 21.436% of the variation in the logarithm of prices. A higher R-squared value could be achieved with more predictors in the model, or by using less spread-out data. Lastly, the F-statistic for this model is quite large, with a value of 1223.83. The F-statistic is statistically significant, with a p-value of less than 2.22e-16. This indicates that our model as a whole is statistically significant, and that the variables we included in our model relate with the dependent variable. By analyzing our results, we can reject our null hypothesis of the prices not significantly changing, and the alternative hypothesis that the prices was significantly reduced seems to hold.

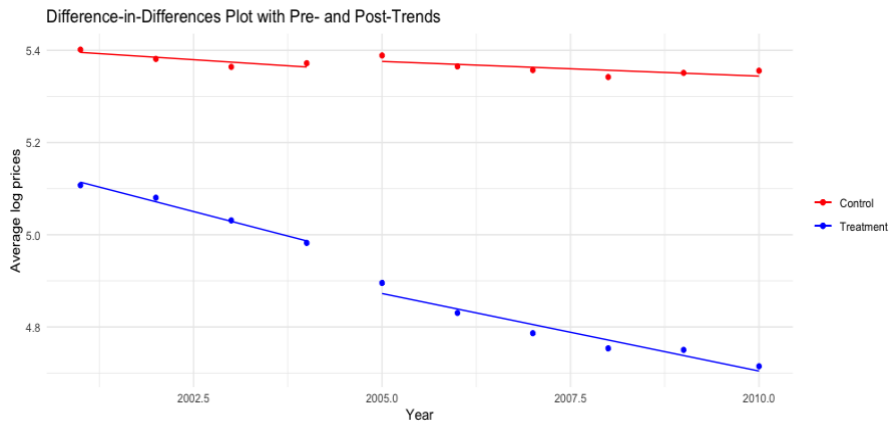

Figure 5: Linear Trends of logarithm of prices 2001-2010

By visually assessing the Difference-in-Differences graph (Figure 5: Linear Trends of logarithm of prices 2001-2010), one can see that the logged prices for the treatment group went considerably down compared to the control group, which stayed relatively flat.

Our subsidiary model can be represented with this equation:

$$logprices_{it} = \alpha_i + \beta_1 * t + \beta_2 * (\Delta_t * treatment_i * post_t) + \varepsilon_{it}$$

The dataset used is exactly the same as discussed for the first model. As discussed earlier, the model controls for any possible time trends present, both in total since 2001 by using the predictor t, and changes in the treatment effect that may come later than 2005 by using the predictor Δ_t in the last interaction term. The model is moreover going to output a third coefficient β_3 for the interaction term $(treatment_i * post_t)$.

When time trends are applied to the model, the results are as follows:

	Estimate	**Std. Error**	**t-value**	**P-value**
t (β_1)	-0.0118560	0.0020489	-5.7867	$7.421e-09^{***}$
Post:Treatment:Δt (β_2)	-0.0217794	0.0035345	-6.1620	$7.492e-10^{***}$
Post:Treatment (β_3)	-0.1480729	0.0112139	-13.2044	$<2e-16^{***}$

Table 3: n = 997, T = 10, NT = 9970. With cluster-robust standard errors.

Model Statistics	
R-squared	0.24471
Adjusted R-squared	0.16059
F-statistic	968.753
F-test p-value	$<2.22e-16^{***}$

Table 4: Model statistics for model with time trends.

The coefficient for the t variable β_1 indicates that there is a time trend present, and that the prices on average decrease by approximately 1.2% each year, holding all other variables constant. This result is statistically significant, with a p-value of 7.421e-09.

The coefficient for the interaction term $(\Delta_t * treatment_i * post_t)$ β_2 captures the gradual change in the treatment effect over time. The value for the coefficient β_2 is -0.0218, indicating that that the prices decrease by approximately 2.18% each additional year after the treatment starts. In other words, the treatment effect becomes increasingly negative each year after it's implemented. This result is

statistically significant, with a p-value of 7.492e-10. The decrease in prices is thus happening gradually over time, and this can be because of the nature of the step-price model, which has its last cut in prices 18 months after the pharmaceutical is included on the exchange list. The effect is hence expected to increase in time.

The coefficient β_3 for the last interaction term, $(treatment_i * post_t)$, is the same interaction term used in our first model. In this model, β_3 gives the estimated average treatment effect in the period after the treatment is introduced. In other words, the coefficient is averaged across all post-treatment periods. The value of β_3 in this case is -0.148, indicating that the treatment decreased the prices of treated pharmaceuticals by 14.8% compared to the control group. This result is also statistically significant, with a p-value of less than 2e-16.

The R-squared for our subsidiary model is 24.47% and our adjusted R-squared is 16.06%. The model as a whole is also statistically significant, with a F-statistic of 968.753 and a p-value of less than 2.22e-16. In our subsidiary model, we can still reject the null hypothesis of there being no significant change in prices after the treatment, and the step-price model seems to have its desired effect. Interestingly, in our model, the effect of the step-price model seems to increase over time, indicated by the prices decreasing more for each year that passes.

Our tertiary model can be represented with this equation:

$$\Delta logprices_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

The dataset used is still exactly the same as discussed for the first and second model. The reason for including this model is the possible violation in the parallel trends assumption, as seen in Figure 6: Trends of logarithm of prices pre-2005. To account for the time trends in the level of prices and to increase robustness, we do a tertiary analysis on the annual change of the logarithm of prices. By doing this, we are effectively differencing away any specific trend factors that could be influencing the price level. By adopting this third model, we are providing a robustness check for our previous findings. If the estimated treatment effects from this model is consistent with those from the previous models, it strengthens our confidence in the validity of our results.

When analyzing the change in the logarithm of the prices, the results are as follows:

	Estimate	Std. Error	t-value	P-value
Post (β_1)	0.0046696	0.0039816	1.1728	0.2409
Post:Treatment (β_2)	-0.0179772	0.0052732	-3.4092	$6.545e-04^{***}$

Table 5: Results of analyzing the change in the logarithm of prices ($\Delta logprices_{it}$). With cluster-robust standard errors.

The post variable with the coefficient β_1 indicates that the prices for the control group had an average annual change of approximately 0.47% after 2005. This result is not statistically significant, with a p-value of 0.2409.

The post:treatment variable with the coefficient β_2 however, indicates that the average annual change in the prices of the pharmaceuticals included on the exchange list was approximately -1.80% after the treatment, compared to the control group. In other words, the pharmaceuticals affected by the step-price model had decreased 1.8% more than the pharmaceuticals not affected by the step-price model. This is not a relatively large number, but the result is statistically significant with a p-value of 6.545e-0.4. These results, which correct for possible linear trend assumption violations, can suggest that the effects of the step-price model are smaller than in our previous results, but the effects are still significant.

This model yields a small R-squared value of less than 1%, indicating that the model's overall explanatory power is weak. The F-statistic is however statistically significant, with a F-statistic of 7.75 and a p-value of 0.0004. Because of this, the results indicate that there exists an association between the treatment and the reduction of prices, but there is a lot of variation in $\Delta logprices_{it}$ not captured by the model. Nevertheless, the results this model outputs are consistent with the results of both the first and second model analyzing prices and provide possible support to the robustness of our results.

Robustness tests:

Parallell Trends assumption:

The parallel trends assumption states that in absence of the treatment, the control group and treatment group would follow the same trend. In order to obtain non-biased results, the pharmaceuticals in the treatment group have to be as similar as possible to the ones in the control group. Before the treatment, they need to follow similar and parallel trends. This way, we can ensure that the post-treatment results are results of the policy change, and not because of other factors.

