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Consumer Inertia and Switching Costs in the Norwegian Electricity Market

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NORWEGIAN SCHOOL OF ECONOMICS

Preface

This master thesis is conducted as a part of the curriculum of our master's degree in Economics and Business Administration at the Norwegian School of Economics.

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Abstract

In this thesis we aim to investigate the degree of consumer inertia and estimate the switching costs in the Norwegian electricity market. We utilize two separate models to estimate the implicit switching costs embedded in the switching behavior of the consumers. Both models enable us to extract meaningful information about both the significance and magnitude of switching costs from highly aggregated market share data. Our dataset contains a panel of monthly observations of prices and market shares of the five largest retailers on each power distribution grid. Each distribution grid can be said to represent a separate market, where both nationwide and local retailers compete for the consumers located within the geographical area of that grid. Due to this type of market structure, we find a large variation in the distribution of market shares across markets. Some markets are close to monopolies, as the largest retailer covers close to the whole market, while other markets have a more even distribution of market shares, and thus stronger competition. Moreover, we find that variable price contracts are systematically higher priced, and have higher markups, than spot price contracts. This leads to our next finding of significant gains from switching, both between retailers and, especially, from variable to spot price contracts.

Despite these potential gains from switching, we find evidence for consumer inertia in the Norwegian electricity market. In particular, we obtain point estimates of switching costs of 19.28 øre/kWh and 16.20 øre/kWh from our two models. In annual terms, this means that Norwegian consumers are on average willing to pay a premium of about 2,600 to 3,100 NOK rather than switching electricity supplier monthly. The estimated switching costs account for as much as 50 % to 60 % of the average yearly electricity bill for the consumers. Additionally, we find evidence that retailers exploit the inertia of their customers, by utilizing "bargain-then-ripoff" pricing strategies. That is, retailers use penetration pricing, introductory offers and price wars to obtain as many new customers as possible, while they charge higher prices to already locked-in customers. Consequently, the existence of switching costs in the Norwegian electricity market leads to weakened competition and inefficient markets.

Keywords – Industrial organization, switching costs, consumer inertia, customer lock-in

Contents

List of Figures

List of Tables

1 Introduction

Although electricity markets generally are characterized by consumer inertia and thus high switching costs[1], the Norwegian electricity market are often said to exhibit high consumer switching frequency. In this paper we want to examine this notion by looking into the degree of customer inertia and estimating the resulting switching costs in the Norwegian electricity market. Consumer inertia and switching costs may give rise to efficiency loss, and are therefore of interest for policy makers and competition authorities.

According to rational choice theory, consumers incorporate all available information in order to choose the action that maximizes the present value of their expected life-time utility. If we consider electricity as a homogeneous product, the stream of prices is the only information that should affect the consumer's choice of electricity supplier. The prediction of rational choice theory is therefore that consumers will continuously switch to the retailer offering an electricity contract at the cheapest price. Through perfectly competitive electricity markets, with perfect information and free consumer mobility, the optimal consumer and firm behavior will lead to an efficient market outcome. However, consumer inertia and switching costs may prevent consumers from switching, and thus reduce economic efficiency by granting retailers market power over locked-in consumers.

The objective of policy makers and competition authorities is to minimize efficiency loss by enhancing competition. When consumers face switching costs, electricity retailers may find it profitable to use so-called "bargain-then-ripoff" pricing strategies. That is, retailers use penetration pricing, introductory offers and price wars to obtain as many new customers as possible, while they charge already locked-in customers higher prices due to switching costs (Farrell and Klemperer, 2006). In fact, in our data, we find evidence for such behavior from the retailers. In the period from 2015 to 2019, the average price on products offered to new customers only is 23.21 øre/kWh for spot price products and 38.89 øre/kWh for variable price products, while the average price on products offered to all customers is 31.88 øre/kWh for spot price products and 40.73 øre/kWh for variable price products. Not only may this indicate the existence of switching costs, but we also see that the retailers exploits the inertia of their customers through price discrimination.

[1] See for example Hortaçsu et al. (2017), Waterson (2003), Wilson and Price (2005), Ek and Söderholm (2008), or von der Fehr and Hansen (2010)

The existence of switching costs may indicate the need of interventions by policy makers and competition authorities. The objective of these interventions could be to reduce the search costs of the consumers, for example through informational solutions. Although the Norwegian Consumer Council operates a price comparison website, formerly operated by the Norwegian Competition Authority, retailers still exploit the inertia of their customers. It could therefore seem like, although such price comparison websites exist, they are not used frequently by the consumers. From the consumer inertia, it seems like many consumers are unaware of the potential gains from switching. Thus, policy makers could highlight the switching costs, implicitly paid by the consumers through their inertia, through market campaigns in order to make consumers more attentive to the potential gains from switching.

The purpose of this thesis is therefore to examine the degree of consumer inertia and estimate the resulting switching costs in the Norwegian electricity market. The novelty of this paper lies in the attempt to quantify implicit switching costs in the Norwegian electricity market. Hence, our research question is as follows:

Research Question: What is the degree of consumer inertia in the Norwegian electricity market, and what do the implicit switching costs amount to?

In order to answer this research question, the thesis is divided into 8 chapters. In this chapter we have explained our motivation for the chosen topic, and described our research question. In chapter 2 we will present the theoretical literature on consumer inertia and switching costs, as well as empirical evidence from other studies. In chapter 3 we present an outline of the Norwegian electricity market. In chapter 4 we describe the models we will use to estimate switching costs, and in chapter 5 we explain our empirical methodology. In chapter 6 we describe the data, the data collection procedure and the construction of variables. In chapter 7 we present the findings of our analysis, while we in chapter 8 discuss the implications, robustness and limitations of our results. Finally, in chapter 9 we answer the research question and come with some concluding remarks.

2 Literature Review

2.1 Theoretical literature

The theoretical literature on switching costs began with Selten's (1965) model of demand inertia. Selten modelled a firm's current sales as a function of the difference between its own previous-period price and its competitor's previous-period price, even though current sales were assumed independent of the competitor's current price. Although he did not explicitly model consumers' behavior in the presence of switching costs, the idea of consumer inertia is closely related to switching costs. Following the publication of Selten's model, the theoretical literature took off.

Among more recent researchers in the field, Klemperer has written several papers on switching costs and their implications for competition. In an early paper, Klemperer (1987) states that, in markets with switching costs, homogeneous products may become differentiated after the purchase of them. This is due to the lock-in effect, i.e. that after purchase, the consumer finds it costly to switch to another supplier and is therefore likely to stay with that supplier. Moreover, he states that the (non-cooperative) equilibrium in markets with switching costs may be the same as the cooperative equilibrium in a homogeneous market without switching costs. This is due to the fact that firms can charge a price above the non-cooperative equilibrium price to the already locked-in customers.

Farrell and Klemperer's (2006) survey summarizes both the theoretical literature and empirical evidence on switching costs. According to Farrell and Klemperer (2006), a product has classic switching costs if a consumer purchases it repeatedly and finds it costly to switch supplier. Thus, switching costs give the consumer an incentive to use its current supplier, even when other suppliers offer identical products at lower prices.

In an earlier paper, Klemperer (1995) states that switching costs are a result of a consumer's wish for compatibility between the current purchase and a previous investment. Switching costs can be real monetary costs imposed by the suppliers, or non-monetary 'hassle' costs arising because switching may require some time or effort from the consumer. The previous investment can be a physical investment in (a) equipment; (b) in setting up a relationship; an informational investment in (c) finding out how to use a product or (d) about its characteristics; (e) an artificially-created investment in buying a high-priced first unit which then allows one to buy subsequent units more cheaply; or (f) even a psychological investment such as non-economic "brand-loyalty" (Klemperer, 1995). Such brand-loyalty are often modelled as state-dependent preferences, which can reflect or have similar effects as switching costs. The investments of type (c) and (d) are caused by learning costs and search costs, respectively, which in the literature is closely related to switching costs.

In electricity markets, switching costs may arise due to investments of type (b). That is, it may be that consumers find it costly to switch due to the time and effort it takes to set up a relationship with a new supplier. When switching supplier, the consumer will have to actively search for information about other suppliers' products and their characteristics, which also leads to switching costs due to (d). Moreover, it may also be that some consumers experience a non-economic brand-loyalty to their supplier, i.e. investments of type (f). Although brand-loyalty to electricity suppliers might seem uncommon, Hortaçsu et al. (2017) find evidence for this, as we will see in the upcoming section.

2.2 Empirical evidence

Compared to the theoretical literature on switching costs, the empirical literature is smaller and more recent. The empirical literature covers several markets, such as the market for bank services, cigarettes, computer software, supermarkets, airlines, phone services, television, bookstores and automobile insurance (Farrell and Klemperer, 2006). However, we will focus on the evidence from electricity retailing only.

Hortaçsu et al. (2017) study consumer inertia in the Texas residential electricity market at the time the market opened up for competition in 2002. In particular, they measure two sources of inertia, namely search friction or inattention to new information and brand-loyalty to their current supplier. They find that households rarely search for alternative suppliers, and when they do search, they attach a brand advantage to their current supplier. Consequently, households are unlikely to switch, although switching is a one time action taking about 15 minutes, and would reduce the average electricity bill by approximately $100 the first year, which accounts for 8 % of the average yearly electricity bill. In particular, through econometric models of consumer choice, they estimate the brand advantage the consumers assign to their current supplier to be $61.86 monthly. This means that, after accounting for the price difference between current and other suppliers, consumers value purchasing from their current supplier $62 more, or about 50 % of the average monthly electricity bill, compared to purchasing the same amount of power from another supplier. This estimate can therefore be interpreted as switching costs due to non-economic brand loyalty, as discussed in the previous section, and can be used for comparison with our estimated switching costs.

Waterson (2003) discusses the importance of switching costs in the UK electricity market. In the paper, he investigates the potential gains from switching and compare these gains with survey participants' self-reported switching costs, i.e. how much they would need to save in order to be willing to switch supplier. Taking these self-reported thresholds at face value, he finds that the incumbent supplier can increase its monthly price up to £8 without the loss in profit from the customers switching away exceeding the profit gain from the price increase. However, what consumers say they would do tend to differ from what they actually do. Switching cost estimates based on observed switching behavior are therefore more interesting than those of surveys. Direct estimation of switching costs, however, would require micro data on each consumer's purchases over time. From these data, the researcher could utilize the information on how much each consumer saves from switching, in order to estimate the threshold at which the each consumer would be willing to switch. However, this type of consumer-specific information is rarely available to researchers. Thus, less direct estimation methods are often needed. Kim et al. (2003) approximate demand and supply equations from highly aggregated data, which does not contain any consumer-specific information, in order to extract information of both the magnitude and significance of switching costs in the Norwegian banking market. We will return to this model in chapter 4, as it is one of the models we utilize in our analysis.

Another study of the UK electricity market, conducted by Wilson and Price (2005), finds three types of switching behavior errors. Namely, consumers who do not switch despite significant gains from switching, consumers who switch from cheap to more expensive suppliers, and consumers who switch to a cheaper, but not the cheapest, supplier. Additionally, they find that consumers make better, more efficient switching decisions when there are fewer retailers in the market, which may reflect the existence of search costs. In particular, they find that out of the 1,834 customers who did not switch, even though they were aware of the possibility, 98.8 % could have achieved annual savings of £43.59, or about 18 % of the average yearly electricity bill, by switching supplier.

Ek and Söderholm (2008) investigate which factors affect Swedish households' decisions to switch electricity suppliers and to actively renegotiate their contract with their current supplier. In the study they find that knowledge about electricity costs is particularly important for the household's decision to switch or renegotiate, which yields evidence for the existence of search costs. In addition, they find that limited time, attention and abilities to process information make consumers use simplifying heuristics, such as the status quo bias, to choose supplier. That is, when the purchasing decision becomes too complex, the consumers may opt in favor of their current supplier. This highlights the need for informational solutions, such as price comparison websites, which reduce the search costs of the consumers.

In the context of the Norwegian electricity retail market, von der Fehr and Hansen (2010) provide a descriptive analysis of consumer behavior. They find that the market for spot price contracts is competitive and that the margins there are small. However, they also find that, for many consumers, there are large unexploited gains from switching supplier, which reflects the existence of switching costs. More specifically, over the period from 2001-2006, they find that the gains from switching supplier weekly range from 0 % to 17 % of the yearly electricity bill for consumers on variable price contracts. In addition, they find that the gains from switching from variable price contracts to spot price contracts range from -26 % to 20 % of the yearly electricity bill for the same period. Considering similar switching strategies, we will renew these estimates for our sample period later in this thesis. Regarding what we add to the existing literature, the novelty of our paper lies in the quantification of implicit switching costs in the Norwegian electricity market.

3 The Norwegian Electricity Market

In order to better understand consumers' choices and switching behavior, we need to understand how the market is organized. Therefore, in this part of the thesis, we present an outline of the Norwegian electricity market. First, we briefly describe the structure of the power market[2]. Then, we focus on the electricity retail market and the different types of electricity contracts and their features.

3.1 The power market

The Norwegian power market can be divided into two markets. Namely, the wholesale market and the retail market. In the wholesale market, producers sell power to the suppliers, either directly or through the power exchange. In the retail market, households buy power from the suppliers only, while industrial customers can buy their power through all channels of the power market. The structure of the market is illustrated by figure 3.1.

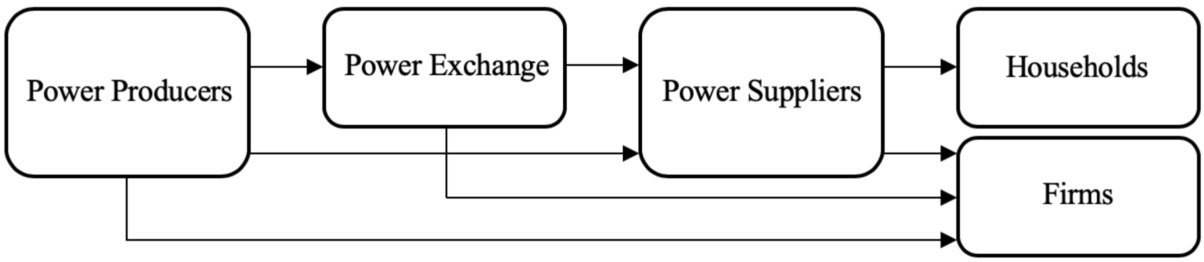


Figure 3.1: Structure of the power market.

