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HOMEOWNERS' PREFERENCES FOR ELECTRICITY CONTRACTS AND DEMAND RESPONSE

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Abstract

Despite the importance of electricity in the lives of 21st century people, the details of electricity contracts and the market system are relatively overlooked matters in people's daily lives. The aim of this master's thesis is to study Finnish homeowners' knowledge about the electricity markets and their preferences for dynamic-priced electricity contracts and demand response. We study these topics by conducting three binary logit regressions based on a sample data that consists of 380 respondents. The data is from a survey that was originally conducted in October 2016. Choosing electricity contract is a discrete choice for a household. Therefore, the empirical part of this thesis was done with discrete regression model.

Based on our findings we argue that raising awareness of individual and more importantly societal advantages is the key to achieve better demand side management of power markets. People who express general interest in electricity issues and their consumption behaviour are more likely to accept demand response contracts. Overall, we argue that people should be more informed about electricity matters. Knowledge about the impacts of one's decisions seem to be good catalyst for people to re-evaluate their choices. Moreover, we suggest that the results of this thesis emphasize the fact that monetary incentives in electricity contracts are not the only value creating element for the household. The results indicate that invoking on environmental aspects of these concepts will improve the overall acceptance of demand side management substantially.

Keywords
homeowner preferences, electricity contracts, demand response, discrete choice, flexibility

Additional information
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1 INTRODUCTION

The importance of electricity in the lives of 21st century people cannot be stressed enough. For a traditional homeowner almost every mundane task, from space heating to tooth brushing involves at least some levels of electricity usage. Despite the importance of electricity, the details of electricity contracts and the market system are relatively overlooked matters in people's daily lives. According to a recent study done by Nordic energy regulators (2019), approximately one third of the Finnish electricity customers do not know how much their annual electricity consumption is. The study also revealed that only sixty percent of the households know the company's name that handles distribution of electricity into their homes. This indicates that for a lot of people the knowledge that electricity comes from the socket, whenever it is needed seems to be enough.

However, when looked at a system level, having electricity available whenever it is needed is not so simple. It requires a vast network of operators and collaboration of multiple different parties. Electricity markets nearly everywhere in the world are constrained by the fundamental problem. The demand side is difficult to forecast and almost completely insensitive to price fluctuations, while the supply side faces limiting constraints at peak times, and storing the electricity is prohibitively costly. (Borenstein, 2002.) Another characteristic feature of the electricity markets is that the supply and demand of the electricity needs to be constantly at equilibrium state. Otherwise the system will face problems, which makes it vulnerable to service failures, such as blackouts. The supply and demand sides are connected to each other via transmission and distribution networks. Constructing these networks include high amounts of sunk costs, hence there are typically no competitive distribution networks around any residential areas. Due to high sunk costs, transmission and distribution companies operate in natural monopoly market, making the distribution of electricity governmentally regulated business. These key characteristics have traditionally outlined the nature of electricity markets. However, the development of technology has enabled to face these fundamental problems with new tools.

One of the most notable developments of technology include the introduction of smart meters that enable accurate and up to date monitoring of electricity consumption. This development has enabled electricity retailers to include economically correct price signals for their customers. This is done by offering contracts that include varying prices for electricity for every hour of the day, every day of the year. Another current wave of development is the rapid increase of renewable but volatile energy generation sources, such as wind power and solar power. These generation methods are difficult to predict without uncertainties. When these intermittent energy sources gain more share in the overall energy generation mix, the power system requires better adjustability to sudden volatilities in supply side of the markets. One way for the system to adjust promptly is to have more flexibility in the demand side.

Demand response is a key concept in this thesis. With high probability it has an essential role in the power systems of near future. The European Commission (2013) defines demand response as: “Voluntary changes by end-consumers of their usual electricity use patterns – in response to market signals, such as time-variable electricity prices or incentive payments, or following the acceptance of consumers’ bids (on their own or through aggregation) to sell in organized energy electricity markets their will to change their demand for electricity at a given point of time”. Electricity contracts that incentivise demand response, for instance by having hourly varying prices, could arguably make residential consumers more active participants in the energy markets.