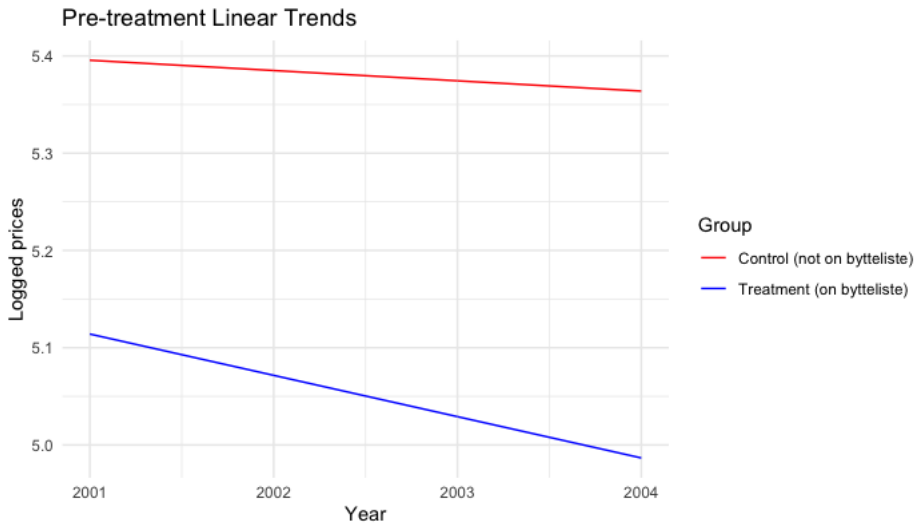

Figure 6: Trends of logarithm of prices pre-2005

As we can see on the figure, the logarithm of the prices for the treatment group was already lower than those in the control group. However, the trends they follow seem to be somehow non-parallel by visual assessment. As previously discussed, we incorporated a third model into our analysis in order to gain additional robustness to the possible violation of the parallel trends assumption.

Heteroscedasticity:

We conducted a Breusch-Pagan test for heteroscedasticity, where the null hypothesis is that the error variances are all equal (homoskedasticity), and the alternative hypothesis is that the error variances are not equal (heteroskedasticity).

The results showed a test statistic of 2.507 and a p-value of 0.474 for the first model. For the subsidiary model, the results showed a test statistic of 4.5515 and a p-value of 0.2077. This means that there is no statistical evidence for heteroskedasticity at the usual significance level of 5% in either of the analyses, and the null hypothesis of homoskedasticity holds.

Autocorrelation:

After conducting a Breusch-Godfrey/Wooldridge test for autocorrelation, also called serial correlation, in panel models, we found that we had autocorrelation in our results. The Breusch-Godfrey test is used to detect the presence of autocorrelation, in other words that the error term in one period depends on the error term in previous periods. The Breusch-Godfrey test showed a chi-squared of 4465 and a p-value of less than 2.2e-16 in the first model. In the subsidiary model, the Breusch-Godfrey test showed a chi-squared of 4657.6 and a p-value of less than 2.2e-16. With the null hypothesis being that that there is no serial correlation in the idiosyncratic errors of the panel regression model, we reject the null hypothesis and there are signs of autocorrelation in our model. Conversely, after visually inspecting the partial autocorrelation function plot (PACF, Figure 1 in appendix), there is a significant lag of the autocorrelation at multiple times. Therefore, there seems to be no evidence that the autocorrelation strictly follows an AR(1) process.

However, by using cluster-robust standard errors, we allow for serial correlation within each cluster of unknown form (Wooldridge, 2020). As previously discussed, we clustered the standard errors for each article number, as the price of a pharmaceutical $logprices_t$ very likely is correlated with the price of the same pharmaceutical at a later time, i.e., $logprices_{t+1}$. By using cluster-robust standard errors, the test results become more reliable, as the standard errors are robust to autocorrelation in any form by being adjusted to the presence of autocorrelation and heteroscedasticity (Wooldridge, 2020). We therefore achieve more accurate confidence intervals.

4.4.3 Differences-in-differences analysis of HHI

Hypothesis for HHI analysis:

Our primary aim is to examine whether the introduction of the step-price model had a clear impact on the competition between pharmacy chains, specifically by focusing on the market concentration measured by the Herfindahl-Hirschman Index (HHI). The step-price model's impact on HHI can be complex and can depend on a variety of factors. Multiple effects can potentially impact the HHI.

One of the reasons generic substitution of drugs was implemented into the current pharmacy law was to increase competition between pharmacies and pharmaceutical manufacturers, and therefore lower the prices of both pharmaceuticals and pharmacy services (NOU 2023:2, 2023). An increase in competition could affect the HHI positively. If this is the case, we would see a decrease in the HHI.

However, the lower prices associated with the step-price model can potentially discourage market entry. New entrants could find the pharmacy market less attractive because they find it more difficult to achieve profitability. This can limit the number of firms in the market, and thus the HHI would be increased. Contrarily, the implementation of the step-price model could make the prices more transparent, which could make it more difficult for the pharmacies to engage in predatory pricing and undercut newly established or less efficient pharmacies. (Bellefamme & Peitz, 2015). Undercutting other pharmacies is the practice of temporarily lowering the prices in order to drive competitors out of the market. More transparent prices may make this more difficult to do, and thus the HHI could potentially be decreased. Differently sized and differently efficient pharmacies might respond differently to the policy change. More efficient pharmacies could also be able to adapt to the pricing regulation more effectively. This may be because of better resource allocation of staff, better management, or as simple as lower unit costs (Bellefamme & Peitz, 2015). If one pharmacy has lower unit costs than others, a decrease in prices will be a smaller decrease percentage wise compared to less efficient pharmacies, and more of the profits will be retained. To illustrate this, consider pharmacy A and B. Pharmacy A has a unit cost of 20 NOK, and pharmacy B has a unit cost of 50 NOK. If the price of a pharmaceutical dropped from 70 to 60 NOK, pharmacy B will only be left with 50% of their original profits, while

pharmacy A will be left with 80% of their original profits. These advantages may make some pharmacies able to handle lower profit on pharmaceuticals better than other pharmacies. If this is one of the biggest firms, we would then see an increase in their market share as the distribution of market shares is more unequal. If it is the smaller competitors that have these advantages, this will distribute the market shares more equally and we will see a decrease in the HHI. However, as previously noted, there seems to be significant benefits of economies of scale in the Norwegian pharmacy market, and thus the larger players would be the ones benefitting from this (NOU 2023:2, 2023).

It is nonetheless important to note that pharmacies in Norway often compete on location and quality, and not on prices (NOU 2023:2, 2023). The market shares could therefore be determined by other factors than the price. As prices become more regulated and transparent, customers could become more price-sensitive and shift to using pharmacies that offer additional services beyond just selling pharmaceuticals. Pharmacies that can't compete on these additional services may lose market share, and thus the HHI will increase. Since we're calculating the HHI on product level, a doctor's preference of writing prescriptions for one specific pharmaceutical can also greatly impact the HHI for that specific product. This could however be captured by the fixed effects intercept α_i. The effects discussed can counteract each other to some extent, as some effects may increase the HHI, and some effects may decrease the HHI. We're interested in finding the total effect of the step-price model on HHI.

The difference-in-differences model with HHI:

Our study groups consist of two distinct sets of pharmaceuticals. The treatment group is the same as in the analysis of prices. The control group encompasses all pharmaceuticals that were not included on the exchange list from 2005 to 2010. As the prices are more sensitive to a large sample of different products, increasing our sample size is beneficial in order to get a better measure of the HHI. This ensures a likeness between our control and treatment groups, negating any potential spillover effects of treatment. Consequently, our study features a total sample size of 2102

unique article numbers, of which 706 belong to the treatment group and 1396 to the control group.

Treated group: All pharmaceuticals that entered the exchange list, both prescription based and non-prescription based, and therefore were affected by the step-price model, in the period from 2005 to 2010.

Control group: All other pharmaceuticals, prescription based or not.