In the wholesale market there are several organized markets, such as the day-ahead market, the continuous intraday market and the balancing market. In these markets different agents are bidding and prices are determined. The balance between supply and demand is primarily settled in the day-ahead market, where most of the volume on the power exchange Nord Pool is traded. Between 08:00 and 12:00, the prices for the next day are calculated in an auction where selling and purchasing bids from different agents are submitted to Nord Pool. After the auction in the day-ahead market, incidences such as change in weather forecast can make the agents' actual production or consumption differ from their submitted levels. In the intraday market, there is continuous trading from the

[2]This section is based on information from Energy Facts Norway (2020), which is operated by the Norwegian Ministry of Petroleum and Energy.

clearance in the day-ahead market and up to one hour before the time of operation. In this way, agents have the opportunity to achieve a balance through trading.

Even though the day-ahead and the intraday market creates balance between production and consumption, different kinds of happenings can disturb the balance in the hour of operation. In order to secure the instantaneous balance, the balancing market is used to regulate consumption or production, up or down, depending on the imbalance. In the balancing market, the frequency is regulated by different reserves, such as primary, secondary and tertiary, depending on the duration of the imbalance. The balancing market is operated by Statnett, who must ensure that there always are sufficient primary reserves.

Moreover, there exists a market for power trading with financial products which are used for both risk management and speculation. These types of contracts are settled financially only, without any physical power delivery. Financial products are often referred to as long term contracts as they are traded for periods that take place further ahead in time than the physical products. The most common types of financial products are future and forward contracts. Future and forward contracts are agreements of a financial settlement of a predetermined amount of power, for a predetermined time period, to a predetermined price. The future contracts are settled both during the trade and delivery period, while the forward contracts are settled at the end of the contract period in full. These types of contracts are important tools for the retailers in order to hedge against price fluctuations.

Customers who purchase power for their own consumption are called end users. In the retail market, each individual end user who makes an agreement to purchase power can freely choose their power supplier. In Norway, the retail market consists of approximately one third individual customers and two-thirds industrial customers. However, for the purpose of this analysis we will focus on the individual customers, i.e. the households.

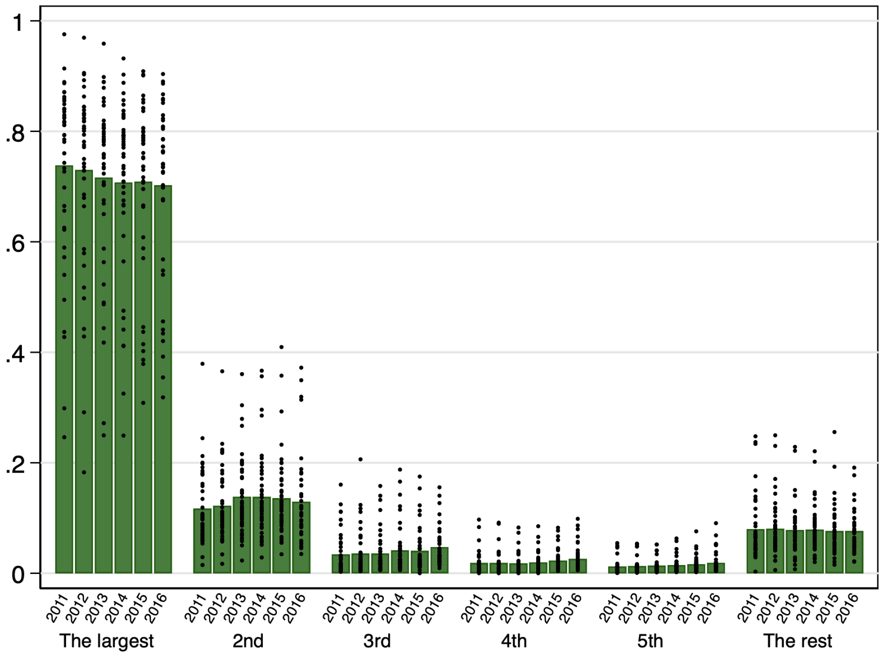
In 1990, the Norwegian Energy Act, based on the principle that production and trading of electricity should be market-based, was introduced. This led the Norwegian customers to be among the first to freely choose their electricity supplier. When customers got the opportunity to choose supplier, competition opened up between the electricity retailers. Later on, other Nordic countries liberated their electricity laws, which led to the establishment of Nord Pool in 1996. In fact, Nord Pool was the first exchange in the world where power was traded across borders.

Each day, Nord Pool calculates the system price for power for the upcoming day. This price is common for the enitre Nordic market and works as a reference price. The producers report how much they want to produce at a specified price, and the end users report how much they want to consume at different price levels. Then, the market price is determined by the balance between supply and demand in the day-ahead market. This type of market based pricing is meant to ensure that the need of power is met at the lowest cost as possible. In a perfectly competitive market, the equilibrium price should equal the marginal cost for the producers. In addition to the system price, Nord Pool calculate area prices separately for different regions, taking bottlenecks on the grid into account. These area prices shall also ensure balance between supply and demand in the different bidding areas in the Nordic countries. Since early 2010, Norway has been divided into five bidding areas.

3.2 The electricity retail market

The Norwegian electricity retail market can be said to be divided into smaller geographical markets, separated by the power distribution grids. On each grid, retailers compete for the consumers located in that geographical area. In these markets, there are both large, nationwide suppliers and smaller, local suppliers. This type of market structure can weaken the competition in the market, as the large, nationwide suppliers typically are more competitive, more robust and have a stronger brand name among consumers. Consequently, we can see a distortion in the distribution of market shares. In figure 3.2 below, we have graphed the market shares of the five largest retailers, both separately for each geographical market, denoted by the dots, and averaged across all markets, represented by the bars. The market shares are measured as a retailer's number of customers relative to the total number of customers on that grid. We find that the largest retailer covers 72 % of the market on average. However, we can see some downward trend in the market share of the largest retailer, which seems to have been shared between the second to fifth largest retailers. By looking at the dots, we see big variation in the distribution of market shares across markets. Some markets are close to monopolies, as the largest retailer has a market share above 90 %. Other markets are close to duopolies, as the second largest retailer has around 40 % market share, while the largest obviously has more. At the same time, there are also markets where the largest retailer has only

20 % market share, indicating strong competition in these markets. As a consequence, the existence of switching costs may have different impact on each market. For instance, in very competitive markets, switching costs may be the only factor keeping the retail prices higher than the perfectly competitive equilibrium price. In markets that are close to monopolies, however, the largest retailer's market power will also ensure that prices are kept above the competitive equilibrium price.



The bars represent the average across all geographical markets, while the dots are the observed market shares in each market. Data source: The Norwegian Water Resources and Energy Directorate.

Figure 3.2: Market shares of the five largest electricity retailers.

However, figure 3.2 does not show the frequency of which the identity of the five largest retailers change. In fact, the identity of the five largest retailers changes only 547 times, out of 13,665 market share observations in total, across all markets. Moreover, the identity changes more often for the smaller retailers than the largest. In particular, the identity of the largest retailer changes only 13 times, the second largest changes 17 times, the third largest changes 85 times, the fourth largest changes 196 times, and the fifth largest changes 236 times. Although some of the identity changes are caused by mergers and acquisitions, this indicates that there are some consumers switching between retailers. However, this also shows that the position of the largest and second largest retailer is relatively stable throughout the whole period.

Regarding the evolution of market shares in our data, we find high intertemporal correlation among market shares. More specific, we find the correlation between current market shares and lagged market shares throughout the entire estimation period to be above 0.97. Such high intertemporal correlation of market shares may indicate two things. Firstly, that the market shares of the five largest retailers are relatively stable over time. Second, high intertemporal correlation of market shares may indicate very little switching and that switching takes time. An alternative explanation is that there may be very intensive switching, such that the net change in market shares from one month to another is close to zero. However, the first seems more reasonable in the presence of switching costs.

Additionally, in order to measure the market concentration in the electricity market, we have calculated the concentration ratio of the five largest retailers (CR_5) and the Herfindahl-Hirschman index (HHI), averaged over all markets. The results are shown in table 3.1 below. We find that the five largest retailers cover 92 % of the market on average. However, as we only have data on the market shares of the five largest retailers, we must make an assumption on the distribution of market shares between the rest of the retailers in order to calculate the HHI. We therefore assume that the remaining part of the market, represented by the bars furthest to the right in figure 3.2 above, is evenly distributed between the rest of the retailers. As a consequence, we are likely to underestimate the HHI, as deviations from an even distribution of market shares lead to higher market concentration and therefore higher values of HHI. We find the HHI, averaged over all markets, to be 5,393. However, the standard deviations are relatively large, which indicates large variation in market concentration across markets. Again, this indicates that the existence of switching costs may have different impact on each market. Furthermore, the CR_5 has been slightly increasing over the years, which we also can see by the decrease in the bars furthest to the right in figure 3.2. However, at the same time, the HHI have been decreasing, which is due to the decrease in the market shares of the largest retailers, as we can see by the bars furthest to the left in figure 3.2.

Year	CR_5	HHI
2011	0.9198	5,604.59
	(0.0535)	(1,865.51)
2012	0.9201	5,458.58
	(0.0473)	(1,810.24)
2013	0.9214	5,333.56
	(0.0434)	(1,744.85)
2014	0.9229	5,282.24
	(0.0400)	(1,703.85)
2015	0.9232	5,310.10
	(0.0394)	(1,759.07)
2016	0.9237	5,201.28
	(0.0375)	(1,784.53)
Average	0.9218	5,393.48
	(0.0435)	(1,784.24)

Standard deviations in parentheses

Table 3.1: Market concentration measures averaged across all markets.

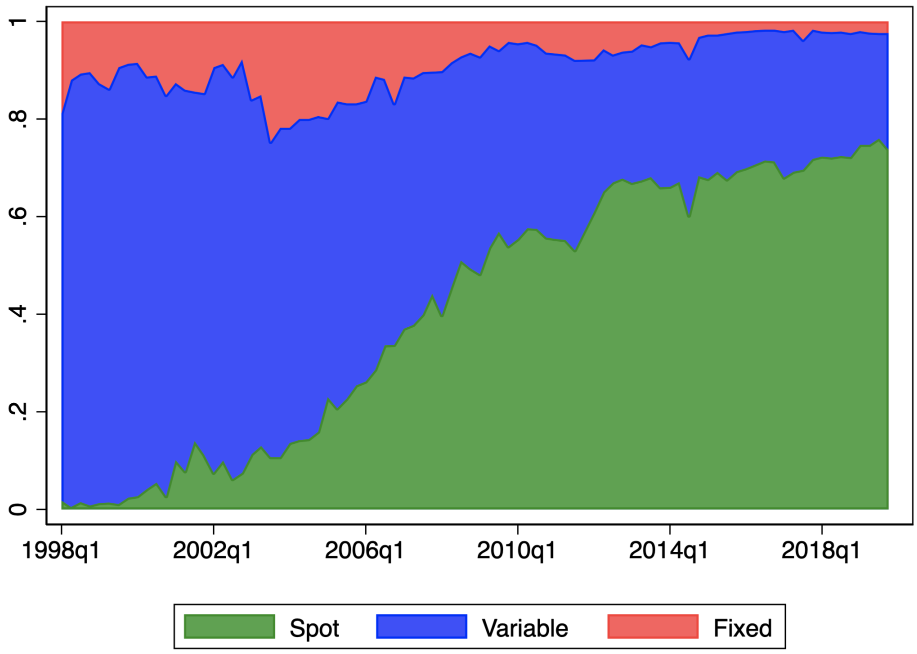
3.2.1 Contract types

In 1996, the Norwegian electricity trade association, Energy Norway, and the Consumer Authority (formerly the Consumer Ombudsman) agreed upon a Standard Agreement for Power Supply in Norway. Since then, the Standard Agreement have been revised several times and latest in 2017. The purpose of the Standard Agreement is to regulate contractual terms such as entry into and termination of the contract, pricing and metering. However, retailers may offer contracts that differ from the Standard Agreement, e.g. in terms of pricing, but these contracts are typically less popular among consumers (von der Fehr and Hansen, 2010). Within the Standard Agreement, retailers often offer one or more of the following three contract types:

- Variable price contracts: The price per kWh of consumption, in addition to any fixed fees, is set by the retailer and can be changed once every other week. However, retailers are obligated to notify the customers about price changes, and the changes are first in effect two weeks after such notifications take place.
- Spot price contracts: The price equals the monthly Nord Pool Elspot price, plus any fixed fees and/or markups per kWh of consumption.

- Fixed price contracts: The price is fixed and the consumer is bound to the contract for a longer time period, typically from one to three years.

Retailers supplying either of these products are obligated to report their prices to the price comparison website, now operated by the Norwegian Consumer Council and previously by the Norwegian Competition Authority. As mentioned, although some other contract types exist, these three contract types cover most of the market. Within these contract types, the variable price have historically been the most popular among households. Before the start of Nord Pool, variable price contracts were considered the standard type of contract. Thus, if a consumer never has changed their electricity contract, they are on a variable price contract. There does not exist, as far as we know, any data or surveys on which contract types new consumers choose. However, we find it likely that the consumers who are on variable price contracts today, are the same consumers as were on variable price contracts in 1998. Moreover, ever since the start of Nord Pool, the spot price contracts have become increasingly more popular, as we can see from figure 3.3 below.



Data source: Statistics Norway.

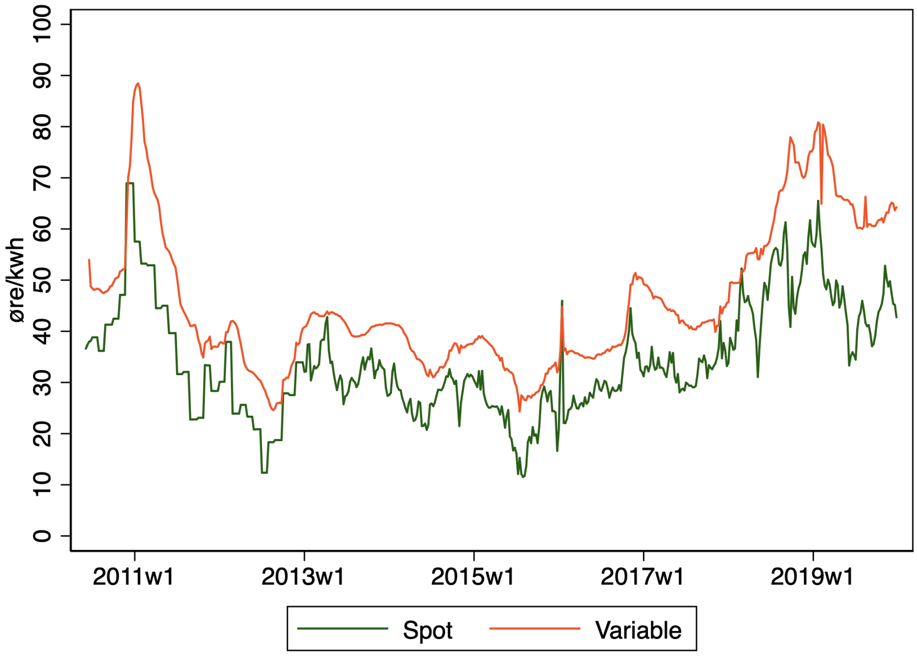
Figure 3.3: The development in the shares of electricity contract types among households.