The aim of this master’s thesis is to study the Finnish homeowners’ preferences for dynamic-priced electricity contracts and demand response. This is done by conducting three binary logit regressions based on a sample data that consists of 380 respondents. The data is from a survey that was originally conducted in October 2016, by a group of researchers from University of Oulu and Finnish Environment Institute (SYKE)[1]. The dependent variables of the three regressions provide information that enhances our knowledge about the research topic. First regression concentrates on studying what factors are common for people who do not know the type of their electricity contract. Second regression concentrates on studying what

[1] The data gathering was supported by the Academy of Finland Strategic Research Council project: BC-DC (AKA292854).

factors are common for people who either have considered or acquired real time priced electricity contract. Third regression examines respondent's willingness to acquire electricity contracts that include consumption control during peak demand periods.

The structure of the thesis is as follows. Chapters 2 and 3 work as a background for this thesis topic. Chapter 2 explains the fundaments of the Finnish electricity market and the working mechanisms of the Nord Pool common market. Chapter 3 presents typical electricity contracts in Finland. In this chapter we introduce the decisions that every residential electricity consumer in Finland needs to make when they choose their electricity contract. Chapter 4 is devoted to explaining the theoretical basis for this thesis' analyses. The analysis will be done according to discrete choice framework by applying binary logit (BL) regression model. Chapter 5 introduces the data and the dependable and explanatory variables that are used in the empirical part of this thesis. The results of the regressions are presented and discussed in chapter 6. Conclusions of this thesis will be made in chapter 7.

2 FINNISH ELECTRICITY MARKET

This chapter of the thesis concisely depicts the characteristics of the Finnish electricity markets. First subchapter describes the recent history of the Finnish electricity market. This covers the deregulation of the market in 1990s that has led to the current market environment, which will also be briefly covered. Chapter 2.2. defines the main components that together form the electricity price that is charged from the Finnish homeowners. Chapter 2.3. focuses on the Nordic[2] power market operator Nord Pool and its role in the Finnish homeowner's electricity contracts. The chapter introduces the Nordic power market's day-ahead trading platform, where majority of the power trade in Nordic and Baltic countries takes place. It also explains the basics of the intraday market, and the mechanism for the formation of the aggregate system price for the electricity, and why it is important for the Finnish homeowners. Lastly this subchapter covers the reasons why there are different electricity prices for different areas inside the Nordic power markets.

2.1 Brief history and current status of the Finnish electricity market

In the same year as Finland joined the European Union, Finland also started to restructure its domestic electricity market. After the passing of the Electricity Market Act in 1995, Finland's electricity market was gradually opened to competition. Since late 1998, all electricity users from companies to private households have been able to choose their preferred electricity supplier. This means that for the past two decades Finnish households have been able to compete their energy service providers. The distribution and transmission services are still done by local companies. (MEAE, 2019.) Finland is part of the Nordic power market, that was originally formed by Norway in 1995. The full integration between Nordic countries was achieved in 2000, when the last country, Denmark joined to the common market (Nord Pool, 2019e).[3]

[2] It should be noted that even though it is called "Nordic" power market, Iceland is excluded.
[3] Sweden joint in 1996, Finland in 1998, Denmark in 2000.

The common power market was formed mainly due to efficiency reasons. The large mix of production technologies in the member countries arguably improves the production efficiency, when market participants can trade between countries (Kopsakangas-Savolainen & Svento, 2010). One example of this obtained efficiency is that the common market enables single countries to have deficits or surpluses in the generation capacities. For instance, Finland is currently heavily dependent on imported energy, especially when the demand peaks during winter months.