We use the same within-subjects regression model as with our analysis with prices:

$$HHI_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

After running the product fixed effects difference-in-differences analysis with cluster-robust standard errors, we got the following results:

	Estimate	Std. Error	t-value	P-value
Post_Treatment (β_1)	166.6066	23.1978	7.1820	$7.125 \times 10^{-13***}$
Treatment:Post_Treatment (β_2)	1.6907	42.6846	0.0396	0.9684

*Table 6 : n = 2102, T = 10, NT = 21020 . β_1 = Average effect of on the HHI on control group after treatment. β_2 = Differential effect on HHI due to the policy change for the treated group compared to the control group. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.*

Model Statistics	
R-squared	0.011597
Adjusted R-squared	-0.09829
F-statistic	110.97
F-test p-value	$< 2.22e-16^{***}$

Table 7 : Model statistics for product fixed effects difference-in-differences model.

The β_1 coefficient for the post treatment variable shows that the HHI increased by 166.6 for the control group post-2005. This is statistically significant at a 1% level, meaning we can be confident this effect is not due to chance. This implies that the policy change in 2005 was associated with an increase in the HHI of 166.6 units on average across all subjects in the control group.

The Treatment:Post_Treatment coefficient β_2 value of 1.69 represents the differential effect on HHI due to the policy change for the treated group compared

to the control group. This coefficient is not statistically significant, and we cannot confidently say that there was a differential effect of the policy change on the treatment group compared to the control group. Nonetheless, this result is neither economically significant. This implies that the policy change in 2005 did not have a statistically significant effect on competition among the treated group compared to the control group.

Our model has a low R-squared value of 1.16% which indicates that the model explains a very small portion of the variance in the dependent variable (HHI).

Given that we calculate the HHI for every single article and observe a large spread, the high variance in the data might be one of the reasons for a low R-squared. Essentially, the outcome variable HHI is subject to a lot of unexplained variability. High variance in the dependent variable makes it difficult for a model to precisely predict each observation, thus reducing the proportion of variability that the model can explain.

Including additional control variables in the model has the potential to enhance the capacity to explain the variation observed in the dependent variable (HHI), which represents the competition. The statement here is that there may be other crucial factors, external to the current model, that influence the degree of competition within the market. If these factors are statistically significant and not currently accounted for in the model, their addition could reduce the unexplained variance, and thus, potentially increase the R-squared value.

Despite the low R-squared, the model's F-statistic is highly significant with a p-value of less than 2.22e-16 This suggests that, despite explaining a small proportion of the variance, the variables in the model are statistically significant as a group. The extremely low p-value signals that the likelihood of observing such results if the null hypothesis were true (i.e., all coefficients equal to zero) is exceedingly low. Therefore, while the model's predictive capability might be limited, the statistical significance of the model's variables is strong.

It's important to view our results in context. The data we have are limited, not encompassing every single product. Moreover, the Herfindahl-Hirschman Index

serves as an indicator of market concentration, identifying whether it is high or low. However, adjustments in the HHI could be influenced by a multitude of other factors. For future research, incorporating additional variables could enhance the robustness and explanatory power of the model.

Within panel data with Lagged dependent Variable Model of HHI:

The initial model assumes that HHI depends solely on the treatment and post_treatment variables, along with their interaction. This is a rather limited assumption, especially for time series data where it is very common for there to be some form of time series dynamics, meaning that the current value of a variable is influenced by its past values.

Our analysis focuses on the quantities purchased by pharmacies, not their sales. It is plausible that pharmacies might stock up heavily towards the end of the year, with the intention of distributing these purchases throughout the following year. As a result, their buying patterns in the subsequent year might be lower. While such strategic bulk buying can significantly affect the volumes purchased, it doesn't necessarily influence the prices. Therefore, to accommodate this behavior in our data, we've adjusted our model. Specifically, we've incorporated lagged data to better capture the potential effects of these year-end bulk purchases on subsequent buying patterns.

$$HHI_{it} = \alpha_i + \beta_1 * laggedHHI_{it-1} + \beta_2 * posttreatment_t + \beta_3(treatment_i * post_t) + \varepsilon_{it}$$

This new model, incorporating the lagged dependent variable, i.e., $laggedHHI$ improves results because it considers the dependence of today's total HHI on previous values. Our model is capable of capturing autocorrelation and time series dynamics in the data, which the initial model fails to do.

Results:

	Estimate	Std. Error	t-value	P-value
lag_mean_hhi (β_1)	0.480547	0.018314	26.2400	$< 2.2e-16^{***}$
post_treatment (β_2)	69.407085	14.290987	4.8567	$1.204e-06^{***}$
treatment:post_treatment (β_3)	-57.773837	38.634813	-1.4954	0.1348

Table 8: n = 2102, T = 9, NT = 18918. $\beta_1 =$ *laggedHHI,* β_2 *= Average effect of on the HHI on control group after treatment.* β_3 *= Differential effect on HHI due to the policy change for the treated group compared to the control group. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.*

Model Statistics	
R-squared	0.21543
Adjusted R-squared	0.11724
F-statistic	1538.82
F-test p-value	$< 2.22e-16^{***}$

Table 9: Model statistics for product fixed effects difference-in-differences mode with laggedHHIl.

The β_1 coefficient for the $laggedHHI$ variable shows that, for each one-unit increase in the HHI from the previous year, there is an increase of 0.48 in the current year's HHI, holding all else constant. This result is highly statistically significant (with a p-value below 2.2e-16, which is less than 0.01), so we can be confident that this effect is not due to random chance.

The β_2 coefficient for the post treatment variable shows that, after the introduction of the law (post-2005), there was an increase of 69.41 in the HHI on average for the control group. This effect is also statistically significant (p-value of 1.204e-06, which is less than 0.01), meaning that we can be confident this increase is not due to random chance.

The β_3 coefficient for the interaction term ($treatment \times post\ treatment$) is -57.77. This represents the average differential effect of the treatment on the treatment group compared to the control group from before to after the introduction of the law. However, this effect is not statistically significant at the conventional level (with a p-value of 0.1348, which is greater than 0.05), so we can't confidently say there was a differential effect of the step-price model on the treated group compared to the control group.

The R-squared value of the model is 0.22286, suggesting that about 22.3% of the variation in HHI can be explained by our model. The Adjusted R-squared is lower at 0.12539, reflecting the fact that each additional variable added to a model consumes degrees of freedom, and thus adjusts for the number of variables included in the model.

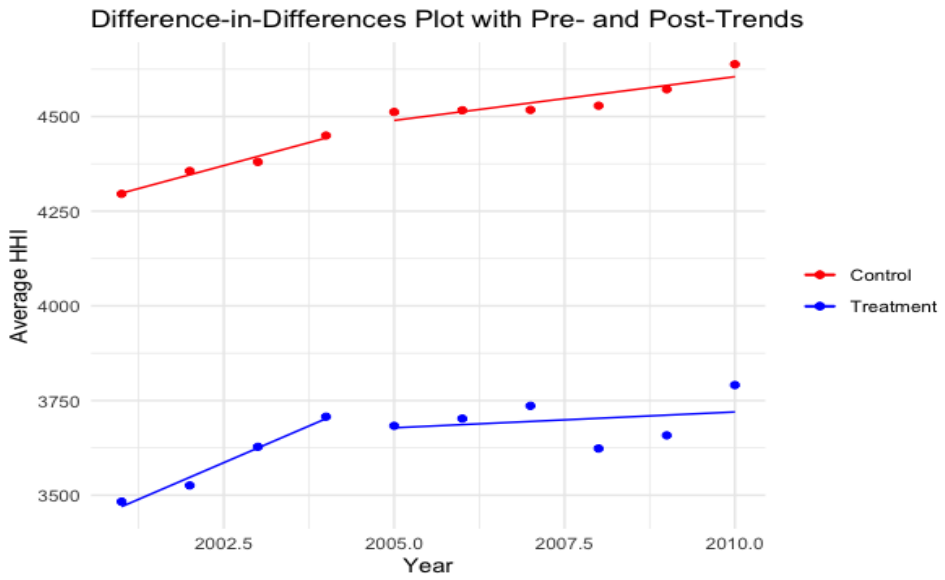

Figure 7 : Linear trends for HHI, before and after treatment period

By visually assessing the post-treatment trends, it appears that the control group is experiencing an upward trend, while the treatment group remains relatively stable.