One potential reason for the increasing popularity of spot price contracts, could be an increase in the supply of spot price contracts. Spot price contracts are typically less costly to administer for the retailers, as they do not need to inform customers about price changes, and it does not require any hedging towards risk of wholesale price fluctuations, since this is fully covered by the customer. With variable price contracts, however, customers must be informed about price changes two weeks before they are implemented. The retailer must therefore hedge towards the risk of wholesale price fluctuations. Another reason for the increasing popularity of spot price contracts could be, as we now will see, that spot price contracts generally are lower priced than variable price contracts. As variable and spot price contracts together cover more than 90 % of the household market, we disregard both fixed price contracts and non-standard contracts going forward.

3.2.2 Prices

In order to compare products, we need a way to measure prices across contract types. Most variable and spot price products are priced with two-part tariffs. That is, the price includes both a variable element, the price per kWh for variable price products and the monthly Elspot price plus a markup for spot price products, as well as a fixed fee. Hence, retailers can extract their profit through either element of the two-part tariff, depending on the type of consumer they are targeting with the product. Intuitively, a low-consumption type of consumer would prefer a high variable element to a high fixed fee, while a high-consumption type would prefer a high fixed fee to a high variable element. There are several ways to model competition under two-part pricing, and such pricing have several implications for competition in the market. However, going forward, we simplify by calculating prices in øre/kWh by fixing the consumption to 16,000 kWh yearly, which approximately is the average yearly consumption for Norwegian households from 2010 until today.

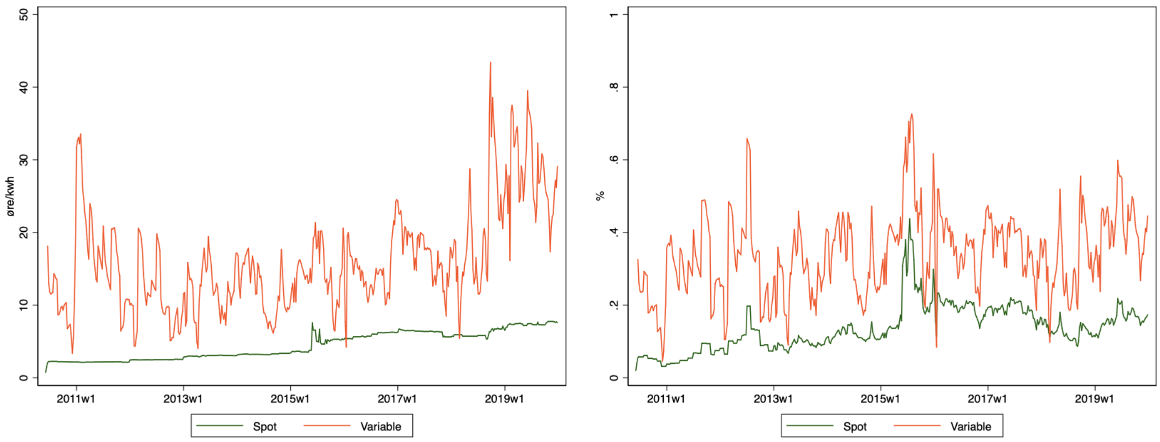
As stated earlier, spot price contracts are generally less costly to administer than variable price contracts. With variable price contracts, retailers need to inform their customers about price changes, and these price changes cannot be implemented earlier than two weeks after such notification has taken place. With spot price contracts, however, retailers have a fixed markup on the wholesale price, and are thereby hedged towards the risk of wholesale price fluctuations. Consequently, prices of spot contracts are generally lower, but more volatile, than those of variable price contracts, as can be seen from figure 3.4.



Data source: The Norwegian Consumer Council and the Norwegian Competition Authority.

Figure 3.4: The average price per contract type.

Another potential reason for the increasing popularity of spot price contracts we saw in figure 3.3, is that the spot price contracts ensure transparency of the retailer's markup on the wholesale price. The reason is that the spot price contracts are listed with markups per kWh, rather than price per kWh as for variable price contracts, plus any fixed fees. Consequently, the consumers can tell whether a price increase is caused by an increase in the retailer's markup or an increase in the wholesale price, i.e. the Elspot price. Due to the transparency of markups, as well as the retailer's need to hedge towards the risk of wholesale price fluctuations on variable price contracts, markups are generally lower on spot price contracts than on variable price contracts. In figure 3.5 below, we have graphed the average markup on the wholesale price per contract type. The absolute markups are calculated by subtracting the Elspot price in the region which the contract is offered, from the price of the contract. The markups in percent are calculated as the absolute markup relative to the price. The average markup on spot price contracts is 4.43 øre/kWh, or 13.49 %, while the average markup on variable price contracts is 16.03 øre/kWh, or 34.06 %. In addition to being lower, we can see that the absolute markups are less volatile for spot price contracts than for variable price contracts. The reason is simply that, for spot price contracts the markups on the wholesale price are fixed, while for variable price contracts the retail prices are fixed, at least for some time period. Consequently, only the markups on variable price contracts are sensitive to wholesale price fluctuations. The percentage markups, however, fluctuate for both contract types, as these are measured relative to the retail prices, which for both contract types are sensitive to wholesale price fluctuations.

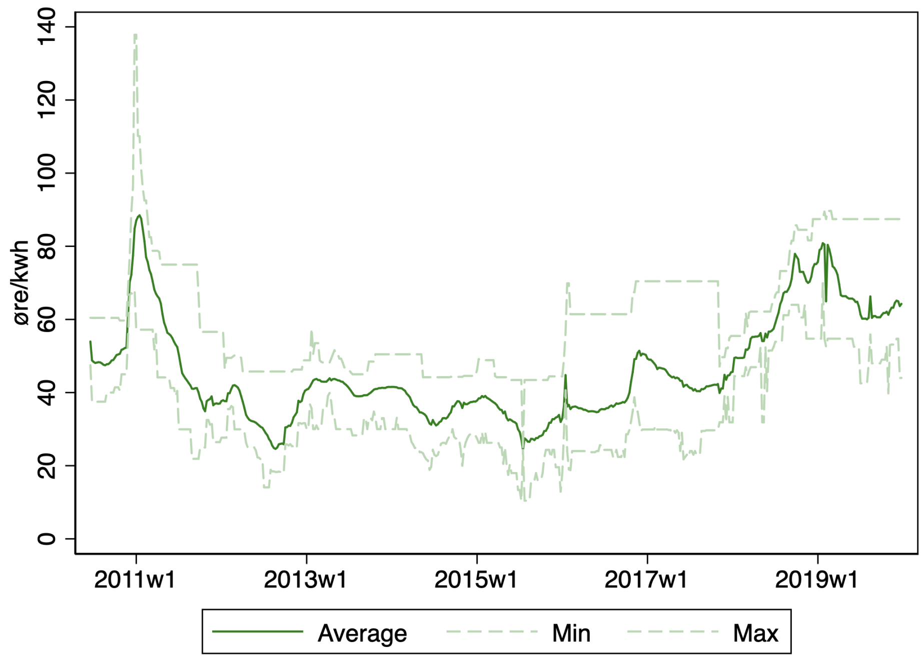


Data source: The Norwegian Consumer Council, the Norwegian Competition Authority and Nord Pool.

Figure 3.5: The average markup on the wholesale price in øre and percent per contract type.

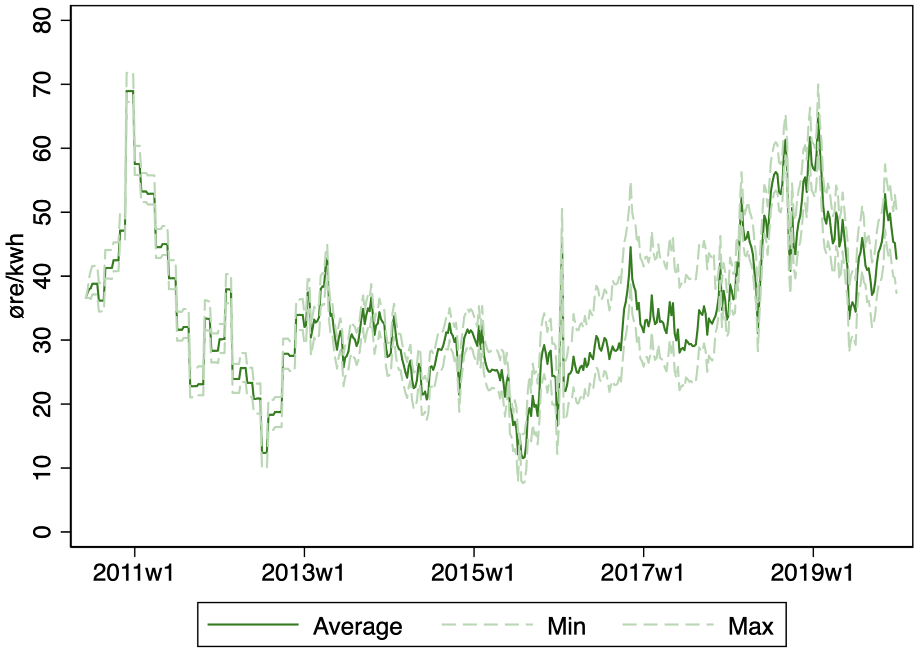
As we saw from the distribution of market shares in figure 3.2, the degree of competition varies across the different geographical markets. Some markets are close to monopolies, while others have a more even distribution of market shares and thus stronger competition. A consequence of weakened competition may be that the largest suppliers, with the most market power, charge higher markups than the other retailers. However, in our sample, the largest supplier has the highest markup in 749 out of 2,733 market observations, or about 27 %, which is just a bit more than one would expect from random sampling. Investigating this further, we can also check whether these 749 market observations are the same markets as those are close to monopolies, i.e. markets where the largest supplier captures more than 90 % of the market. However, the average market share of the largest suppliers who also has the highest markups is 76 %, only a bit higher than the sample average of 72 %. Thus, we do not find any evidence that higher market shares and more market power lead to higher markups in the Norwegian electricity market. One explanation may be that the largest retailer in each geographical market tends to be a large nationwide retailer offering nationwide contracts without any price discrimination across markets.

In addition to variable price contracts generally being more expensive and having a higher markup on the wholesale price, there is also a bigger price variation between variable price contracts than between spot price contracts. In figure 3.6 and 3.7 below, we have graphed the minimum, maximum and the (unweighted) average price observed for variable and spot price contracts, respectively. Comparing these figures, it seems like there is more price variation among the variable price products than the spot price products, which can have some implications for consumer choice. Although variable price contracts in general are more expensive than spot price contracts, there is also possible to find relatively cheap variable price contracts. However, a bigger variation in the price of variable price contracts implies that finding a cheap variable price contract can require more information and searching, than finding a cheap spot price contract. Consequently, as the consumer's purchase decision requires information and searching, switching costs may arise. On the contrary, due to smaller variation in prices, searching is less important and switching costs are thus likely to be lower for spot price contracts than for variable price contracts.



Data source: The Norwegian Consumer Council and the Norwegian Competition Authority.

Figure 3.6: The average, minimum and maximum price on variable price contracts.



Data source: The Norwegian Consumer Council and the Norwegian Competition Authority.

Figure 3.7: The average, minimum and maximum price on spot price contracts.

Although variable price contracts generally are more expensive and have higher markups than spot price contracts, it may be that the two contract types are aimed towards different segments. It can be said that spot price contracts involves more risk than variable price contracts, as spot price contracts are tied to the Elspot price which can fluctuate. With variable price contracts the consumer is notified about every price change two weeks before implementation. However, every significant or persistent change in the Elspot price will eventually also cause a price change in the variable price contracts, as the wholesale price is the supplier's marginal cost of selling the product. Therefore, although the two contract types may involve different degrees of risk, we will consider them homogeneous when we estimate switching costs. Consequently, as searching is more important among variable price contracts than spot price contracts, due to more price variation, we might be underestimating the switching costs of the consumers on variable price contracts and overestimating the switching costs of the consumers on spot price contracts. Nevertheless, as we cannot distinguish customers on one contract type from customers on another contract type in our aggregated market share data, we consider the two contract types homogeneous in our estimation. But before we go on to estimate switching costs, it is interesting to see if there in fact are any gains from switching between retailers.

3.2.3 Arbitrage

Another way of measuring systematic price differences is to consider gains from arbitrage. That is, to estimate the potential gains from switching between retailers. We could also consider switching between contract types within the same retailer, but in the presence of switching costs, this is likely to be less costly for the customers as they do not need to set up new supplier relationships. Additionally, as we saw from the previous section, the variable price contracts are systematically higher priced than the spot price contracts. In fact, the customers of all suppliers offering both a variable price contract and a spot price contract, would gain from switching to their current supplier's spot price contract.

In table 3.2 and 3.3, we have estimated the yearly gains from switching between nationwide offered contracts within each contract type. Similar to von der Fehr and Hansen (2010), we consider the potential gain from following a perfect-foresight, optimal switching strategy by switching to the cheapest retailer in the beginning of each week, rather than staying with each particular supplier throughout the whole year. We realize that the weekly switching strategy may be too heroic for most consumers. The estimates can therefore be interpreted as an upper bound for the gains from switching. If a consumer were to rather switch once a year, the gains from switching would decrease, as the prices of the contracts varies throughout the year. More specific, the gains from switching are estimated by first calculating the price differences in øre/kWh between each contract and the cheapest contract offered each week, within each contract type. These price differences are then multiplied by the yearly average consumption of 16,000 kWh, such that we are left with weekly observations of yearly gains if the consumer could pay this price throughout the year. However, the prices used to calculate these gains apply to the week of switching only. Therefore, we average the yearly gains from weekly switching over each year. The yearly gains are also divided by 100, in order to convert the gains from øre to NOK. That is, within each contract type $C = \{variable, spot\}$, the yearly gain from weekly switching to the cheapest contract, relative to staying with firm i throughout the year, is given by

$$gains_i = \frac{1}{52} \sum_{t=1}^{52} \left(p^C_{i,t} - p^C_{min,t} \right) \frac{16000}{100} \tag{3.1}$$

where $p^C_{i,t}$ is the price of firm i's contract of type C at time t, and $p^C_{min,t}$ is the cheapest contract of type C offered at time t.

In table 3.2 below, we have only included the nationwide suppliers that offered a variable price product throughout the whole estimation period of 2010-2015.