At the end of 2018, the total installed generation capacity in Finland was about 17 600 MW. However, the total available generation capacity in the peak load situation was vastly lower. In winter 2018-2019 it was estimated to be about 11 950 MW, whereas the years highest hourly load was 14 062 MW. The gap between installed generation capacity and available generation capacity is explained through variations in the availability of production facilities. For instance, the total capacity of wind power at the end of 2018 was around 2000 MW, yet it is likely that the generation capacity is never available in full due to unstable weather conditions. In fact, the estimated wind power capacity during peak load period in winter is only 120 MW or 6 percent of the total capacity. (Energy authority, 2019c.)

Through the common power market, Finland can import electricity to cover the deficit and maintain a balance in the country's internal market. Currently, the total importing capacity is around 5200MW. Naturally the market works both ways, meaning that Finland can also export energy, as it does on a daily basis. This is one example of how the common power market provides efficiency for its members. Another example is the fact that Finland imports electricity throughout the year even when the domestic capacity would be able to cover the demand. This is simply because the electricity is cheaper to procure from abroad than generate within the nation's borders. (Energy authority, 2019c.)

Even though the common market enables Finland to have deficit in the generation capacity, the Finnish government have recently issued permits for two new nuclear power plants that are set to generate electricity in the coming years. The generation capacity of the two nuclear power plants are 1600 MW for Olkiluoto 3 and 1200 MW for Pyhäjoki 1. It should be noted though that the manufacturing of these power plants tends to be lengthy business in Finland. For instance, Olkiluoto 3 was originally set to be commissioned by the end of 2009. The most recent estimations are that it will be in operation some time in 2020. Pyhäjoki 1 is also still waiting for a construction licence and will miss the original commission year 2024. Current estimation is that the commercial operation will begin in 2028 (Fennovoima, 2019). The government has also subsidised significantly the investments in production capacity of renewable energy sources (RES), most notably wind power plants[4]. (Energy authority, 2018b; 2019c.) The delays in the commissions of the new nuclear power plants and the fact that overall demand of electricity is projected to stay in similar levels means that Finland will remain as import dependent country also in the near future. In fact, Finnish energy authority (2019c) states that Finland will be dependent on electricity import in peak load situation, even after Olkiluoto 3 will be completed.

2.2 Components of electricity price in Finland

For the Finnish electricity customer the total price of the product can be divided into three components. These components are the price of the energy, cost of distribution service and taxes. Similarly, to many deregulated energy markets, Finnish customers may have separate contracts for energy and distribution. This is because the retail market for electricity is a competitive market, whereas distribution market is handled by government regulated local monopolies. Due to high sunk costs, there is no point of constructing competing transmission and distribution grids across the nation. Therefore, competition in the electricity markets currently excludes network services[5] and from the households' point of view the distribution price is fixed[6]. (Kopsakangas-Savolainen, 2002.) The third component, taxes are included in distribution services' bill. These taxes include strategic stockpile fee, electricity excise tax, as well as value added tax. All end users need to pay the same strategic

[4] In 2017, wind power capacity of almost 400MW was commissioned. Also, the grid connected solar power capacity was more than doubled during 2017. In late 2018 the capacity was around 120MW.

[5] Network services consist of two activities, transmission and distribution. In transmission grid, electricity is transmitted over high voltage networks, whereas distribution grids transmits power flows to the final consumers.

[6] Even though the price is considered to be fixed, the aggregate transmission price has increased in Finland substantially during the last few years.

stockpile fee 0.013 c/kWh, whereas electricity excise tax has two categories depending on consumer profile. (Energy authority, 2019c).

Determining the total price for electricity in Finland is a compilation of many moving parts. The three most influential features are: the terms of user's energy contract, transmission charges from the distribution company, and the annual amount of electricity usage, i.e. what is the user's consumption band. When Eurostat produces the price comparisons between EU countries' households, the used consumption band is so called medium standard household, which means that the annual consumption is between 2500 and 5000 kWh. Even though Finnish households have faced drastic increases in the distribution prices, the average price of the electricity is still among the cheapest within the European Union. (Eurostat, 2018.)

Figure 1 shows the different levels of total electricity prices according to the nature of the end-user. The data is from the beginning of July to the end of December 2018.