Within panel data with change in HHI:

$$\Delta HHI_{it} = \alpha_i + \beta_1 * post_t + \beta_2 * (treatment_i * post_t) + \varepsilon_{it}$$

To account for a possible violation of the parallel trends assumption, we wanted to incorporate a model where we analyze the change in HHI as a robustness check. If the estimated treatment effects from this model is consistent with those from the previous models, it strengthens our confidence in the validity of our results.

The results with this model are as follows:

	Estimate	Std. Error	t-value	P-value
Post:Treatment (β_1)	-7.1301	9.3027	-0.7665	0.4434
Treatment:Post Treatment (β_2)	-35.0086	28.4138	-1.2321	0.2179

Table 10: Results with annual change in HHI. With cluster-robust standard errors.

In these results, we don't see any significantly different results from our other analyses. The R-squared is also very low, with a value of less than 1%. As indicated by the Treatment:Posttreatment variable with the coefficient β_2, the HHI for the treated products decreased about 35 points post-treatment compared to the control group. This is not a statistically significant result with a p-value of 0.2179. However, it's beneficial to see these results in the light of the previous models, which shows consistent results on all three models. We can therefore be more confident that the results presented are accurate.

Robustness tests:

Parallel trends assumption:

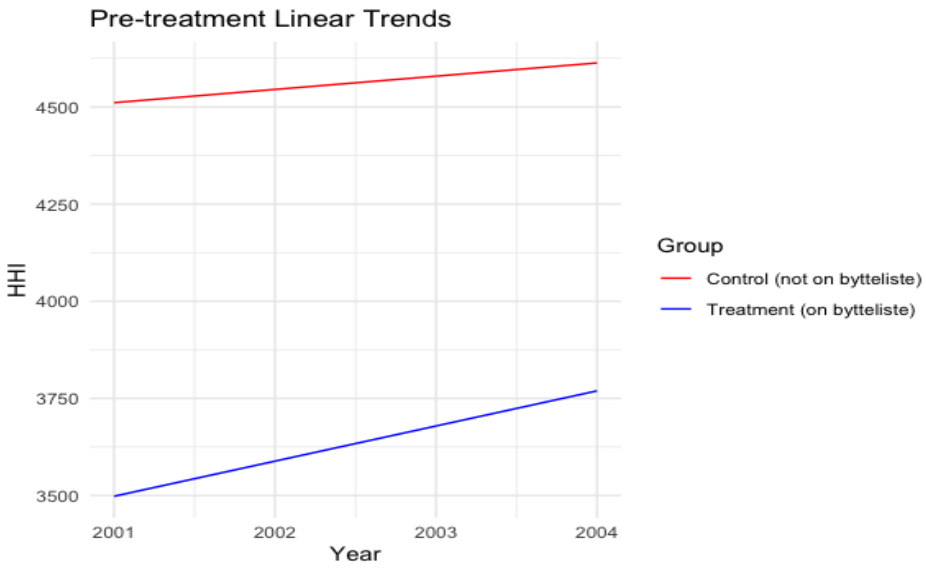

Figure 8: Post treatment linear trends

By visually assessing the trends before the treatment in 2005, they seem to follow somehow similar trends. Here we see that the treatment group, the products on the exchange list, have a lower HHI than the control group. As long as the different groups have a parallel trend, the gap should not have an impact on the results.

Heteroscedasticity:

After performing the Breusch-Pagan test, we obtained a significant P-value, rejecting our null hypothesis, implying the presence of heteroskedasticity within both of our models analyzing HHI (Wooldridge, 2020). This occurrence may lead to inefficiencies in estimates and may bias the standard errors, potentially resulting in misinterpretations about the statistical significance of the predictors (Wooldridge, 2020). However, by using cluster-robust standard errors, we obtain more accurate standard errors, leading to more precise hypothesis tests and confidence intervals, even in the presence of heteroskedasticity. Computed in a manner that makes them resistant to violations of homoscedasticity, robust standard errors serve as an effective adjustment for heteroskedasticity. This is important because it increases the trustworthiness of our test results and helps us create more accurate confidence intervals (which are range estimates within which we expect the true values to fall). Although this method doesn't fix the inconsistency in variances in our data, it does a good job of reducing its effects on our standard errors, and that makes our analysis more reliable (Wooldridge, 2020).

Autocorrelation

The Breusch-Godfrey/Wooldridge test conducted on our panel model points to the presence of serial correlation within the idiosyncratic errors, as evidenced by a chi-squared value of 4465 and an extremely small p-value (< 2.2e-16) in the first model. In the model with lag, we obtained a chi-squared of 1370 and a p-value of less than 2.2e-16. This implies that the error terms across different time periods are not independent of each other, an indication of autocorrelation. Reviewing the partial autocorrelation function plot (PACF, see Figure 2 in Appendix), reveals significant lag in the autocorrelation at various points. This indicates that the nature of autocorrelation in our model may not be captured fully by a simple AR process.

However, by adopting cluster-robust standard errors, we can mitigate the impact of serial correlation. We have clustered the standard errors at the article number level, reflecting the high likelihood of correlation between the HHI of the same pharmaceutical at different time points. This approach equips our model with

resilience to both autocorrelation and heteroscedasticity (Wooldridge, 2020), providing us with more reliable statistical inferences and robust confidence intervals.

5 Development of market shares in recent years

5.1 Introduction

In this part, we want to look closely at how competition works in the Norwegian pharmacy market. We're not focusing on measurements like the Herfindahl-Hirschman Index (HHI). Instead, we're interested in how the market has changed over the last 20 years. We're especially curious about how hard it is for new pharmacies to enter the market, particularly when there are already many chain-affiliated pharmacies established in an area. Even though competition isn't mainly about price, but about things like location and service, these difficulties in entering the market could still influence competition. There are also signs of over-establishment of pharmacies in the larger cities, and that the large vertically integrated players are able to operate at a loss in the pharmacy sector. In that way, they are able to outcompete other pharmacies, especially the independent pharmacies, in the same geographical area (NOU 2023:2, 2023). According to our results, competition measured by HHI was not influenced by the step-price model, and thus we want to better understand the market dynamics of the Norwegian pharmacy market. To better help us understand how this market works, we want to look at how the establishments of pharmacies has developed for the last 20 years.

5.2 Market structure

An oligopoly, characterized by a few dominating firms, might possess the potential to distort competition through their influence over pricing and market accessibility. The impacts of such a market structure might be more acute if these influential entities are vertically integrated, applying control over the whole supply chain, including import, distribution, and retail. Although such vertical integration can at times ease issues like double marginalization, leading to potential price reductions

for consumers, it can concurrently create substantial entry barriers for other firms, thereby posing difficult challenges to market competition (Belleflamme & Peitz, 2019).

A vertically integrated firm's profitability is not influenced by wholesale pricing. Since the firm controls both the wholesale and retail sectors, it can independently change the prices for its products, irrespective of the wholesale price. This control eliminates the impact of the wholesale price on the firm's profit maximization strategy, as it can adjust retail prices to balance any shifts in the wholesale price (Belleflamme & Peitz, 2019). This could be beneficial to consumers if the savings from avoiding double marginalization are passed on to them. Conversely, a non-integrated firm, which depends on a wholesaler for its supply chain, is significantly impacted by the wholesale price. As it does not control the wholesaler, it cannot set the prices for the products it sells. Instead, it must procure products at the wholesale price and sell them with a markup. Here, the wholesale price directly influences the firm's profit maximization strategy, limiting its ability to enhance profit margins by elevating its retail prices (Belleflamme & Peitz, 2019). This scenario illustrates the effect of double marginalization, where the markup at the wholesale stage can lead to higher prices for non-integrated retailers.