Year	Fjord-kraft	Gudbr-andsdal	Hafslund	Luster	Lærdal	Stranda	Telinet	Tussa-24	Uste-kveikja
2010	570 (8 %)	1,208 (14 %)	336 (4 %)	1426 (17 %)	1,562 (18 %)	1,502 (17 %)	1,136 (12 %)	1,162 (14 %)	1,138 (13 %)
2011	541 (7 %)	1,307 (15 %)	285 (4 %)	1,541 (19 %)	1,587 (19 %)	1,592 (19 %)	1,152 (12 %)	1,205 (15 %)	1,419 (17 %)
2012	479 (11 %)	1,379 (24 %)	176 (4 %)	1,152 (21 %)	1,436 (25 %)	1,270 (23 %)	848 (15 %)	916 (18 %)	754 (15 %)
2013	1,117 (16 %)	1,154 (17 %)	450 (7 %)	1,282 (18 %)	897 (13 %)	1,362 (19 %)	988 (14 %)	821 (13 %)	848 (13 %)
2014	1,949 (30 %)	1,347 (22 %)	1,197 (21 %)	1,486 (25 %)	1,240 (20 %)	1,315 (22 %)	1,176 (19 %)	787 (14 %)	1,243 (21 %)
2015	1,509 (25 %)	1,544 (25 %)	619 (18 %)	1,891 (35 %)	1,532 (25 %)	2,551 (43 %)	2,399 (37 %)	790 (18 %)	1,672 (31 %)

Table 3.2: Potential gains from switching between variable price contracts in NOK and percent.

We can see that the highest gain from switching was for customers of Stranda in 2015, who on average could save 2,551 NOK or 43 % on their yearly electricity bill by following the optimal switching strategy. That is, rather than staying with Stranda throughout 2015, one could save 2,551 NOK by, in the beginning of each week, switching to the retailer offering the cheapest variable price contract that week. The average yearly gain from switching across all nationwide retailers, throughout the whole estimation period, was 1,190 NOK or 18 %. These estimates indicate significant gains from arbitrage between variable price contracts. As stated earlier, von der Fehr and Hansen (2010) find gains from the same switching strategy in the range of 0 % to 17 % for the period of 2001-2006. Consequently, there are more gains from switching, and thus more price variation, in our sample period.

Moreover, in order to measure systematic price variation among spot price contracts, we have estimated the potential gains from switching between the retailers' spot price products over the same time period. Similar to above, we have estimated the potential gain from following the optimal switching strategy among spot price contracts rather than staying with each specific retailer. The results are shown in table 3.3 below.

Year	Fortum	Gudbr-andsdal	Kraftinor	Luster	Lærdal	Norges-Energi	SKS	Svorka	Uste-kveikja
2010	150 (2 %)	175 (2 %)	45 (1 %)	278 (4 %)	254 (4 %)	156 (2 %)	198 (3 %)	212 (3 %)	141 (2 %)
2011	159 (3 %)	199 (4 %)	53 (1 %)	284 (5 %)	260 (5 %)	163 (3 %)	205 (4 %)	237 (4 %)	192 (3 %)
2012	277 (8 %)	296 (8 %)	72 (2 %)	303 (8 %)	329 (9 %)	277 (8 %)	343 (9 %)	441 (12 %)	373 (10 %)
2013	301 (6 %)	465 (9 %)	285 (6 %)	489 (9 %)	413 (8 %)	221 (4 %)	429 (8 %)	450 (9 %)	264 (5 %)
2014	373 (8 %)	581 (13 %)	475 (11 %)	592 (13 %)	533 (12 %)	43 (1 %)	395 (9 %)	498 (11 %)	222 (5 %)
2015	568 (16 %)	579 (13 %)	814 (18 %)	523 (15 %)	664 (15 %)	48 (1 %)	479 (11 %)	541 (13 %)	103 (2 %)

Table 3.3: Potential gains from switching between spot price contracts in NOK and percent.

As we can see, the highest gain from switching was for customers of Kraftinor in 2015, who on average could save 814 NOK or 18 % on their yearly electricity bill. Comparing with table 3.2, we see that the gains from switching retailer is generally lower for spot price contracts. The average gain from switching retailer between variable price contracts was 1,190 NOK or 18 %, while for spot price contracts the average gain was 323 NOK or 7 %. This shows that there is much less price variation among spot price contracts, than among variable price contracts.

This finding can be further justified by the potential gains from switching from the variable price contracts considered in table 3.2 to the average spot price contract, i.e. the average price on all nationwide offered spot price contracts in table 3.3. To obtain these gains, the consumer does not need to follow the optimal weekly switching strategy, but rather switch to an average spot price contract one time only. This switching strategy is therefore a more realistic one. However, it is only possible to obtain these gains for consumers who currently are on variable price contracts. These gains are estimated by first calculating the difference between the price of each variable price contract and the average spot price contract. Similar to in (3.1), these price differences are multiplied with 16,000 kWh and divided by 100, such that we obtain the yearly gains from switching in NOK, which in turn is averaged over each year. That is, the yearly gains from switching from firm i's variable price contract to an average spot price contract, is given by

$$gains_i = \frac{1}{52} \sum_{t=1}^{52} \left(p_{i,t}^{variable} - \bar{p}_t^{spot} \right) \frac{16000}{100} \tag{3.2}$$

where $p_{i,t}^{variable}$ is the price of firm i's variable price contract, and $\bar{p}_t^{spot}$ is the average price of the spot price contracts, both at time t. The potential gains from arbitrage between variable price contracts and the average spot price contract is shown in table 3.4 below.

Year	Fjord-kraft	Gudbr-andsdal	Hafslund	Luster	Lærdal	Stranda	Telinet	Tussa-24	Uste-kveikja
2010	856 (12 %)	1,422 (16 %)	619 (8 %)	1,672 (20 %)	1,808 (21 %)	1,748 (20 %)	1,482 (16 %)	1,425 (17 %)	1,375 (16 %)
2011	2,003 (23 %)	2,699 (29 %)	1,851 (22 %)	2,900 (32 %)	2,946 (32 %)	2,952 (32 %)	2,561 (27 %)	2,564 (28 %)	2,828 (31 %)
2012	1,006 (21 %)	1,772 (31 %)	731 (16 %)	1,547 (28 %)	1,699 (30 %)	1,666 (30 %)	1,335 (24 %)	1,344 (26 %)	1,197 (23 %)
2013	1,553 (23 %)	1,592 (23 %)	921 (15 %)	1,714 (24 %)	1,376 (20 %)	1,794 (25 %)	1,427 (20 %)	1,253 (19 %)	1,292 (20 %)
2014	2,067 (32 %)	1,523 (25 %)	1,344 (23 %)	1,604 (26 %)	1,489 (24 %)	1,433 (23 %)	1,347 (21 %)	909 (15 %)	1,415 (24 %)
2015	1,804 (30 %)	1,759 (28 %)	882 (17 %)	1,739 (31 %)	1,857 (30 %)	2,262 (38 %)	2,280 (34 %)	803 (16 %)	1,707 (33 %)

Table 3.4: Potential gains from switching from variable contracts to the average spot contract.

Again, we find significant gains from switching from variable price contracts to spot price contracts. The gains from switching to the average spot price contract is a good approximation for the gains from switching to any spot price contract, due to small price variation among spot price products. This is highlighted by figure 3.7, as well as the small gains from arbitrage in table 3.3. Similar to in table 3.2, we can see that the largest gain from switching, in relative terms, is for customers of Stranda in 2015. These customers could on average save as much as 2,262 NOK or 38 % on their yearly electricity bill by switching to spot price contracts. On average, the yearly gain from switching from a variable price contract to a spot price contract was 1,651 NOK or 24 %. Note that, although the gains from switching between variable price contracts in table 3.2 are higher than the gains from switching to the average spot price contract, the estimates in table 3.2 are based on a weekly switching strategy. The gains in table 3.4, however, can be obtained by switching to a spot price contract one time only.

Comparing with the estimates in von der Fehr and Hansen (2010), we find significantly higher gains from switching from variable price contracts to spot price contracts in our sample. Specifically, they find gains from switching from variable price contracts to the average spot price contract in the range from -26 % to 20 %. Consequently, it seems like the price difference between variable price contracts and spot price contracts is larger for our sample period of 2010-2015, compared to their sample period of 2001-2006. This may also explain the increasing popularity of spot price contracts since then.

4 Models for Estimating Switching Costs

Based on the evidence from the previous chapter, there is a lot to gain from switching supplier. However, we do not observe every consumer switching weekly, indicating that the consumers may perceive switching as costly. We will therefore present the two models we utilize to estimate switching costs. The reason that we use two different models is to ensure robustness of our results, such that we can say something significant about the switching costs in the Norwegian electricity market. The two models are based on different assumptions, however, which is why we will discuss their differences, and the implications of these, in section 4.3. Although there are some differences, the novelty of both of these models lies in their ability to extract information about the significance and magnitude of the switching costs from highly aggregated market share data. Model 1 is an application of the model in Shy (2002), while Model 2 follows the methodology in Kim et al. (2003) with some minor adjustments in order for the model to fit our data. Moreover, both models consider an oligopoly with homogeneous products and multiple-stage price competition, i.e. dynamic Bertrand competition. In other words, firms compete on prices and each period's actions affect both current and future profits.

4.1 Model 1: Shy's 'quick-and-easy' method

Consider first a duopoly[3] where firm A produces brand A and firm B produces brand B. Let N_A denote the number of consumers who have already bought brand A (α consumers) and N_B denote the number of consumers who have already bought brand B (β consumers). Furthermore, let the prices charged by firm A and firm B be denoted by p_A and p_B, respectively. Let $S > 0$ denote the switching cost the consumer face when switching between the two firms. Also, let U_α denote the utility from purchasing brand A, and U_β denote the utility for purchasing brand B. In sum, each consumer type's utility from the

[3]We will extend the model to an oligopoly with $I > 2$ firms later on.

next purchase is given by

$$
\begin{aligned}
U_\alpha &:= \begin{cases} -p_A & \text{if staying with brand A} \\ -p_B - S & \text{if switching to brand B,} \end{cases} \\
U_\beta &:= \begin{cases} -p_B & \text{if staying with brand B} \\ -p_A - S & \text{if switching to brand A.} \end{cases}
\end{aligned}
\tag{4.1}
$$

Moreover, let n_A and n_B denote the number of consumers who choose brand A and brand B, respectively, on their next purchase. Then, from the utility function in (4.1), we have that

$$
\begin{aligned}
n_A &= \begin{cases} 0 & \text{if } p_A > p_B + S \\ N_A & \text{if } p_B - S \leqslant p_A \leqslant p_B + S \\ N_A + N_B & \text{if } p_A < p_B - S, \end{cases} \\
n_B &= \begin{cases} 0 & \text{if } p_B > p_A + S \\ N_B & \text{if } p_A - S \leqslant p_B \leqslant p_A + S \\ N_A + N_B & \text{if } p_B < p_A - S. \end{cases}
\end{aligned}
\tag{4.2}
$$

Assuming that the production costs are zero, the firms' profits as functions of prices are given by

$$
\pi_A(p_A, p_B) = p_A n_A \quad \text{and} \quad \pi_B(p_A, p_B) = p_B n_B, \tag{4.3}
$$

where n_A and n_B comes from (4.2). Without loss of generality, this also applies to the Norwegian electricity retail market where firms have equal marginal costs, given by the Elspot price.

Moving forward, we need to establish the *undercut-proof property* (UPP) of a Nash-Bertrand equilibrium. First, a Nash-Bertrand equilibrium refers to the Nash equilibrium of a market with price (Bertrand) competition. That is, given firm B's optimal price p_B^N, firm A choose the price p_A^N that maximizes its profit. Similarly, given p_A^N, firm B choose the profit-maximizing price p_B^N. Thus, the pair of prices (p_A^N, p_B^N) constitutes a Nash-Bertrand equilibrium if no firm have any incentive to deviate. However, in the presence of switching costs, no such equilibrium exists in pure strategies. The reason is that firm A can set its price to $p_A = p_B + S$ without losing any customers, while firm B can set its price to $p_B = p_A + S$ without losing any customers. We can easily verify that these two best response functions have no solution in pure strategies (given $S > 0$).

However, although there are no pure-strategy Nash-Bertrand equilibrium in this simple model, one important property of the Nash-Bertrand equilibrium, namely the undercut-proof property, is present. This property can be used to predict the prices set by the firms in the presence of switching costs. For instance, firm A is said to undercut firm B if it sets its price such that $p_A < p_B - S$. That is, firm A subsidize the switching costs of firm B's customers in order to win them over. Thus, from (4.2), we can see that if firm A undercuts firm B, all consumers choose firm A, i.e. $n_A = N_A + N_B$ and $n_B = 0$. Then, the UPP is satisfied if there exists a price pair such that neither firm can increase their profit by undercutting the competitor, nor increase its price without being undercut by the competitor. That is, a pair of prices satisfies the UPP if

1. For a given p_B^U and n_B^U, firm A sets the highest p_A^U subject to $\pi_B^U = p_B^U n_B^U \geq (p_A - S)(N_A + N_B)$.
2. For a given p_A^U and n_A^U, firm B sets the highest p_B^U subject to $\pi_A^U = p_A^U n_A^U \geq (p_B - S)(N_A + N_B)$.
3. The distribution of customers between the firms are given by equation (4.2).

The first two captures the condition that no firm should be able to profitably undercut its competitor. However, the firms will increase their prices until the two inequalities are binding. We can therefore solve the two equations for the unique pair of prices that satisfies the UPP, i.e.

$$p_A^U = \frac{(N_A + N_B)(N_A + 2N_B)S}{(N_A)^2 + N_A N_B + (N_B)^2} \quad \text{and} \quad p_B^U = \frac{(N_A + N_B)(2N_A + N_B)S}{(N_A)^2 + N_A N_B + (N_B)^2}. \tag{4.4}$$

We are now ready to extend the model to a multi-firm industry. Rather than the simple duopoly, consider now an oligopoly with $I \geq 2$ firms who set prices p_i $(i = 1, 2, ...I)$. Assume that each firm considers undercutting one competing firm at a time. If prices satisfy the UPP, the larger market share a firm has, the more profitable is the firm. Thus, the firm with the smallest market share will have the strongest incentive to undercut all other firms. Let us sort the firms after their market shares in descending order, i.e. $N_1 > N_2 > ... > N_I$. Given that firm I has an incentive to undercut all other firms, each firm $i \neq I$ set its price p_i with reference to p_I to prevent being undercut. On the other hand, firm I fears being targeted by firm 1, and therefore sets its price p_I with reference to p_1 to prevent being undercut.