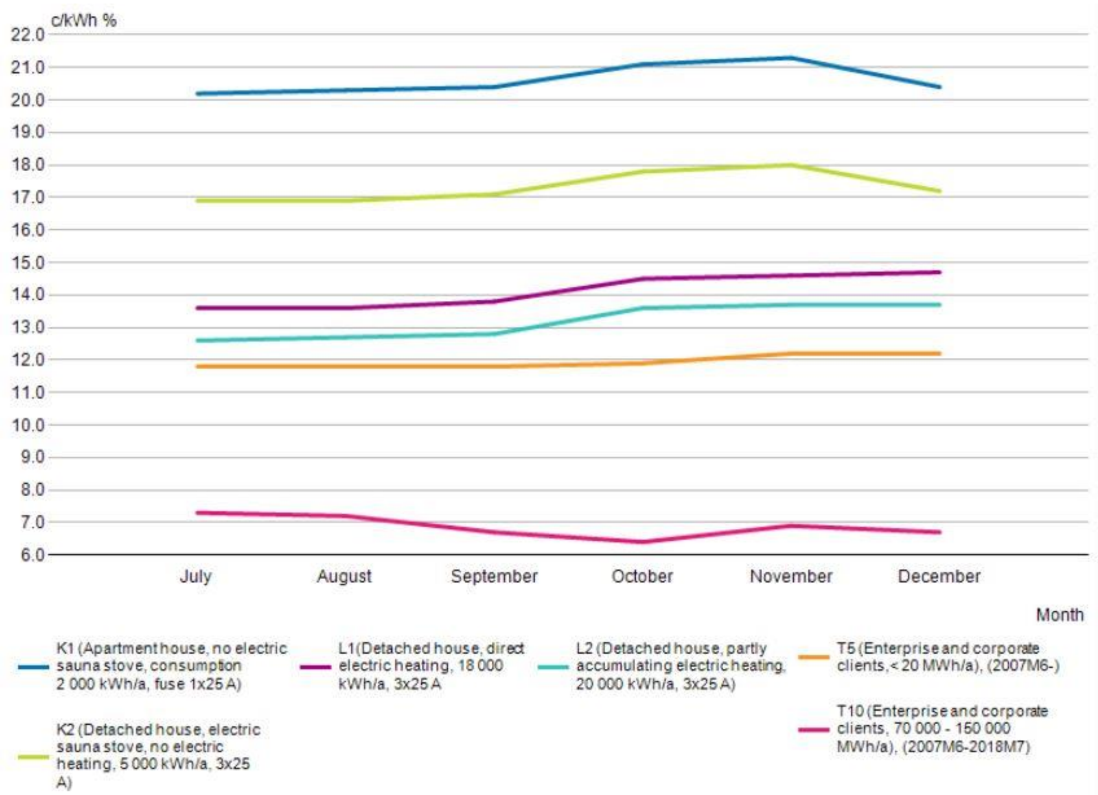

Figure 1. Price of electricity by type of consumer, c/kWh (OSF, 2019).

Figure 1 demonstrates that the price varies drastically according to annual consumption and whether the consumer is private household or a commercial customer[7]. Therefore, it is hard to determine specific common percentages about how much each components weigh in the total price of the electricity. However, let us consider the typical household consumer that has annual consumption of 2500 to 5000 kWh per year. According to Finnish Energy authority's national report (2018b), the average total electricity price for this type of a consumer was 15.81 c/kWh during the period 1.7.-31.12.2017[8]. Figure 2 displays how the shares of each component is distributed to form the total price of the electricity.