5.3 Pharmacy Openings and Closures

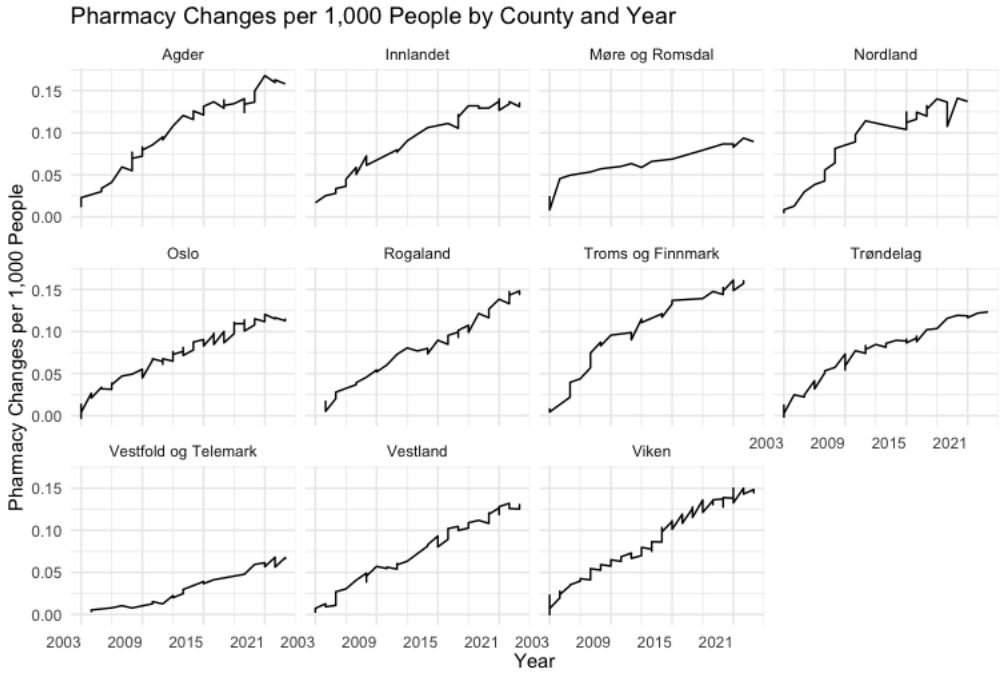

Figure 9: Cumulative change of new pharmacies and closures of pharmacies per county per capita. Data from Farmalogg.

The plot represents the cumulative change in the number of pharmacies per 1,000 residents, adjusted for population growth, across various counties in Norway from 2003 to 2023. The vertical axis indicates the extent of this change, while the horizontal axis charts the progression of years. It is important to note that there are more pharmacies per capita than our graphs show, as our graphs start at zero and only include new pharmacies opening minus pharmacies closing. The reason our graphs start at zero is that our data only contains pharmacy openings and closures since 2003, and not the number of pharmacies before it. In other words, the graph only includes the changes since 2003. For example, Rogaland has gained approximately 0.15 pharmacies per 1,000 residents since 2003, or in other words, Rogaland has had an increase of about 15 pharmacies per 100,000 residents in the last 20 years.

These trends provide a valuable perspective on the evolution of the pharmacy market in Norway over the span of two decades. They emphasize the potential influence of various factors, such as demographics, economics, and policy, that shape the growth and distribution of pharmacies across different regions. It's

particularly noteworthy how the highly subsidized nature of medicine prices in Norway might drive pharmacies to compete based on location and accessibility rather than price, which could contribute to these observed trends. Further investigation, however, would be needed to understand these complexities and their specific impacts on the market.

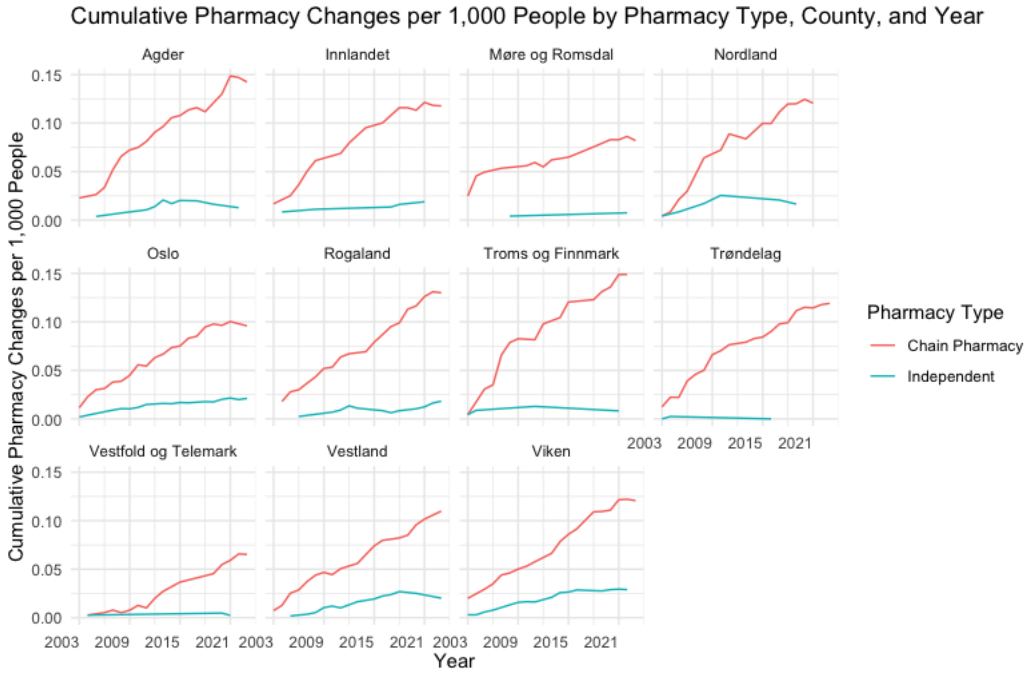

Figure 10: Cumulative changes in the number of pharmacies per 1,000 residents in each county in Norway. It differentiates between independent pharmacies and chain pharmacies, highlighting their respective growth trends over time. Data from Farmalogg.

This figure shows us the cumulative growth (opening and closures) of pharmacies from 2003 to 2023 per county per 1000 people, similar to Figure 9: Cumulative change of new pharmacies and closures of pharmacies per county per capita. Data from Farmalogg.. The red line represents pharmacies that are affiliated with chains, and the blue line represents independent pharmacies not affiliated with chains. In all counties, chain pharmacies have shown a considerably larger growth than independent pharmacies. However, in some counties the number of independent pharmacies has shown some growth too. The plot gives an indication that chain pharmacies have gained substantially more market shares than independent pharmacies in this time frame. It is important to note that the graphs don't show how many pharmacies each county had before 2003, and we don't see the composition of independent versus chain pharmacies from before this date. Thus, the difference in number of pharmacies per pharmacy type in total might be different. The reason for this disproportion might be because of the increased power

the chains get when being vertically integrated with their respective wholesalers. While the chain pharmacies buy their pharmaceuticals from their own wholesalers, the independent pharmacies have to buy pharmaceuticals from competing pharmacy chains, in addition to the over-establishment of chain pharmacies in larger cities. This may act as a barrier to entry for the independent pharmacies, and therefore it's easier for chain pharmacies to grow than the independent pharmacies. These analyses of the Norwegian pharmacy market appear to reflect certain aspects of the Hotelling model of spatial competition (in appendix), which assumes that businesses strive to minimize the distance customers must travel, thus influencing their choice of location. This model suggests that companies tend to cluster around the same area to tap into a larger customer base, leading to a high concentration of pharmacies in one area.

When we look at Norway's pharmaceutical sector, prescription drug prices are effectively kept in check due to a regulated pricing mechanism, creating a consistent pricing landscape. In this environment, competing is less about price wars and more about other factors such as ease of access, customer service, or physical closeness.