If we let S_i denote the switching cost for the customers of a specific firm i, each firm $i \neq I$ takes p_I as given and sets the maximal p_i subject to the first condition of the UPP, i.e.

$$\pi_I^U = p_I^U n_I^U \geq (p_i - S)(N_i + N_I). \tag{4.5}$$

In other words, each firm i sets the highest price it can, while at the same time making sure undercutting is not profitable for firm I. Again, as each firm will increase its price until (4.5) is binding, we can solve the equation for the unobserved switching costs. That is, from the observed prices and market shares we can find the implicit switching costs, given by

$$S_i = p_i - \frac{N_I p_I}{N_i + N_I}, \tag{4.6}$$

for customers of firm $i \neq I$. Similarly, firm I sets the highest price it can, subject to the second condition of the UPP, i.e.

$$\pi_1^U = p_1^U n_1^U \geq (p_I - S)(N_1 + N_I). \tag{4.7}$$

Thus, ensuring (4.7) is binding, switching costs for customers of firm I is given by

$$S_I = p_I - \frac{N_1 p_1}{N_1 + N_I}. \tag{4.8}$$

Finally, we can rewrite (4.6) and (4.8) as a single equation identifying switching costs, given by

$$S_i = \begin{cases} p_i - \frac{N_I p_I}{N_i + N_I} & \text{for } i \neq I \\ p_i - \frac{N_1 p_1}{N_1 + N_i} & \text{for } i = I. \end{cases} \tag{4.9}$$

We will return to this equation in chapter 5, when we will explain the empirical methodology used to calculate switching cost.

4.2 Model 2: Kim, Kliger and Vale's model

Consider an oligopoly with n firms who sell a homogeneous product and compete in a multiple-stage price competition, i.e. dynamic Bertrand competition. The product is nondurable, meaning it must be consumed the same period as it is bought. Moreover, the demand for the product is inelastic. To start with, we assume that each consumer buys one unit of the product in each of infinitely many discrete periods[4]. We will now derive the demand and supply equations in the presence of switching costs, which through simultaneous estimation will determine the implicit switching costs embedded in the optimal consumer and firm behavior.

4.2.1 Demand and optimal consumer behavior

The consumers are utility maximizing and take both current prices and the fact that switching is costly into account when deciding on which firm to buy the product from. From the utility maximizing behavior of the consumers, we can obtain *transition probabilities* as functions of prices and switching costs. The transition probabilities are simply the probabilities for consumers to switch between firms. Hence, the aggregated transition probabilities is the demand faced by each firm. By approximating demand this way, we allow for consumer heterogeneity in the model, in the sense that not all consumers necessarily choose the firm that charges the lowest price. In fact, conditional on the transition probabilities not being null or unity, some consumers will switch to and from each firm.

Let the probability that a current customer of firm i stays with the same firm in period t be denoted by $Pr_{i\to i,t}$, and the probability for a customer of firm j to switch to firm i be denoted by $Pr_{j\to i,t}$. These transition probabilities are functions of firm i's price, $p_{i,t}$, the $(n-1)$ vector of prices charged by the rival firms, $\mathbf{p}_{iR,t}$, and the cost of switching to another firm, s. Then, the probability for a consumer to stay with firm i is given by

$$Pr_{i\to i,t} = f(p_{i,t}, \mathbf{p}_{iR,t} + \mathbf{s}). \tag{4.10}$$

Note that switching costs are embedded in the function as the vector $\mathbf{s}$, which equals the

[4] We will relax on this assumption in a bit.

scalar s multiplied by a $(n-1)$ unity vector. This implies that switching to any other firm is equally costly. Given this, the probability for a consumer of another firm j to switch to firm i is given by

$$Pr_{j\to i,t} = f(p_{i,t} + s, \mathbf{p}_{iR,t} + \mathbf{s}_j). \tag{4.11}$$

Here, the vector of switching costs, $\mathbf{s}_j$, is the scalar s times a $(n-1)$ vector where each element is unity, except for the jth, which is zero. However, as actual switching is not observed in aggregate market share data, we must formulate the probability of a consumer switching to firm i unconditional on the rival j's identity. Thus, we can rewrite (4.11) as

$$Pr_{iR\to i,t} = \sum_{j\neq i}\left(f(p_{i,t} + s, \mathbf{p}_{iR,t} + \mathbf{s}_j)\frac{y_{j,t-1}}{\sum_{k\neq i} y_{k,t-1}}\right), \tag{4.12}$$

where $Pr_{iR\to i,t}$ is the probability that any of the rivals' customers switch to firm i. We denote each rival j's output at time $t-1$ by $y_{j,t-1}$, such that $y_{j,t-1}/\sum_{k\neq i} y_{k,t-1}$ denotes the probability that the customer of a randomly selected rival, iR, is indeed a customer of firm j. By aggregating the transition probabilities over all consumers, we find the demand faced by firm i at time t, given by

$$y_{i,t} = y_{i,t-1}Pr_{i\to i,t} + y_{iR,t-1}Pr_{iR\to i,t}. \tag{4.13}$$

The first term of the demand function approximates the number of customers retained, while the second term approximates the number of customers won over from the firm's rivals. We now relax the assumption that each consumer buys only one unit of the good in each period, by multiplying the demand faced by each firm with the market growth rate $g_t = \sum y_{i,t}/\sum y_{i,t-1}$. Thus, we can rewrite (4.13) as

$$y_{i,t} = (y_{i,t-1}Pr_{i\to i,t} + y_{iR,t-1}Pr_{iR\to i,t})g_t. \tag{4.14}$$

However, our aggregate market share data only reveal the net consumer switching to each firm. The net number of switches can result from numerous different combinations of consumers switching to and from each firm. Moving forward, we therefore need to approximate the transition probabilities from aggregate data, such that we can obtain the demand faced by each firm as functions of prices, market shares and implicit switching costs only. In order to do so, we first apply a first-order, linear approximation of the transition probabilities. If we let $\bar{p}_{iR,t}$ denote the average price charged by firm i's rivals, we can rewrite the linearly approximated transition probabilities as

$$\begin{aligned} Pr_{i \to i,t} &= \alpha_0^i + \alpha_1 p_{i,t} + \alpha_2(\bar{p}_{iR,t} + s), \\ Pr_{iR \to i,t} &= \alpha_0^i + \alpha_1(p_{i,t} + s) + \alpha_2(\bar{p}_{iR,t} + \frac{n-2}{n-1}s), \end{aligned} \tag{4.15}$$

where α_0^i are firm-specific intercepts, α_1 measures the price sensitivity and α_2 measures the cross-price sensitivity of the transition probabilities. For economic interpretation, the transition probabilities should be decreasing in the firm's own price, i.e. $\alpha_1 < 0$, and be increasing in the rivals' average price, i.e. $\alpha_2 > 0$. Moreover, we assume that a marginal increase in firm i's price $p_{i,t}$, should have the same effect on the transition probabilities as a marginal decrease in the rivals' average price $\bar{p}_{iR,t}$. That is, we restrict $\alpha_2 = -\alpha_1$. Hence, we can rewrite the equations in (4.15) as

$$\begin{aligned} Pr_{i \to i,t} &= \alpha_0^i + \alpha_1(p_{i,t} - \bar{p}_{iR,t} - s), \\ Pr_{iR \to i,t} &= \alpha_0^i + \alpha_1(p_{i,t} - \bar{p}_{iR,t} + \frac{s}{n-1}). \end{aligned} \tag{4.16}$$

By substituting the linear transition probabilities above into firm i's demand function (4.14), and divide through the equation by time t, we obtain firm i's market share at time t, given by

$$\sigma_{i,t} = -\sigma_{i,t-1}\frac{n}{n-1}s\alpha_1 + \alpha_0^i + \alpha_1\Big(p_{i,t} - \bar{p}_{iR,t} + \frac{s}{n-1}\Big). \tag{4.17}$$

From the market share equation, we can see that a firm's market share is a function of their last period's market share, the number of competing firms, the switching costs, the firms' heterogeneity (represented by α_0^i), and their rivals' prices. Moreover, from the market share equation, we can break the effect of implicit switching costs into the *lock-in effect* and the *switching-cost effect*. The lock-in effect denotes the effect of a firm's preceding period's market share on current market share, and is given by

$$\frac{\partial \sigma_{i,t}}{\partial \sigma_{i,t-1}} = -\frac{n}{n-1}s\alpha_1 > 0. \tag{4.18}$$

By taking the derivative of (4.18) with respect to s, we can see that the lock-in effect is increasing in the switching costs. That is, the higher the switching costs are, the more customers are each firm able to retain from one period to another. The switching-cost effect, however, denotes the effect of switching costs on current market share, and is given by

$$\frac{\partial \sigma_{i,t}}{\partial s} = \left(\frac{1}{n} - \sigma_{i,t-1}\right)\frac{n}{n-1}\alpha_1 \begin{cases} < 0 & \text{if } \sigma_{i,t-1} < 1/n \\ > 0 & \text{if } \sigma_{i,t-1} > 1/n. \end{cases} \tag{4.19}$$

From the switching-cost effect, we can see that the existence of switching costs works in favor of larger-than-average firms, and against the smaller than-average firms. The reason is simply that the larger market share a firm has, the more consumers are locked in with that firm and the less consumers are locked out.

4.2.2 Supply and optimal firm behavior

Each firm maximizes a value function, which is equal to the present value of their infinite annuity of profits, at any given time τ. Thus, the optimization problem of the firm is given by

$$\max V_{i,\tau} = \sum_{t=\tau}^{\infty} \delta^{t-\tau} \pi_{i,t}, \tag{4.20}$$

where δ is a discount factor and the firm's time t profit $\pi_{i,t} = y_{i,t} \cdot p_{i,t} - c_{i,t}$. The first-order[5] condition of the maximization problem is given by

$$\frac{\partial V_{i,\tau}}{\partial p_{i,\tau}} = y_{i,\tau} + \sum_{t=\tau}^{\infty} \delta^{t-\tau}\left(p_{i,t} - \frac{\partial c_{i,t}}{\partial y_{i,t}}\right)\frac{\partial y_{i,t}}{\partial p_{i,\tau}} = 0. \tag{4.21}$$

Moreover, as current prices also affect future demand, another condition for the firm's maximization problem is that the derivative of the value function (4.20) with respect to the time $\tau + 1$ price, $p_{i,\tau+1}$, also is zero. That is,

$$\frac{\partial V_{i,\tau}}{\partial p_{i,\tau+1}} = y_{i,\tau+1} + \sum_{t=\tau}^{\infty} \delta^{t-\tau+1}\left(p_{i,t} - \frac{\partial c_{i,t}}{\partial y_{i,t}}\right)\frac{\partial y_{i,t}}{\partial p_{i,\tau+1}} = 0. \tag{4.22}$$

The necessary conditions for optimal firm behavior are therefore given by (4.21) and (4.22), and any linear combination of them should hold as well. That is, for any $dp_{i,\tau}$ and

[5] The second-order condition is also satisfied, as the value function is a discounted sum of concave profit functions, $\pi_{i,t}$, and the future demanded quantities can be expressed as a linear function of current demand $y_{i,t}$, such that the value function itself indeed is concave.

$dp_{i,\tau+1}$, the firm's pricing strategy should be such that

$$\frac{\partial V_{i,\tau}}{\partial p_{i,\tau}} dp_{i,\tau} + \frac{\partial V_{i,\tau}}{\partial p_{i,\tau+1}} dp_{i,\tau+1} = 0. \tag{4.23}$$

Consider the price differentials $dp_{i,\tau}$ and $dp_{i,\tau+1}$ that keeps demand $y_{i,\tau+1}$ constant. Then, we have

$$\begin{aligned} \frac{\partial y_{i,\tau+1}}{\partial p_{i,\tau}} dp_{i,\tau} + \frac{\partial y_{i,\tau+1}}{\partial p_{i,\tau+1}} dp_{i,\tau+1} = 0 \\ \Leftrightarrow dp_{i,\tau+1} = -\frac{\partial y_{i,\tau+1}}{\partial p_{i,\tau}} \bigg/ \frac{\partial y_{i,\tau+1}}{\partial p_{i,\tau+1}} dp_{i,\tau}. \end{aligned} \tag{4.24}$$

By substituting the expression for the output derivatives[6]

$$\begin{aligned} \partial y_{i,\tau+1}/\partial p_{i,\tau} &= -y_{\tau-1}\alpha_1 \frac{n}{n-1} \alpha_1 s g_\tau g_{\tau+1}, \\ \partial y_{i,\tau+1}/\partial p_{i,\tau} &= y_{\tau-1}\alpha_1 g_\tau g_{\tau+1}, \end{aligned} \tag{4.25}$$

into (4.24) above, we obtain the optimal time $\tau + 1$ price differential, $dp_{i,\tau+1}$, as a function of the time τ price differential, $dp_{i,\tau}$, for a constant future demand $y_{i,\tau+1}$. That is,

$$dp_{i,\tau+1} = dp_{i,\tau} \frac{n}{n-1} \alpha_1 s. \tag{4.26}$$

Moreover, as the future demand $y_{i,\tau+1}$ is constant, the linear combination of the necessary conditions in (4.23), can be rewritten as

$$\begin{aligned} \left(\frac{\partial \pi_{i,\tau}}{\partial p_{i,\tau+1}} + \delta \frac{\partial \pi_{i,\tau}}{\partial p_{i,\tau}} \right) dp_{i,\tau} + \delta \frac{\partial \pi_{i,\tau+1}}{\partial p_{i,\tau+1}} = 0 \\ \Leftrightarrow \frac{\partial \pi_{i,\tau}}{\partial p_{i,\tau}} dp_{i,t} + \delta \frac{\partial \pi_{i,\tau+1}}{\partial p_{i,\tau+1}} dp_{i,\tau+1} = 0. \end{aligned} \tag{4.27}$$

Then, if we write the derivative of the time τ profit, $\pi_{i,\tau}$, explicitly, we have that

$$y_{i,\tau} + \left(p_{i,\tau} - \frac{\partial c_{i,\tau}}{\partial y_{i,\tau}} \right) \frac{\partial y_{i,\tau}}{\partial p_{i,\tau}} + \delta y_{i,\tau+1} \frac{n}{n-1} \alpha_1 s = 0. \tag{4.28}$$

Finally, as $\partial y_{i,\tau}/\partial p_{i,\tau} = y_{\tau-1}\alpha_1 g_\tau$, we can rewrite (4.28) as

$$pcm_{i,t} = -\delta \sigma_{i,t+1} \frac{n}{n-1} s g_{t+1} - \frac{\sigma_{i,t}}{\alpha_1}, \tag{4.29}$$

[6] We skip the details, but confer with Appendix C in Kim et al. (2003) for a derivation of the output derivatives.

where $pcm_{i,t} = p_{i,t} - mc_{i,t}$ is the firm's price-cost margin at time t. This equation captures the relation between the firm's price-cost margin, the market shares and the switching costs, and represents both necessary conditions for the profit-maximizing behavior of the firm. The first term of the equation reflects the firm's benefit from capturing customers in period t that will be locked in with that firm in future periods. That is, if switching costs, s, or the market growth rate, g_{t+1}, is high, the firm will lower its price-cost margin in order to capture more customers. The second term reflects the market power of the firm. If the firm has a large market share, and thus more market power, they will have a larger price-cost margin. In the absence of switching costs, i.e. $s = 0$, the first order condition reduces to the standard one-period oligopoly outcome $pcm_{i,t} = -\sigma_{i,t}/\alpha_1$. Consequently, we can see that the existence of switching costs transforms the pricing strategy of the firm from a one-period decision to an intertemporal decision.