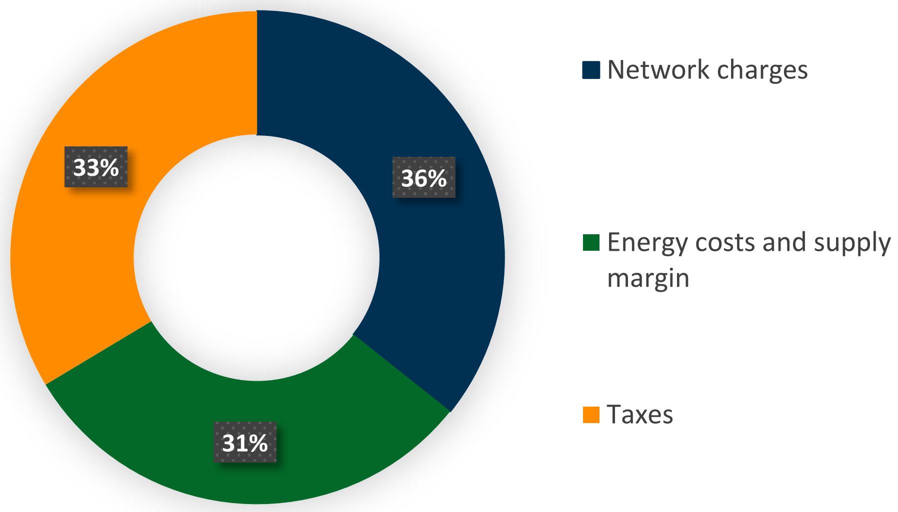

Figure 2. The distribution of electricity price in Finland (Energy authority, 2018b).

Figure 2 shows that with these prices and taxes the components have almost equal weight in the total price of electricity. The share for the energy costs is the lowest[9], which is an interesting insight for the purposes of this study. Consumers have little to

[7] Finnish government subsidises firms by charging smaller energy taxes on commercial customers than normal household customers, therefore the price for companies is vastly lower than the price for households.

[8] Prices are based on the Eurostat's methodology for collecting electricity prices from 2007 onwards. Prices are average of the 6 months.

[9] The share for the energy costs increases when the consumption increases. This is because, with lower amount of consumption the distribution bill consists of mainly the standard fee. Therefore, when the consumption increases the margin of energy costs increases more compared to network charges.

say regarding on taxes and distribution costs. Therefore, apart from actually reducing the usage of the electricity, energy contract is basically the only factor where individual households can have an effect on the total price of the electricity. Nordic energy regulators (2019) recently published a research which stated that among customers that had signed new contracts in the past three years the main motivation on signing new contracts was to save money. Similar results have been reached in academic studies as well (see e.g. Annala, Viljainen, Tuunanen & Honkapuro, 2014). However, as it can be seen in the Figure 2, the effects in the total price of the electricity is fairly limited upon just changing the energy contract.

2.3 Nord Pool

According to Finnish energy authority (2019c), the total amount of electricity consumption was 87.4 terawatt hours (TWh) in Finland in 2018. Approximately 23% of this electricity was imported from abroad, resulting that the total amount of generated electricity in Finland was 67.5 TWh. The deficit was covered mainly via Nord Pool's common power market and also from Russia. The share of residential electricity usage was 28 percent from the total consumption in 2018. (Finnish Energy Industries, 2019.)

The role of the Nord Pool is extremely important for Finnish electricity customers in two ways. Firstly, Nord Pool enables us to trade electricity across nation's borders. This means that when the transmission constraints are taken into account, electricity can be procured from where it is the most cost efficient to produce. And secondly, Nord Pool provides the system and area prices for the electricity that works as a benchmark for the electricity contracts prices in the retail markets. The common wholesale electricity market currently has expanded to nine countries covering the original Nordic countries, Norway, Sweden, Denmark and Finland, as well as the Baltic states, Estonia, Latvia and Lithuania. The latest additions to the market has been gradual expansions to the United Kingdom and Germany. (Nord Pool, 2019e).

Nord Pool is Europe's leading power market that offer trading, clearing, settlement and associated services. Nord Pool hosts a trading platform for 360 customers from a total of 20 countries. In this setting there are different market members who each have specific role to play for the market to function properly. (Nord Pool, 2019g.) Table 1 concisely describes what is the function of each market member, and also includes brief notes from the Finnish point of view.