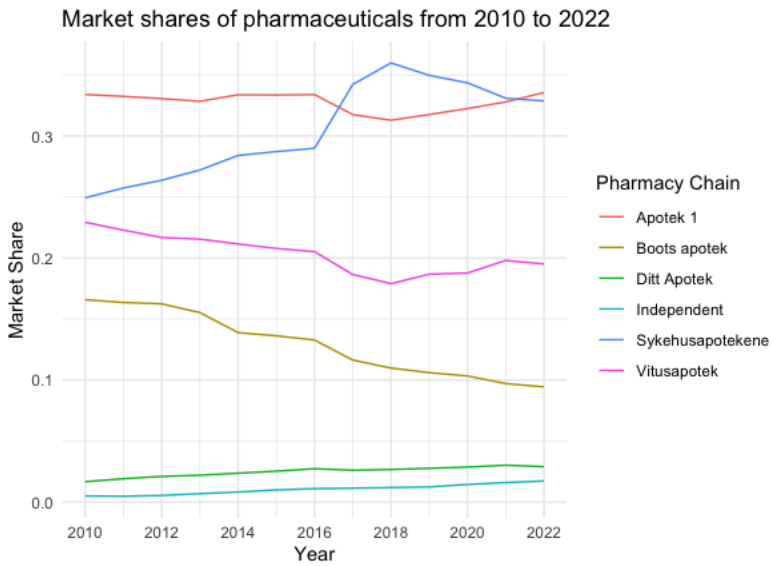

Figure 11: Market shares of pharmaceuticals from 2010 to 2022.

Upon examining an overview of market shares in the pharmaceutical sector, we observe that Boots Pharmacy seems to be on a downward trajectory, declining from a market share of 16.5% in 2010 to 9.5% by 2022. Meanwhile, Vitus Apotek experienced a reduction in its market share from 23% to 19% during the same period but has shown growth over the last five years. Apotek 1 has maintained a

stable market share of approximately 32%. This data is consistent with the findings outlined in the Norges offentlige utredninger (NOU), which suggests that Apotek 1 and Vitus Apotek are competing in a manner that seemingly diminishes Boots Pharmacy's market share (NOU 2023:2, 2023). It seems that as Apotek 1 and Vitus Apotek strengthen their positions in the market, Boots Pharmacy is gradually losing its footing. Therefore, the Hotelling model's concept of competition based on location (in appendix) can serve as a precise tool in understanding the strategies used by pharmacy chains in Norway.

The observed decline in Boots Pharmacy's market share from 16.5% in 2010 to 9.5% in 2022 demands further inspection. This diminishing market share could have significant implications for the competitiveness of the Norwegian pharmaceutical market. If this trend continues, it may lead to a duopolistic structure with dominant players like Apotek 1 and Vitus Apotek controlling the majority of the market. Presumably, the two largest pharmacies do not want more regulation on competition, and therefore the trend of Boots becoming smaller may stop before the Norwegian competition authority makes any regulatory adjustments to hinder the decline in competition.

It's crucial to conduct further in-depth research to untangle these complexities. A clearer understanding of these dynamics could inform policy recommendations, ensuring a robust and competitive pharmaceutical market that serves the best interests of Norwegian residents. This is particularly important in the context of Norway, where pharmacies are not just commercial entities but also play a crucial role in public health by ensuring access to essential medications.

6 Discussion

Our analysis revealed a significant decrease in the prices of pharmaceuticals included on the exchange list in Norway between 2005 and 2010. This indicates that the step-price model effectively reduced the prices of these medicines. Our results yielded a decrease of the prices of 24%, 14.8% with a yearly decrease of 2.2%, and a change in the first difference of 1.8% compared to the products not affected by the step-price model. These findings align with our initial hypothesis and expectations, as the step-price model was implemented to reduce the prices of pharmaceuticals facing competition from generic alternatives. Our results suggest that the step-price model has been successful in achieving its goal. Our findings contribute to the existing body of knowledge by providing empirical evidence of the step-price model's impact on pharmaceutical prices. While there has been limited research on the quantitative effect of the step-price model, previous research has suggested that the prices have been reduced after its implementation, for example Apotekforeningen's 2021 report and Brekke et. al., 2010. Our study provides a quantitative measure of this effect by comparing the prices with pharmaceuticals not affected by this policy change. In conclusion, the step-price model has had a positive impact on the pharmaceutical prices in Norway.

The analysis of the 2005 policy change's impact on the Herfindahl-Hirschman Index (HHI) shows mixed results. Our models indicate that the HHI stays relatively constant compared to the control group, where two of the analyses show a decrease in HHI after the implementation of the step-price model. However, these results are not significant, indicating that the HHI for the treatment group didn't significantly change compared to the control group following the policy change. While one reason for the implementation of generic substitution in pharmacies was to increase competition between pharmacies, the implementation of the step-price model does not seem to have any effect on the competition measured by HHI. While the implementation of the step-price model primarily aimed to impact the prices, our suggestion that it also could have an effect on the competition and market concentration does not hold in our analyses.

Our study is not without limitations. Our data only comprises the pharmacies' purchase prices and volumes, and not their retail prices. Furthermore, more

variables in the data could help us make a more complex model with control variables, and possibly allow us to get more robust results. The presence of autocorrelation and heteroscedasticity in our results could potentially bias our estimates. Additionally, some of our models' relatively low explanatory power, measured by the R-squared, suggests that there are other factors influencing HHI and pharmaceutical prices that our models don't account for.

Future research could aim to address these limitations and further refine our understanding of the factors influencing pharmaceutical prices. For example, adding more variables to the analysis could increase the explanatory power of the models. Furthermore, it could be beneficial to reproduce the studies in other contexts to assess the generalizability of our findings, and to look at the long-term effects of the model. Further research could also compare the step-price model to systems in other countries.

By analyzing the cumulative change in the number of pharmacies per 1,000 residents in Norwegian counties from 2003 to 2023, we noticed a disproportionally larger growth of chain pharmacies than independent pharmacies. This can be attributed to that the chain pharmacies are over-establishing in larger cities, and that they are able to compete at a loss in the pharmacy sector while still profiting in total. Given that there are no rules for where and how many pharmacies can be established, and this may act as a significant barrier to entry for independent pharmacies. Further research in this field could analyze this trend in greater detail, evaluating its implications for market competition, consumer access to pharmacy services, drug prices, and the overall sustainability of independent pharmacies in Norway.

7 Conclusion

In conclusion, this study has provided an analysis of the Norwegian pharmacy market, its historical development, current situation, and the impact of regulatory environment and legislation, particularly the step-price model. The research method used, the fixed effects difference-in-differences method, allowed for a systematic empirical analysis of the effect the step-price model had on the prices of pharmaceuticals and competition by using the Herfindahl-Hirschman Index.

Our results suggest that the step-price model's implementation has led to significant changes in the prices of pharmaceuticals. The model has been important in reducing the prices of pharmaceuticals in competitive markets with generic drugs, which aligns with the original incentive of the model. This has implications for the consumer welfare, as lower prices can increase accessibility of medications for consumers. However, our results suggest that the implementation of the model did not lead to any changes in the market concentration measured by the Herfindahl-Hirschman Index. Furthermore, we analyzed the openings and closures of pharmacies from 2003 to 2023, where we found that the number of pharmacies grew considerably. It could be tougher for independent pharmacies to enter the market because they have to buy pharmaceuticals from competing pharmacy chains at maximum AIP, as well as the observed over-establishment of chain pharmacies.

The findings of this study could have important implications. The findings emphasize the effectiveness of the step-price model in its reduction of prices, and it can provide a basis for further policy decisions in the pharmacy sector. Future research could explore the effects of the step-price model in the long term and compare it to pricing models in other countries.

References

Ali, A. M. (2019). *Generika*. Store medisinske leksikon. https://sml.snl.no/generika.

Angrist, J. D., & Pischke, J. S. (2015). *Mastering 'metrics: The path from cause to effect.* Princeton University Press.

Apotekforeningen (2021). *Er markedet for generiske og biotilsvarende legemidler bærekraftig? En rapport om medisinbytte innenfor primærhelsetjenesten.* https://www.apotek.no/Files/Filer_2014/Rapporter/FarmaNorge_Apotekforeningen_rapportomgenerikamarkedet.pdf

Apotekloven. (2001). *Lov om apotek.* LOV-2000-06-02-39. Lovdata. https://lovdata.no/dokument/NL/lov/2000-06-02-39#KAPITTEL_1

Belleflamme, L., & Peitx, M. (2019). *Industrial Organization: Markets and Strategies* (5th ed.). Cambridge University Press.