4.3 Model comparison

In the beginning of this chapter, we stated that we use two models in order to ensure robustness of our results. The models are derived from different assumptions, and we do therefore not expect to get exactly the same estimate of switching costs from them. However, if we get significant estimates of switching costs from both models, we believe that we have found firm evidence for the existence of switching costs.

The main difference between the two models is that Model 2 is a multiperiod model taking the intertemporal dynamics of demand and supply into account, while Model 1 identifies switching costs through a static equation of current prices and current market shares only. With time series of prices and market shares we can therefore obtain a time series of switching costs from Model 1, which we can use to see whether switching costs have changed over the estimation period. Model 2, on the other hand, accounts for the intertemporal dynamics of demand and supply by including lags and leads of prices and market shares in the identifying equations. The set of equations are in turn estimated simultaneously, in order to obtain a point estimate of switching costs for the entire estimation period. In addition, Model 2 allows for consumer heterogeneity in the sense that some consumers are switching to and from each firm with some probability, while Model 1 assumes that all consumers are switching if the gains from switching exceeds the switching costs. Moreover, Model 2 assumes that firms are maximizing the present value of their stream of future profits, while Model 1 assumes that firms are profit maximizing without being forward-looking. From Model 2 we can also obtain some other interesting estimates implied by the model, which we will return to when we present our results.

5 Empirical Methodology

In this part of the thesis, we describe the empirical methodology applied to estimate the models presented in chapter 4. From (4.9), we have that Model 1 identifies switching costs through the following equation

$$S_i = \begin{cases} p_i - \frac{N_I p_I}{N_i + N_I} & \text{for } i \neq I \\ p_i - \frac{N_1 p_1}{N_1 + N_i} & \text{for } i = I. \end{cases} \tag{5.1}$$

Hence, with Model 1 we can calculate switching costs using simple arithmetic operations. We do therefore not elaborate in further detail about the estimation process for Model 1 here.

For Model 2, however, an econometric method is needed to estimate the nonlinear system of equations that identifies switching costs. Recall that Model 2 identifies switching costs through (4.17) and (4.29). That is, the first-order condition

$$pcm_{i,t} = -\delta \sigma_{i,t+1} \frac{n}{n-1} sg_{t+1} - \frac{\sigma_{i,t}}{\alpha_1} + u_{1,i,t}, \tag{5.2}$$

and the market share equation

$$\sigma_{i,t} = -\sigma_{i,t-1} \frac{n}{n-1} s\alpha_1 + \alpha_0^i + \alpha_1 \Big(p_{i,t} - \bar{p}_{iR,t} + \frac{s}{n-1} \Big) + u_{2,i,t}, \tag{5.3}$$

where $u_{1,i,t}$ and $u_{2,i,t}$ are the idiosyncratic error terms from equation (5.2) and (5.3), respectively. The error terms capture measurements errors, random disturbances and shocks, as well as all explanatory variables excluded from the model, and are assumed to have zero mean. For instance, retailers may utilize different marketing strategies which are likely to affect demand and thus the market shares of the firms. In particular, it may be that both current and historical marketing effort affect the market share of the firm, meaning $u_{2,i,t}$ may contain both contemporaneous and lagged values of the unobserved marketing effort. The unobserved marketing effort may in turn affect the retailer's price-cost margin over time through the market shares in equation (5.2). Moreover, it may be that environmental consciousness and sustainability affect the purchasing decision of the consumer and therefore the market shares of the firms. For instance, some retailers offer products with guarantee of origin (GO), meaning the electricity is produced from renewable energy sources. This may add value to the product which is not accounted for in our model and thus captured by the error terms. Additionally, other corporate social responsibility (CSR) activities, such as charitable giving, volunteering in the community or improving labor policies, may make the consumers prefer one retailer over another. Consequently, these omitted variables may bias our estimates, as the model might attribute the effect of the variables excluded from the model to the included variables.

Furthermore, in order to eliminate the firm-specific intercepts, α_0^i, the market share equation (5.3) is first differenced. Thus, the system of equations to be estimated is given by the first order condition (5.2) and the first-differenced market share equation (5.4), i.e.

$$\Delta\sigma_{i,t} = -\Delta\sigma_{i,t-1}\frac{n}{n-1}s\alpha_1 + \alpha_1(\Delta p_{i,t} - \Delta\bar{p}_{iR,t}) + \Delta u_{2,i,t}. \tag{5.4}$$

Estimating the two equations separately by ordinary least squares (OLS) would give inconsistent and biased estimates, due to the simultaneity bias. The reason is that the dependent variables of each equation are independent variables in the other equation. Thus, the dependent variables are to be jointly determined by the two equations, such that the equations should be treated as a system of equations rather than separate equations.

The validity of the model is conditional on the transition probabilities in (4.16) being inside of the [0,1] interval. When switching costs are high, $Pr_{i\to i,t}$ and $Pr_{iR\to i,t}$ approach unity and zero, respectively. Thus, the valid switching cost range can be rewritten as

$$-1 \leq Pr_{i\to i,t} - Pr_{iR\to i,t} = -\alpha_1 s\frac{n}{n-1} \leq 1, \tag{5.5}$$

which is equivalent to

$$\frac{1}{\alpha_1}\frac{n-1}{n} \leq s \leq \frac{1}{-\alpha_1}\frac{n-1}{n}. \tag{5.6}$$

So, if the estimated switching costs lies outside of the range defined by (5.6), the estimates are invalid[7].

[7] In our estimation process, however, the constraint in (5.6) did hold, such that the implied transition probabilities are inside of the [0,1] interval.

5.1 Simultaneous equations models

Model 2 is a particular case of a simultaneous equations model (SEM). More generally, SEMs are a type of statistical model where the dependent variables are functions of other dependent variables, which are jointly determined within the system of equations. The system of equations consists of multiple structural equations imposed by economic theory, and the estimated values are typically the result of an equilibrium mechanism in the system.

In Model 2, the equilibrium mechanism is a result of the optimal firm and consumer behavior, explained in subsection 4.2.1 and 4.2.2, respectively. The model consists of the two structural equations in (5.2) and (5.4), where the endogenous variables to be jointly determined are the price-cost margins, $pcm_{i,t}$, the market shares, $\sigma_{i,t}$, and the prices, $p_{i,t}$ and $\bar{p}_{iR,t}$. That is, they are simultaneously determined within the system. The discount factor, δ, the number of firms, n, and the market growth rate, $g_{i,t}$, however, are assumed to be exogenous, i.e. determined outside of the model. Finally, the switching costs, s, and the price sensitivity of demand, α_1, are our parameters of interest. Our basic indication for the existence of switching costs is a positive value for s, and the validity of the model is conditional on a negative value for α_1 as demand should be downward sloping.

As Greene (2003) points out, the underlying theory on estimation of nonlinear system of equations is essentially the same as for linear systems. Moreover, he highlights two common estimation methods for these types of nonlinear systems, namely maximum likelihood estimation (MLE) and generalized method of moments (GMM). We utilize GMM to estimate our model, because GMM is generally considered more robust to parametric assumptions[8].

[8] The maximum likelihood estimator is, in context of the specified parametric model, efficient among consistent and asymptotically normally distributed estimators. The shortcomings of MLE is that in order to attain that efficiency, we need to make strong and restrictive assumptions about the distribution of the error terms. GMM, however, enables us to move away from those parametric assumptions, and obtain estimators that are robust to some variation in the underlying data generating process (Greene, 2003).

5.2 GMM, instruments and moment conditions

Recall that with SEMs, we have endogenous variables on both sides of both of the structural equations in our model. Therefore, if we were to use GMM estimation with no instrumental variables, our estimates would suffer from an endogeneity bias. The reason is that our endogenous independent variables in one equation are correlated with the error term of the other equation. The solution is therefore to use the instrumental variables (IV) approach. With IV estimation we can account for endogeneity by instrumenting each of the endogenous regressors with instrumental variables. The instruments must satisfy two conditions. Namely, that the instrument affects the dependent variable only through the endogenous regressor (the relevance condition), and that the instrument is uncorrelated with the error term (the exclusion restriction).

The endogenous variables in the model, namely the market shares, the retail prices and the price-cost margins, are instrumented by lagged values of market shares, output and the wholesale price. With exception of the wholesale price, the selected instruments correspond with those of Kim et al. (2003). Additionally, as pointed out by Silva and Lucinda (2017), since both equations are structural equations coming directly from the optimal firm and consumer behavior, the exclusion restrictions ensuring instrumental validity come directly from the derivation of the model. That is, if we believe that the model truly explains the optimal firm and consumer behavior, the instruments are valid as long as they do not affect the decision of the firms and consumers, other than through the endogenous regressors. Moreover, due to the high intertemporal correlation between market shares explained in section 3.2, we have included several lags of market shares in order to account for the persistent behavior of market shares. Additionally, it is common practice in applied econometrics to include lagged variables of the endogenous regressors in order to avoid the simultaneity bias, i.e. an endogeneity bias caused by the regressors being simultaneously determined with the dependent variable. In particular, we have instrumented the first-order condition (5.2) with three lags of market shares, $\sigma_{i,t-1}, \sigma_{i,t-2}$ and $\sigma_{i,t-3}$, one lag of output measured as the retailer's number of customers, $y^{cust}_{i,t-1}$, and one lag of output measured as the level of consumption, $y^{cons}_{i,t-1}$. That is, (5.2) is instrumented by $Z_{1,i,t} = (\sigma_{i,t-1}, \sigma_{i,t-2}, \sigma_{i,t-3}, y^{cust}_{i,t-1}, y^{cons}_{i,t-1})$. Furthermore, since the market share equation is first differenced, we have used first-differenced instruments. Particularly, we have instrumented equation (5.4) with three lags of first-differenced market shares, $\Delta\sigma_{i,t-1}, \Delta\sigma_{i,t-2}$ and $\Delta\sigma_{i,t-3}$, and the contemporaneous first-differenced wholesale price, i.e. the retailer's marginal cost, $\Delta c_{i,t}$. The wholesale price is included to instrument the endogenous retail prices, $\Delta p_{i,t}$ and $\Delta \bar{p}_{iR,t}$, in the last term of the market share equation. Thus, (5.4) is instrumented by $Z_{2,i,t} = (\Delta\sigma_{i,t-1}, \Delta\sigma_{i,t-2}, \Delta\sigma_{i,t-3}, \Delta c_{i,t})$. From the derivation of the model, we have that neither of the instruments $Z_{1,i,t}$ and $Z_{2,i,t}$ directly affect the optimizing behavior of the firm and consumer, respectively, meaning the set of instruments satisfies the exclusion restrictions. Moreover, with exception of the lagged values of market shares, the instruments seem likely to be uncorrelated with the omitted variables, such as marketing effort, environmental consciousness, sustainability and other CSR activities, and therefore with the the error terms as well. The lagged values of market shares are included as instruments, however, both to account for the persistent behavior of market shares and to avoid the simultaneity bias, which is common practice in applied econometrics.

Let $Z_{i,t} = (Z_{1,i,t}, Z_{2,i,t})$ denote the full set of instruments. The $L = 9$ instruments result in 9 moment conditions which, in matrix notation, are given by

$$g_i(\beta) = Z'_{i,t}u_{i,t} = Z'_{i,t}(y_{i,t} - X_i\beta), \tag{5.7}$$

where g_i is a $L \times 1$ matrix and $Z'_{i,t}$ is the transpose of the instrument vector $Z_{i,t}$, thus also a $L \times 1$ matrix (Baum et al., 2003). The assumption that each of the instrumental variables are exogenous can be expressed as $E(z_{i,t}u_{i,t}) = 0$. Thus, the L moment conditions, or orthogonality conditions, will be satisfied at the true values of β, given by

$$E(g_i(\beta)) = 0. \tag{5.8}$$

These L population moments correspond to L sample moments, written as

$$\bar{g}(\beta) = \frac{1}{n}\sum_{i=1}^{n} g_i(\beta) = \frac{1}{n}\sum_{i=1}^{n} Z'_{i,t}(y_{i,t} - X_i\beta) = \frac{1}{n}Z'u. \tag{5.9}$$

The objective of GMM is to choose the estimator for β, that is $\hat{\beta}$, which minimizes these L sample moments. The system is just identified if the number of moments, L, is exactly equal to the number of unknown parameters, i.e. the K coefficients in β. Then, if $L = K$, it is possible to find a $\hat{\beta}$ which solves equation (5.8). In our system of equations, however, the number of instruments, 9, is larger than the number of unknowns, 2. Consequently, the system is said to be overidentified. It is therefore not possible to find a $\hat{\beta}$ that sets all moment conditions equal to zero. That is, the system does not have an unique solution for the parameter values. Thus, GMM utilizes a $L \times L$ weighting matrix, W, in order to construct a weighted, quadratic form of the moment conditions. This results in the GMM objective function, given by

$$J(\beta) = n\bar{g}(\beta)'W\bar{g}(\beta). \tag{5.10}$$

The solution to the minimization problem gives us the GMM estimator, $\hat{\beta}_{GMM}$. Consequently, rather than just minimizing the sum of squared deviations, as with least squares estimation, we minimize a weighted function of the moment conditions. That is, with least squares estimation we assume that deviations from each moment condition is equally costly. However, a given absolute deviation from a moment condition with a relatively large variation, or that is more likely to deviate, should be less costly than the same absolute deviation from a moment condition with a smaller variation.

Moreover, the weighting matrix also allows for correlation across the moment conditions, which will be accounted for by the off-diagonal elements of the matrix. We start of with an initial weighting matrix, which is used to estimate the parameters. Then, we use the estimated parameters to recalculate the weighting matrix, which in turn is used to calculate new parameter estimates. We recalculate the weighting matrix for each iteration of the estimation process. The number of iterations can be predetermined, as with the two-step GMM estimator, or repeated until convergence, which is called the iterative GMM estimator. The two-step GMM estimator is generally considered sufficient, and the gains from using the iterative GMM estimator is ambiguous. Hall (2005) claims that there may be gains to finite-sample efficiency by using the iterative GMM estimator. However, as our sample size is relatively large, we only utilize the standard two-step GMM estimator in our analysis. Furthermore, we use the identity matrix as our initial weighting matrix, which will correspond to equal weights on each moment condition and no cross-moment correlation, as with least squares estimation.