Table 1. Market members in Nord Pool common electricity market (Nord Pool, 2019g).

Market member	Definition	Finnish perspective
Transmission system operator (TSO)	Ensure that an area is electrically stable and supplied in a secure manner	In Finland this task is appointed to Fingrid Oyj [a]
Producer	Responsible for power production	In 2018, 150 electricity producing companies and ca. 400 production plants [b]
Distributor (DSO)	Enable power transmission from producers to end-users	Regulated natural monopolies
Supplier	Buys power either directly from a producer or through Nord Pool	72 retail suppliers of which 55 offered their products nationwide [c]
Trader	Represents entity which owns the power, while the trading process is taking place	
Broker	Similarly, as estate agents do in the property markets. A broker does not own power, but acts as an intermediary	
End-users	Either a company or a private household. Can compete the suppliers, but cannot do the same for TSO or distributor	In 2018, circa 3.5 million electricity customers[c]

a: Nord Pool is owned by TSO's of Nordic and Baltic countries. Fingrid Oyj owns 18,8% of Nord Pool's shares (Fingrid, 2019b).

b: The share of the three biggest generating companies of the total installed capacity is about 50 percent (Energy authority, 2018b).

c: According to Energy authority's national report (2019c).

From the Finnish perspective, the power exchange in Nord Pool comprises of two markets that by nature complement each other and form the basis for the system to operate properly. These markets differentiate from each other by their objective. The other is day-ahead market called Elspot, and the other is intraday market called

Elbas. (Nord Pool, 2019e.) In 2018, a total of 524 TWh of power was traded in the Nord Pool. The largest amount of volume (396 TWh) came from the Nordic and Baltic day-ahead market. (Nord Pool, 2019a.)

2.3.1 Day-ahead market, Elspot

Nord Pool's day-ahead market Elspot is an auction where sellers and buyers can place orders for the delivery of power for the coming day. It is the main platform for power trade within the Nord Pool area. The market relies on the participants' careful planning. A buyer estimates next day's energy demand on an hourly basis, and how much it is willing to pay for that volume in each hour. Similarly, the seller decides how much she[10] can deliver and at what price, hour by hour. Nord Pool's day-ahead trading system then receives these orders and forms the market equilibrium price. (Nord Pool, 2019c.) This is displayed in the Figure 3, where the equilibrium can be seen as the intersection of the demand curve and the supply curve.

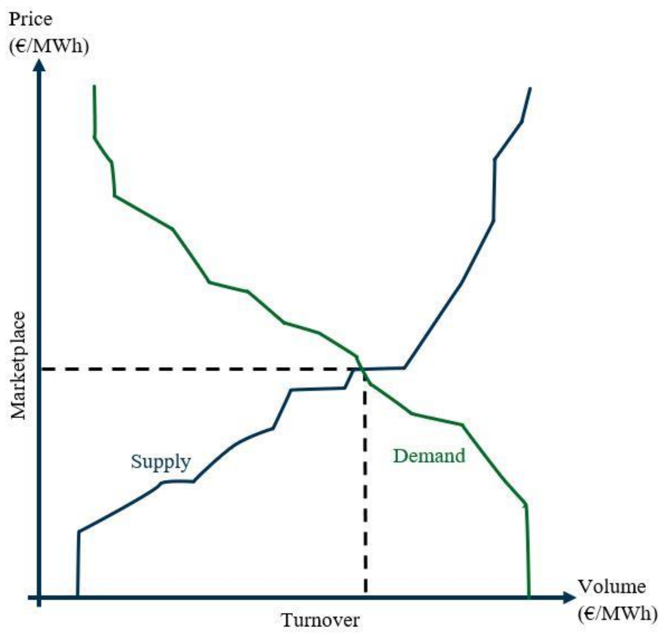

Figure 3. System price formation in Nord Pool day-ahead market (Adapted from Nord Pool, 2019c).

[10] To make the text in this thesis more fluent to read. We have used the pronoun she every time we discuss about a person whose gender is unknown.