Brekke, K. R., Holmås, T. H. &. Straume, O. R. (2010). *Are Pharmaceuticals Still Inexpensive in Norway? A Comparison of Prescription Drug Prices in Ten European Countries.* SNF Report No. 08/10, The Institute for Research in Economics and Business Administration.

Dalen, D., M., Furu, K., Locatelli, M., & Strøm, H. (2011). Generic substitution: micro evidence from register data in Norway. *The European Journal of Health Economics, 12*(1), 27-39.

d'Aspremont, C., Jaskold Gabszewicz, J., & Thisse, J. F. (1979). On Hotelling's "Stability in Competition". *The Economic Journal, 47*, pp. 1145-1150. https://doi.org/10.2307/1911955

Dranove, D. (2011). Health Care Markets, Regulators, and Certifiers.

Handbook of Health Economics, 2, pp. 639–690). Elsevier B.V. https://doi.org/10.1016/B978-0-444-53592-4.00010-4

Gudbrandsen, K. B., & Fellkjær, K. T. (2011). *Grossistenes incentiver i legemiddelmarkedet: En undersøkelse av prissetting fra grossist til apotek i et vertikalt integrert marked.* SNF. https://snf.no/media/ytthwmpb/an22_11.pdf

Helsedepartementet (1998). *Om lov om apotek (apotekloven): Ny Apoteklov som ledd i en samlet gjennomgang av legemiddelpolitikken.* https://www.regjeringen.no/no/dokumenter/otprp-nr-29-1998-99-/id159588/

Helsedepartementet (2004). *Evaluering av apotekloven og Indeksprissystemet*. ECON. https://www.regjeringen.no/globalassets/upload/kilde/hd/rap/2004/0007/ddd/pdfv/211779-r-2004-010_akh_evaluering_av_apotekloven_og_indeksprissystemet_m_velegg.pdf

Håkonsen, H., & Horn, A. M. (2009). The impact of the step price system on the pharmaceutical market in Norway. *Journal of Pharmaceutical Health Services Research*, *1*(1), 45-52.

Imbens, G. W., & Wooldridge, J. M. (2009). Recent developments in the econometrics of program evaluation. *Journal of Economic Literature*, *47*(1), 5-86. https://doi.org/10.1257/jel.47.1.

Joint Nordic Report (2021). Online pharmacy markets in the Nordics.

Legmiddelverket (2016). *Trinnpris – ikke-patenterte legemidler.* *https://legemiddelverket.no/offentlig-finansiering/trinnpris*

Legemiddelverket (2022). *Maksimalpris på legemidler.* https://legemiddelverket.no/offentlig-finansiering/maksimalpris#revurdering-av-maksimalpriser

Legemiddelverket (2023). *Apotekavanse.* https://legemiddelverket.no/offentlig-finansiering/apotekavanse

Mankiw, N. G. (2017). *The Economics of Healthcare*. Harvard University https://scholar.harvard.edu/sites/scholar.harvard.edu/files/mankiw/files/economics_of_healthcare.pdf

NOU 2023:2 (2023). *Fremtidens apotek – fleksibelt og forsvarlig.* Helse- og Omsorgsdepartementet. https://www.regjeringen.no/contentassets/20fd061ab41443d78ee2196dddf6e781/no/pdfs/nou202320230002000dddpdfs.pdf

Pepall, L. R, Richards, D. & Norman, G. (2014). *Industrial Organization – Contemporary Theory and Empirical Applications* (5th ed). John Wiley & Sons.

Wooldridge, J. M. (2020). *Introductory econometrics: A modern approach* (7th ed.). Cengage Learning.

Appendix

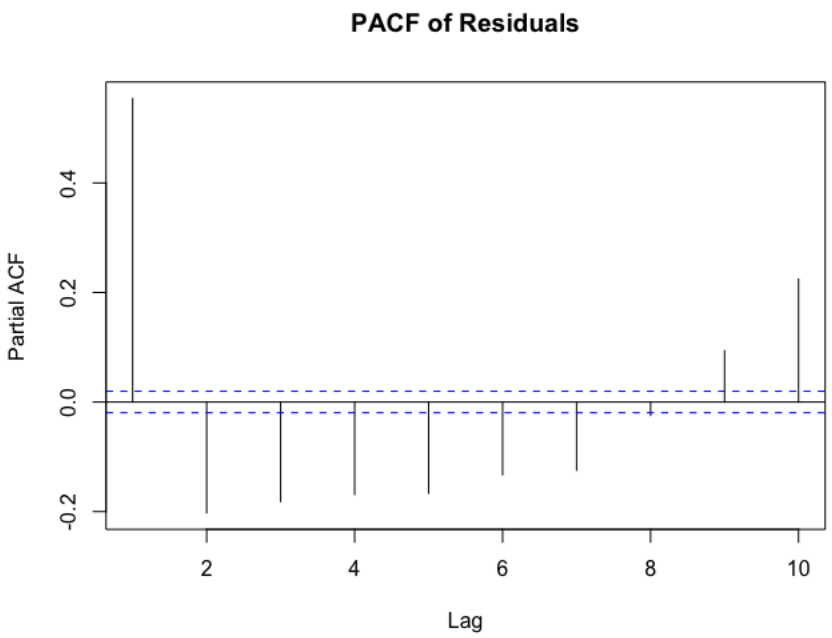

Figure 1 Appendix*: Partial Autocorrelation Function for first model* of log *prices. The blue lines show the accepted level of autocorrelation in the residuals.*

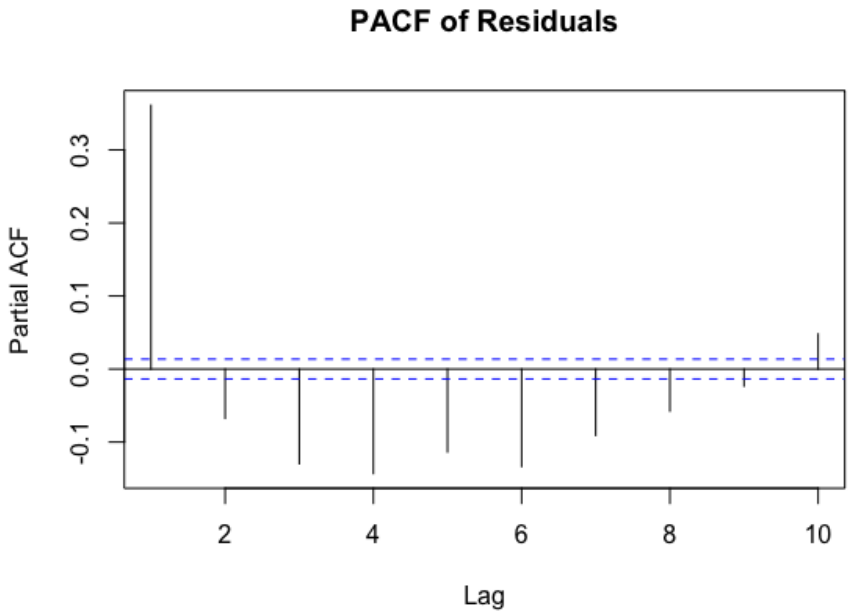

Figure 2 Appendix*: Partial Autocorrelation Function for first model of HHI. The blue lines show the accepted level of autocorrelation in the residuals.*

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Double marginalization and vertical integration

In the case of a supplier producing a good at a marginal cost of c and selling it to a distributor at a wholesale price of w, and the distributor subsequently selling it to the consumer at a retail price of p, double marginalization occurs when both the supplier and distributor have market power and engage in price markups. Without double marginalization, the supplier would set w equal to c, and the distributor would set p equal to $w + c$, resulting in a final price to the consumer of $p = 2c$. However, with double marginalization, the supplier may set $w = c + m_1$ and the distributor may set $p = w + m_2$, where m_1 and m_2 are the markup percentages. This leads to a final price to the consumer of $p = (c + m_1) + m_2 = c + (m_1 + m_2)$, which is higher than the efficient price of $2c$.