6 Data

6.1 Data collection, cleaning and sensitivity

Our dataset contains a panel of monthly observations on the Norwegian electricity retail market, running from January 2011 to March 2016. We have data on the number of customers and the consumption for each of the five largest retailers on the 45 largest distribution grids. This is competition sensitive information provided by the Norwegian Water Resource and Energy Directorate (NVE), so whenever we use these, all companies will be made anonymous. Moreover, we have data on the prices of the products each retailer offers, provided by the Norwegian Competition Authority (until June 2015) and the Norwegian Consumer Council (from June 2015). As shown in figure 3.4 to 3.7, our data on prices spans from mid 2010 to the end of 2019. Our estimation period for switching costs, however, will be from January 2011 to March 2016, as this is the period which we have data on the retailers' market shares.

In the data cleaning process, we have dropped all products that are campaign products, limited offers, or offered exclusively to some customers (e.g. new customers, students, members of unions, etc.). We have also dropped all products that are not spot price contracts or variable price contracts in accordance with the Standard Agreement for Power Supply. The reason is that both non-standard contracts and, especially, fixed price contracts involves other degrees of risk, and can therefore not be considered homogeneous to spot price contracts and variable price contracts, which is an important assumption in both our models[9]. For instance, consumers who choose a fixed price contract over a variable price contract are typically more risk averse, and will therefore be willing to pay a (risk) premium in order to not be exposed to the risky element of the variable price contract. Additionally, as stated in subsection 3.2.1, spot price contracts and variable price contracts together cover about 80 % to 90 % of the market.

[9]Although spot price contracts and variable price contracts may be said to be heterogeneous as they involve different degrees of risk (one is tied to the Elspot price, while the other is priced by the retailer in full), both use two-part pricing. That is, they contain both a fixed fee and a (risky) variable price element.

6.2 Construction of variables

As discussed in subsection 3.2.2, due to two-part pricing, the prices for each product are measured in øre/kWh by fixing the annual consumption to the Norwegian average of 16,000 kWh. Whenever a supplier offers multiple products of the same product type, an (unweighted) average price is calculated. Whenever a supplier offers both a spot and a variable price product, a weighted average across product types is calculated, weighted with the shares of contract types shown in figure 3.3. With these manipulations, we can calculate the price paid by the average customer of each supplier, as we can only observe the (net) switching between suppliers, and not between products or product types.

Contrary to Kim et al. (2003), we do not approximate a cost function to obtain the price-cost margins needed in Model 2. We simply calculate the price-cost margins as the retail price minus the wholesale price, represented by the monthly Elspot price in the region which the product is offered. With this simplification, we do not need to approximate a cost function. However, the simplification also implies that retailers maximize their profit over the wholesale price, rather than overall profit. Nevertheless, as the marginal cost of selling electricity contracts mainly consist of the wholesale price, we believe that the implications of this are negligible for our results.

The market shares are calculated as each supplier's number of customers relative to the total number of customers, separately for each power distribution grid. Hence, each grid is treated as a different market where retailers compete for the customers located in the geographical area of that grid. Also, the reason that we use the number of customers rather than the level of consumption to measure market shares is that the level of consumption suffers from serious seasonality.

The market growth rate, however, is measured as the monthly percentage change in the total consumption on each grid. Recall from (4.14) that the market growth rate is meant to account the fact that each consumer can buy more than one unit of the good. Due to the seasonality of consumption, demand varies throughout the year, and the firm's pricing strategy will be a function of this variation.

Similar to Kim et al. (2003), we use Treasury Bill rates collected from Norges Bank (2020) as the discount rates. As our data consist of monthly observations, and Norges Bank does not issue T-bills with maturity of less than 3 months, we proxy a monthly T-bill rate by dividing the annual yield on the 3-month T-bill by 12 months. Then, the discount factor is calculated as 1 divided by 1 plus the discount rate.

In table 6.1 below we have summarized the number of observations, mean, standard deviation, minimum and maximum value for the variables used in our analysis.

Variable	No. obs.	Mean	St. dev.	Min	Max
Retail price	10,800	32.27	11.00	1.86	101.68
Wholesale price	10,800	27.07	8.84	7.84	56.56
Price-cost margin	10,800	6.17	4.96	-27.28	46.84
Market share	13,635	0.1847	0.2820	0.0002	0.9760
Market growth rate	13,194	1.0290	0.3464	0.0646	12.7957
T-bill 1m	13,635	0.1182	0.0398	0.0383	0.1975

Table 6.1: Summary statistics.

7 Results

7.1 Results from Model 1

In table 7.1 below, we have summarized the results from Model 1, i.e. Shy's quick-and-easy method for estimating switching costs. The table contains absolute switching costs in terms of øre/kWh, i.e. the minimum amount of øre a consumer needs to save per kWh of consumption in order to be willing to switch supplier, with standard deviations in parentheses. The second column contains the switching costs averaged across all consumers, while the succeeding columns contain switching costs for the customers of the five largest suppliers averaged across all grids. That is, the five largest suppliers as shown in the distribution of market shares in figure 3.2.

Year	Average	Largest	2nd	3rd	4th	5th
2011	27.83	46.5	36.31	30.7	27.39	-1.77
	(9.55)	(14.77)	(12.09)	(10.54)	(9.51)	(0.81)
2012	16.62	28.16	21.97	18.19	15.84	-1.05
	(3.69)	(5.95)	(5.36)	(3.75)	(2.87)	(0.51)
2013	21.46	35.67	29.46	23.22	20.18	-1.23
	(1.94)	(2.27)	(2.44)	(2.02)	(2.06)	(0.92)
2014	17.46	29.65	23.86	19.66	16.26	-2.13
	(1.98)	(2.84)	(2.45)	(2.13)	(1.56)	(0.94)
2015	15.57	25.76	21.56	16.68	15.95	-2.09
	(2.68)	(3.75)	(2.02)	(3.04)	(3.21)	(1.38)
2016	16.73	25.48	25.12	16.28	14.35	2.42
	(1.94)	(2.02)	(3.51)	(0.99)	(2.09)	(1.09)
Average	19.28	31.87	26.38	20.79	18.33	-0.97
	(3.63)	(5.27)	(4.64)	(3.75)	(3.55)	(0.94)

Standard deviations in parentheses.

Table 7.1: Absolute switching costs in øre/kWh from Model 1.

As we can see from the second column, the absolute switching costs averaged over the retailers vary from 27.83 to 15.57 øre/kWh yearly. Over the entire estimation period, the average absolute switching cost amounts to 19.28 øre/kWh. However, as we can see from the parentheses, some of the estimates have relatively large standard deviations, especially those of 2011. This may be due to a larger variation in market shares in 2011, as we can see from figure 3.2. Alternatively, it may also come from higher prices with more variation in 2011 than the rest of the estimation period, as can be see from figure 3.6 and 3.7. Particularly, figure 3.6 shows one outlier among the variable price contracts which increases the variation in prices that year. Higher variation in prices leads to higher variation in the switching cost estimates.

We also find, similar to Shy (2002), that switching costs are highest for the customers of the largest suppliers and lowest for the customers of the smallest suppliers. As Shy points out, this may be due to the fact that the smallest suppliers capture the consumers with the lowest value of time, who therefore are more willing to search for cheaper alternatives and switch more frequently. However, in our sample, the smallest supplier offers the cheapest product in only 626 out of 2,733 market observations, or about 22 %, which is what we would expect from random sampling. We do therefore not find evidence for his statement.

In fact, in five out of six years, the estimated switching costs for the customers of the smallest suppliers are even negative, meaning customers of these suppliers switch even though there are no monetary gains from switching. This indicates that consumers may have non-monetary incentives to switch supplier. However, the estimates are only slightly negative, so we should not put to much emphasis on these.

Furthermore, in order to compare the estimated switching costs to the potential gains from switching found in subsection 3.2.3, we have calculated the switching costs in annual terms. The estimates in table 7.2 are annualized by multiplying with the average yearly consumption of 16,000 kWh, as well as converted to NOK by dividing by 100. Hence, the estimates indicate the amount a consumer must expect to save on their yearly electricity bill in order to be willing to switch. In addition, we have calculated the switching costs relative to the price, i.e. relative switching costs. The yearly, absolute switching costs in NOK and the relative switching costs in percent are shown in table 7.2 below.

Year	Average	Largest	2nd	3rd	4th	5th
2011	4,452 (62 %)	7,439 (98 %)	5,809 (89 %)	4,913 (67 %)	4,382 (60 %)	-283 (-6 %)
2012	2,660 (61 %)	4,506 (98 %)	3,516 (89 %)	2,911 (66 %)	2,535 (58 %)	-168 (-6 %)
2013	3,434 (62 %)	5,708 (98 %)	4,714 (90 %)	3,715 (68 %)	3,229 (58 %)	-196 (-5 %)
2014	2,793 (61 %)	4,744 (98 %)	3,817 (89 %)	3,145 (69 %)	2,601 (58 %)	-341 (-8 %)
2015	2,491 (62 %)	4,121 (98 %)	3,446 (91 %)	2,668 (69 %)	2,552 (63 %)	-335 (-9 %)
2016	2,677 (61 %)	4,077 (94 %)	4,019 (96 %)	2,605 (55 %)	2,297 (53 %)	388 (7 %)
Average	3,085 (61 %)	5,099 (97 %)	4,221 (91 %)	3,326 (66 %)	2,932 (58 %)	-156 (-4 %)

Table 7.2: Yearly and relative switching costs in NOK and percent from Model 1.

By comparing the yearly switching costs with table 3.2, 3.3 and 3.4, we can see that the gains from switching from all of the nationwide products are lower than the average switching cost. On average, the switching cost amounts to 3,085 NOK yearly, or about 61 % of the average electricity bill. Recall that the gains from switching calculated in those tables were based on an optimal weekly switching strategy, and could therefore be interpreted as an upper bound for the gains from switching. Thus, the average switching cost imposed by Model 1, will always be higher than the gains from switching. The intuition is that the switching costs may include both non-monetary gains from not switching, such as psychological factors, and unobserved monetary gains, such as introductory offers and non-list price offers, which are not included in the estimated monetary gains from switching. That is, consumers who switch to seemingly more expensive suppliers, when comparing the prices listed at the price comparison website, may in fact earn from switching due to receiving other offers than those used to estimate the monetary gains from switching. However, it seems that consumers do generally not perceive switching as profitable, and are therefore likely to stay with their provider.

7.2 Results from Model 2

Table 7.3 below reports the parameter estimates from the jointly estimated system of equations (5.2) and (5.4), which together constitutes Model 2. The estimated switching cost is 16.20 øre/kWh. The average price over the estimation period is 32.27 øre/kWh, meaning that the switching cost accounts for 50 % of the price paid by the average consumer. From Model 1, the point estimate across the estimation period was 19.28 øre/kWh or about 61 %. Thus, the estimated switching cost is about 3.08 øre/kWh or 11 percentage points lower in Model 2 than in Model 1. Although, the standard error of the switching cost estimate is relatively large, with a value of 5.515. Thus, the corresponding 95 % confidence interval of the estimate ranges from 5.39 to 27.01 øre/kWh. The switching cost estimate is, however, significant at a 1 % significance level. The estimated slope of the transition probabilities is negative and significant, with a value of -0.0329, which was one of our basic conditions for the validity of the model. Recall that the transition probability slope is the marginal change in the probability of a consumer staying with firm i from one month to another, following a one øre increase in the firm's own price, $p_{i,t}$, or a one øre decrease in the rivals' average price, $\bar{p}_{iR,t}$, or the switching cost, s.

	Parameter estimates
s (switching costs)	16.20*** (5.515)
α_1 (transition probability slope)	-0.0329*** (0.00558)
Number of observations	9060

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7.3: GMM estimate of the absolute switching cost in øre/kWh from Model 2.

We can utilize the Sargan-Hansen test in order to test the overidentifying restrictions of our estimates (Hansen, 1982). The overidentification test yields a significant J-statistic, meaning we cannot reject the null hypothesis $H_0 : E\{Z_{i,t}u_{i,t}(\beta)\} = 0$, i.e. that our set instruments $Z_{i,t}$ are uncorrelated with the error terms $u_{i,t}$. Consequently, it seems like at least one of our assumed exogenous instruments is endogenous, and that our estimates may suffer from an endogeneity bias. However, we will discuss the overidentification test, and what may cause the rejection, in more detail in section 8.3.

Furthermore, Model 2 also allows us to obtain some other interesting estimates implied by the model. These implications are summarized in table 7.4 below. The estimated transition probabilities, $\hat{Pr}_{i\to i,t}$ and $\hat{Pr}_{iR\to i,t}$, come directly from (4.16). Similar to Kim et al. (2003), we assume that $\alpha_0^i = 1/n$. Thus, we find that the probability for a consumer to stay with their provider from one month to the next is 55.86 % on average. The standard error is relatively high, however, such that the 95 % confidence interval of the estimate ranges from 37.90 % to 73.81 %. Similarly, the probability that a customer of a randomly selected supplier switches to a given supplier is 3.90 %, with a 95 % confidence interval from 0.27 % to 7.53 %. However, these are monthly transition probabilities, which can be annualized by calculating $\theta = 1 - (\hat{Pr}_{i\to i,t})^{12}$. Thus, θ is the annual churn rate, which is estimated to 91.29 %, with a 95 % confidence interval from 83.95 % to 98.64 %. However, the estimated churn rate seems unrealistically high. This may be due to the large variation in the transition probability, $\hat{Pr}_{i\to i,t}$, as the churn rate comes directly from the estimation of the transition probability. Moreover, $\lambda_{k=0.99} = ln(1-k)/ln(1-\theta)$ is the time needed for 99 % of a retailer's customers to switch supplier, and therefore reflects the length of the average customer-retailer relationship. The estimate comes directly from the estimation of theta and is estimated to be 70.12 % of a year, or just less than three quarters. The estimate is insignificant, however, with a very large standard error. Then, the term $\frac{\partial\sigma_{i,t}}{\partial\sigma_{i,t-1}}$ comes from (4.18), where we dubbed it as the lock-in effect, and represents the marginal effect of a retailer's last period market share on current market share. With our estimation, the lock-in effect amounts to 54.72 %, with a 95 % confidence interval ranging from 36.33 % to 73.11 %. In other words, on average, 54.72 % of a retailer's market share in a given month is due to it's market share the previous month. Finally, $\frac{mvl_{i,t}}{\partial V_{i,t}/\partial y_{i,t}} = -\delta\frac{n}{n-1}s/\alpha_1$ is the marginal value of an additional locked-in customer to a firm's present value, which amounts to 49.00 %. The 95 % confidence interval of this estimate ranges from 32.53 % to 65.46 %.

	Model implications
$\hat{P}r_{i\rightarrow i,t}$	0.5586 (0.0916) [0.3790 ; 0.7381]
$\hat{P}r_{iR\rightarrow i,t}$	0.0390 (0.0185) [0.0027 ; 0.0753]
θ	0.9129 (0.0375) [0.8395 ; 0.9864]
$\lambda_{k=0.99}$	0.7012 (1.7334) [-2.6962 ; 4.0986]
$\frac{\partial\sigma_{i,t}}{\partial\sigma_{i,t-1}}$	0.5472 (0.0938) [0.3633 ; 0.7311]
$\frac{mvl_{i,t}}{\partial V_{i,t}/\partial y_{i,t}}$	0.4900 (0.0840) [0.3253 ; 0.6546]

Standard errors in parentheses
95 % confidence intervals in brackets

Table 7.4: Implications of Model 2.

8 Discussion

8.1 Implications of the results

The existence of switching costs may have severe implications for competition in the Norwegian electricity market, and thus for economic efficiency as well.

The point estimate for the entire estimation period from Model 1 is 19.28 øre/kWh, while the point estimate from Model 2 is 16.20 øre/kWh. We can also scale up the switching cost imposed by Model 2 to yearly switching cost, in order to compare these results with those of Model 1. By multiplying the point estimate from Model 2 with an average consumption of 16,000 kWh yearly, and dividing by 100, we get the yearly switching cost of the average Norwegian household expressed in NOK. From Model 2, we get that the average switching cost amounts to 2,592 NOK yearly, while the yearly switching cost estimate from Model 1 amounts to 3,085 NOK. Hence, our results indicate that Norwegian consumers are on average willing to pay a premium of about 2,600 to 3,100 NOK yearly, or 50 % to 60 % of their electricity bill, rather than switching electricity supplier monthly. In order for competitive markets to achieve an efficient outcome, there must be free consumer mobility between suppliers. The existence of switching costs, however, lock customers in with their current suppliers and thereby enhance consumer inertia. Thus, in markets with switching costs, consumers avoid switching to a cheaper supplier offering an identical product, which may in turn lead to a sub-optimal market outcome and prevent economic efficiency.

On the contrary, Dubé et al. (2009) find that, for some levels of switching costs, the equilibrium price of two frequently purchased consumer products, namely orange juice and margarine, falls in the presence of switching costs. They find switching costs in the range of 15 % to 19 % of the prices for the two products. Then, through simulations of demand and supply, they find prices to be as much as 18 % lower in the presence of switching costs than without any switching costs. The intuition is that the firm's incentive to lower its price to acquire new customers outweighs the incentive to increase the price to harvest their already existing customer base. This finding reflects the strategic effect of firms lowering prices to prevent other firms stealing their customers. For large levels of switching costs, however, the equilibrium prices increase with switching costs. These findings indicate that the implications for market efficiency is dependent on the magnitude of switching costs. However, they also emphasize that their research focuses on markets where firms cannot distinguish new customers from already locked-in customers, and therefore cannot price discriminate between the two customer segments. In markets with subscription based products, such as the electricity market, firms can in fact charge a higher price to locked-in customers than to new customers.

In markets with switching costs, firms compete ex-ante for ex-post market power. Such intertemporal competition can give rise to weakened competition, if firms can distinguish new customers from existing customers, as they can utilize a "bargain-then-ripoff" pricing strategy. That is, firms can use penetration pricing, introductory offers and price wars to obtain as many new customers as possible, while they can charge already locked-in customers higher prices due to switching costs (Farrell and Klemperer, 2006). In the most recent part of our data, from 2015 to 2019, we can distinguish between products offered to new customers only and those offered to both new and existing customers. The average price on products offered to new customers only is 23.21 øre/kWh for spot price products and 38.89 øre/kWh for variable price products, while the average price on products offered to all customers is 31.88 øre/kWh for spot price products and 40.73 øre/kWh for variable price products. As we can see, there is a price difference between products offered to new customers only and those offered to new and existing customers, for both spot price products and variable price products. This provides evidence for the existence of such bargain-then-ripoff pricing strategies among Norwegian electricity retailers.

8.2 Robustness

As we saw from table 7.1, the estimates from Model 1 have varying standard deviations, and thus varying levels of significance. In particular, the estimates for 2011 have relatively large standard deviations which may be due to higher variation in market shares and prices that particular year. However, the point estimate for the entire estimation period of 19.28 øre/kWh has a standard deviation of 3.63, and thus a 95 % confidence interval ranging from 12.17 to 26.39 øre/kWh. Thus, Model 1 yields significant indications for the existence of switching costs. The point estimate of 16.20 øre/kWh from Model 2, however, have a larger standard error of 5.515. Thus, the corresponding 95 % confidence interval ranges from 5.39 to 27.01 øre/kWh. Although less significant, the results from Model 2 yields additional evidence for the existence of switching costs.

Although none of the empirical studies mentioned in section 2.2 have a point estimate of switching costs we can compare our results to, there are some relevant magnitudes from these papers. For instance, Hortaçsu et al. (2017) find that consumers in the Texas electricity market value purchasing from their current supplier $62 more, or about 50 % of the average monthly electricity bill, than purchasing the same amount of power from another supplier. This estimate can be assigned to brand loyalty, which is one particular type of investment that can give rise to switching costs. Thus, their results are pretty similar to our finding of switching costs of about 50 % to 60 % of the average electricity bill. Our finding, however, does not reveal the reason why switching costs arise. Although, we find it likely that non-economic brand loyalty, together with inattention and search costs, can be among the reasons. Moreover, Wilson and Price (2005) find that nearly all of the customers in their study who did not switch, although being aware of the opportunity, could have achieved annual savings of £43.59 by switching supplier, or about 18 % of the average yearly electricity bill. This finding does not reveal the actual switching costs these consumers face. However, the fact that consumers do not switch, despite being aware of the opportunity, indicates switching costs of at least 18 % of the average electricity bill. Although our point estimate of switching costs is higher than this, their estimate can be interpreted as a lower bound for the actual switching costs.

Consequently, both our models yield significant estimates of switching costs that are in line with results from other papers. We therefore believe that, although the point estimates may be imprecise, we have found evidence for the existence of significant switching costs in the Norwegian electricity retail market.

8.3 Limitations

In Model 2 we rejected the null hypothesis of the Sargan-Hansen overidentification test, indicating that at least one of our assumed exogenous instruments may be endogenous. Consequently, the estimates may suffer from an endogeneity bias, caused by endogenous variables on both sides of the structural equations. Although, the rejection of the overidentification test may also have been caused by other reasons. The test rejection may be caused by the instruments being correlated with the residuals, which approximates the true unobservable model errors, which is what we really would like to test. Moreover, the rejection may also be caused by functional form misspecification, due to approximation errors in the derivation of the model. For instance, the transition probabilities in (4.20) are linearly approximated, although it is likely that these probabilities in reality take another functional form, such as logit or probit. Consequently, the problem may lie in the model specification, rather than the exogeneity of our instruments.

We also found the annual churn rate implied by Model 2 to be 91.29 %, with a 95 % confidence interval ranging from 83.95 % to 98.64 %. Such high estimates of the churn rate indicate that, although switching is perceived as costly, consumers switch suppliers frequently. This finding is in line with the notion that the Norwegian electricity retail market exhibits high consumer switching frequency. However, the churn rate seems too high, which can be an indication of model misspecification. In comparison, actual data on the number of switches, provided by the Norwegian Water Resources and Energy Directorate, reveal that there was about 300,000 switches yearly over the estimation period, which accounts for 13 % of the households. Assuming the number of switches are evenly distributed across all consumers, this implies an annual churn rate of 13 %, which is significantly lower than our estimated churn rate of 91.29 %. Additionally, all of the remaining estimates in table 7.4 are either imprecise or insignificant, with large standard errors and broad confidence intervals. We therefore choose to not put too much emphasis on these implied estimates. However, the high churn rate may also come from the assumption that $\alpha_0^i = 1/n$. The assumption implies that, when the price difference between a consumer's current supplier and the average price of the rivals plus the switching costs equals zero, such that there are no gains from switching supplier, consumers are equally likely to choose any supplier. That is, there are no firm heterogeneity. This may be an unrealistic assumption, as a consumer would probably not switch if there were no gains from switching, and consumers may have non-monetary reasons or preferences for choosing one supplier over another.

One potential drawback of our analysis is that the switching costs are calculated for a period from 2011 to 2016 only. It could be that the consumer's switching behavior has changed since then. For example, the Norwegian Consumer Council started a new price comparison website in 2015 which was intended to be more user friendly than its predecessor, operated by the Norwegian Competition Authority. It may be that the new price comparison website has made the searching and information gathering procedure easier for the electricity consumers, and thereby reduced the switching costs.

Another potential drawback of our analysis is that we do not distinguish between customers with variable price contracts from those with spot price contracts, although we have pointed out significant price differences between the two contract types. The reason is that estimating switching costs separately for variable price customers and spot price customers would require market share data on the product or contract type level. Our data reveals only the number of customers of each supplier, but not which contract type these customers are signed to. Hence, our data does not reveal any switching between products or contract types, so that we cannot estimate switching costs separately for each contract type. By not distinguishing between the contract types, we might underestimate the switching costs of the customers on variable price contracts, who have a lot to gain from switching, and overestimate the switching costs for the customers of spot price contracts, who have less to gain from switching. However, we cannot know for sure, as we do not know whether it is the customers on variable price contracts or spot price contracts who switch more often.

9 Conclusion

In this thesis we have examined the degree of consumer inertia and estimated the resulting switching costs in the Norwegian electricity market. In order to answer our research question, we utilize two separate models to estimate the implicit switching costs embedded in the switching behavior of the consumers. From Model 1, the point estimate of switching costs for the entire estimation period was 19.28 øre/kWh, while the point estimate from Model 2 was 16.20 øre/kWh. In annual terms, the estimated switching costs amount to 3,085 NOK from Model 1 and 2,592 NOK from Model 2. Consequently, our results indicate that Norwegian consumers are on average willing to pay a premium of about 2,600 to 3,100 NOK yearly, which accounts for about 50 % to 60 % of their electricity bill, rather than switching electricity supplier monthly.

These switching costs also exceed the potential gains from switching supplier, which can explain the consumer inertia we find evidence for. Our findings therefore contradict the notion that the Norwegian electricity market exhibits high consumer switching frequency. A potential reason can be that both our models attempt to reveal consumer switching from aggregated market share data, when the net changes in market shares may result from numerous combinations of consumers switching to and from each supplier.

Moreover, although some of our estimates have relatively large standard errors and broad confidence intervals, both models yield significant estimates of switching costs. We therefore believe that, although the point estimates may be imprecise, we have found evidence for the existence of switching costs in the Norwegian electricity retail market. Our results are also in line with the findings of other empirical studies of electricity markets, although none of these carry out any direct estimation of switching costs. Thus, the novelty of our thesis lies in the attempt to estimate switching costs in the Norwegian electricity market.

The existence of switching costs can, as we have seen, weaken competition in the Norwegian electricity market and thus reduce economic efficiency. The main solution for policy makers and competition authorities, in order to enhance economic efficiency, is therefore to make switching less costly for the consumers. One way of doing so, is through the use of price comparison websites. Although the Norwegian Consumer Council already operates a price comparison website, one could use different marketing strategies to increase the number of consumers using the website. For instance, one could run marketing campaigns highlighting the estimated switching costs, implicitly paid by the consumer through their inertia. Thus, the market campaign could say something along the lines of: *Remember to set aside 3,000 NOK of your yearly salary, because that's the annual amount you pay for not switching electricity supplier.*

In further research one could attempt to renew our estimates, as our sample period ends in 2016. It may be that switching behavior has changed since then, for instance due to the new price comparison website in 2015, which was intended to be more user friendly than its predecessor and therefore can have lowered search costs for consumers. In relation to this, one could also attempt to estimate the effect the opening of the new price comparison website, or the number of visits on the website, has had on the switching behavior and the switching costs. Additionally, if switching costs still are significant in the Norwegian electricity market, one could explore the reasons why consumers experience switching costs.

References

Baum, C., Schaffer, M., and Stillman, S. (2003). Instrumental variables and gmm: Estimation and testing. *Stata Journal*, 3(1):1–31.

Dubé, J.-P., Hitsch, G. J., and Rossdi, P. E. (2009). Do switching costs make markets less competitive? *Journal of Marketing Research*, 46(4):435.

Ek, K. and Söderholm, P. (2008). Households' switching behavior between electricity suppliers in sweden. *Utilities Policy*, 16(4):254–261.

Energy Facts Norway (2020). The power market. https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/. Accessed: 2020-04-02.

Farrell, J. and Klemperer, P. (2006). Coordination and lock-in: Competition with switching costs and network effects. *IDEAS Working Paper Series from RePEc*.

Greene, W. H. (2003). *Econometric analysis*. Prentice Hall, Upper Saddle River, N.J, 5th ed. edition.

Hall, A. R. (2005). *Generalized method of moments*. Advanced texts in econometrics. Oxford University Press, Oxford.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica*, 50(4):1029–1054.

Hortaçsu, A., Madanizadeh, S. A., and Puller, S. L. (2017). Power to choose? an analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy*, 9(4):192–226.

Kim, M., Kliger, D., and Vale, B. (2003). Estimating switching costs: the case of banking. *Journal of Financial Intermediation*, 12(1):25–56.

Klemperer, P. (1987). Markets with consumer switching costs. *The Quarterly Journal of Economics*, 102(2):375–394.

Klemperer, P. (1995). Competition when consumers have switching costs: An overview with applications to industrial organization, macroeconomics, and international trade. *The Review of Economic Studies*, 62(213):515.

Norges Bank (2020). Treasury bills monthly average. https://www.norges-bank.no/en/topics/Statistics/Interest-rates/Treasury-bills-monthly/. Accessed: 2020-02-20.

Selten, R. (1965). Spieltheoretische behandlung eines oligopolmodells mit nachfrageträgheit. *Zeitschrift für die Gesamte Staatswissenschaft*, 121:301–324 and 667–689.

Shy, O. (2002). A quick-and-easy method for estimating switching costs. *International Journal of Industrial Organization*, 20(1):71–87.

Silva, M. O. and Lucinda, C. R. (2017). Switching costs and the extent of potential competition in brazilian banking. *EconomiA*, 18(1):117–128.

von der Fehr, N.-H. M. and Hansen, P. V. (2010). Electricity retailing in norway. *The Energy Journal*, 31(1):25–45.

Waterson, M. (2003). The role of consumers in competition and competition policy. *International Journal of Industrial Organization*, 21(2):129–150.

Wilson, C. M. and Price, C. W. (2005). Irrationality in consumers' switching decisions: When more firms may mean less benefit.