One solution to double marginalization is vertical integration, in which the supplier and distributor merge to become a single firm. This allows for coordination of production and distribution, and results in a final price to the consumer of $p = c + m$, where m is the markup percentage of the integrated firm. However, it is important to note that vertical integration may also lead to reduced competition and increased market power for the integrated firm, which can result in higher prices for consumers. The pros and cons of vertical integration depend on the market structure and competition in the specific market (Belleflamme & Peitz, 2019).

Hotelling Model

By illustrating this model we are able to show why further entries from one of the dominant actors can result in an inefficient allocation of resources.

The Hotelling model, also known as Hotelling's Law, is a fundamental concept in spatial economics, industrial organization, and location theory. It suggests that in a market where products are relatively homogeneous, sellers tend to cluster their locations towards the middle of the market to maximize market share. This model is named after Harold Hotelling, who developed it in 1929. For the Norwegian pharmacy market, which often competes on locations, this can explain parts of the

dynamics in the market. As discussed in the 2023 NOU, pharmacies tend to cluster around city centers.

5.2.1 Assumptions

Visualize a linear city that extends from 0 to 1, where consumers are evenly dispersed throughout this range. Within this horizontally oriented city are two stores, 1 and 2, situated at opposite extremes. Each store offers a single, identical product at a price denoted as p. Central to this model is the element of transportation cost, denoted as t, which consumers must bear to reach their chosen store.

5.2.2 Model

Consumers get utility from purchasing the product:

$U_1(x_i) = r - tx_i - p_1$ If visiting store 1
$U_2(x_i) = r - t(1 - x_i) - p_2$ If visiting store 2

r represents the worth derived from utilizing the product, while t symbolizes the expense incurred for transportation over a single unit of distance. Additionally, x is used to denote the spatial gap between consumer and the geographical location of firm 1 and 2. By examining the utility function, it becomes clear that closeness to the store is advantageous in order to minimize transportation expenses, thus maximizing the overall utility for the consumer.

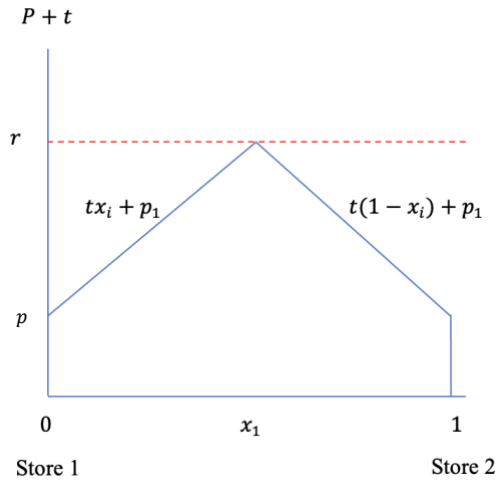

Figure 3 Appendix: Indifferent where to go in the hotelling model

In this figure the consumer is allocated at point x_i and because of this, they're indifferent on where to go. The consumer will always buy if the transportation cost plus the price is less than r.

The demand for Store 1 is x and $(1-x)$ for Store 2. If they share half the market the demand will look like this:

$$q_1 = \frac{1}{2} + \frac{p_2 - p_1}{2t}$$

The more the competitor (2) rises their prices, the more the demand firm 1 will absorb. The bigger the transportation cost t the less the consumer will demand.

Profit function

$$\pi_1 = \left(\frac{1}{2} + \frac{p_2 - p_1}{2t}\right)(p_1 - c_1)$$

The Profit equals the quantity multiplied with the price minus cost.

For this example, to be related to the pharmacy sector in Norway. The price *P* must be more or less fixed, in terms of the Norwegian law about how the Norwegian pharmacy prices are regulated (Chapter 2.3.1). To further illustrate we will assume a constant price for the product as p_{max} for the whole market. As a max AUP price.

With fixed prices $p_2 = p_1 = p_{max}$

$$\pi_1 = \left(\frac{1}{2}\right)(p_1 - c_1)$$

If the whole market is captured

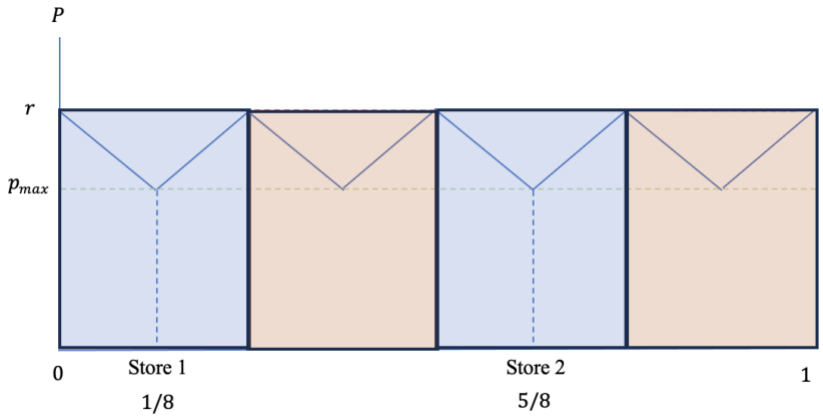

Figure 4 Appendix: Not efficient covered market in Hotelling

Figure 4 AppendixFigure 4 presents the geographical positioning of Store 1 and Store 2, illustrating their relative distances and their current inability to cover the entirety of the market. The blue squares denote the areas where these stores have effectively captured market share, while the orange squares highlight potential entry points for new businesses with their current price which is set to p_{max}. In this scenario store 1 will have a profit of (same with store 2):

$$\pi_1 = \left(\frac{1}{4}\right)(p_{max} - c_1)$$

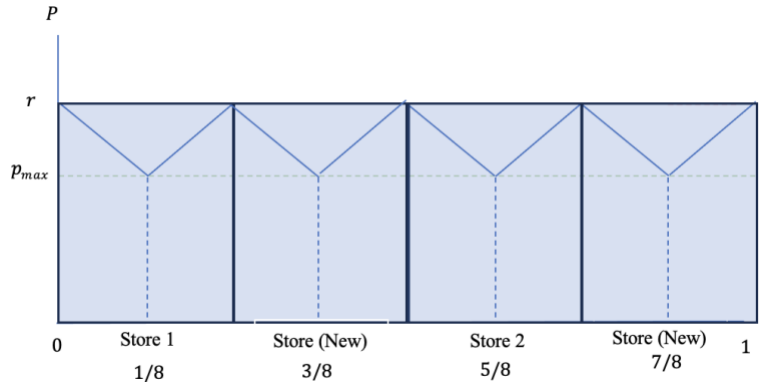

Figure 5 Appendix: Efficient covered market in Hotelling

Figure Figure 5 provides a comprehensive view of the newly saturated market, reflecting the entrance of additional stores. This newly balanced market environment is now entirely claimed, leaving little to no room for fresh entrants. Profitability for new players is substantially minimized, thus making a market entry under such circumstances unfavorable. In terms of population growth in a city we

can think about that the market is increasing and the interval from 0 to 1 is getting longer and because of this it will fit more firms. In this way it will fit a lot more stores (Pharmacies) in a big city with a lot of inhabitants, than in a small city with lack of people.

Given that the market is already effectively supplying to the majority of consumer needs, further entries from one of the dominant actors can result in an inefficient allocation of resources. These resources, if deployed strategically, could instead be used to cultivate more efficient supply chains, enhance management systems, and drive innovation in other underserved areas. The only logical motivation for an aspiring entrant would be to strategically capture market shares from existing competitors. This approach could provoke significant losses for these competitors and lead to a competitive survival scenario providing a clear perspective on the strongest and most resilient market participants (d'Aspremont et.al., 1979). The competitor's ability to sustain in this market not only depends on their financial stability or pricing mechanism, but also on their strategic positioning and local market penetration. Thus, Figure 6 is a demonstration to the complex interplay of location, market share, and the competitive landscape.