Once the market prices have been calculated the trades are settled. In the following day power contracts will be delivered hour by hour according to the agreed contracts. (Nord Pool, 2019c). Electricity retailers use these hourly varying prices in their dynamic spot price contracts. The basics of these electricity contracts will be explained in detail in chapter 3.2.2. In 2018, approximately 70 percent of the total electricity consumption of Finland was handled through the Elspot market (Energy authority, 2019c).

2.3.2 Intraday market, Elbas

Nord Pool's intraday market Elbas operates as a supplement for the day-ahead market and enables the security for the necessary balance between the supply and demand in the Northern Europe's power market. Day-ahead market covers most of the traded electricity, and for the most part the balance between supply and demand is protected there. However, there may be incidents which can lead to disruptions in the equilibrium. This can be for instance malfunction in some of the generation sites or sudden increase of demand due to colder than anticipated temperatures. This means that the market balance needs to be rearranged within the current day. Unlike the day-ahead market, where there is a deadline for submitting bids, the Intraday market works as a continuous market, where the trading happens every day around the clock, until one hour before the delivery. Prices are set similarly to day-ahead market. (Nord Pool, 2019f.)

The importance of intraday market is currently increasing vastly. This is due to the increased amounts of renewable but variable energy sources, such as wind and solar power increase their share in the countries' energy production mix. These energy sources are prone by nature to be difficult to accurately forecast, and sudden changes in the weather can lead to imbalances between day-ahead contracts and produced volume. This imbalance needs to be offset, which inevitably increases the intraday trading. This means that the functionality of the intraday market is a significant enabler for the increased share of renewable but variable energy sources in the energy mixes of different countries. (Nord Pool, 2019f.) The intraday volume turnover was 8.3 TWh in 2018. The volume has increased rapidly within the recent years, rising 35 percent between the years 2016 and 2017, and lastly 23 percent between 2017 and 2018 (Nord Pool, 2019a).

2.3.3 Nord Pool's bidding areas

In the electricity markets, demand and supply sides are connected through transmission and distribution networks. For the system to stay in the equilibrium state, the market needs to have sufficient transmission capabilities in order for the electricity to be transferred from the generation plant to the end-user. The possible constraints in the transmission means that different areas inside the Nord Pool power market may need to pay different prices for their electricity. In order to track these constraints Nord Pool is divided into several bidding areas (Nord Pool, 2019b).

The Nord Pool market area covers different countries, however the market itself is divided into several bidding areas. Norway, Sweden and Denmark have multiple bidding areas within the country, whereas Finland, Estonia, Latvia and Lithuania are each considered as one bidding area. The different bidding areas are formed in order to indicate the possible transmission systems constraints, and also ensure that the price reflects the regional market conditions. Therefore, the day-ahead market provides two different type of prices for the electricity: system price that is same for the whole market and area prices that may vary according to the bidding areas transmission constraints. If there is no constraints on transmission, system price and area price are equal. (Nord Pool, 2019b.)

System price is calculated solely on the basis of purchase and sales orders. It excludes the transmission constraints between the bidding areas and is used as a Nordic reference price for trading and clearing of most financial contracts. Area price includes the possible bottlenecks in the transmission systems, and therefore forms a price that may vary between different bidding areas. Since Finland is only one single bidding area, the area price is the same for every end-user in the country. (Nord Pool, 2019b). Figure 4 shows the different bidding areas for Nordic and Baltic countries, as well as the differences in average area prices.

Figure 4. Nord Pool's bidding areas and area prices[11] (Nord Pool, 2019d).

Finland's dependency on imported electricity often constrains the transmission network between Finland and its neighbouring countries. This has drove the Finnish area price generally to be higher than the day-ahead system price. The annual average price was at its highest level in 2018 for both Finnish area price as well as the Nordic system price since the year 2011. (Fingrid, 2019a). Table 2 displays the development and magnitude of the price difference between Nordic system price and Finnish area price for the past four years. Finland has been paying more from its energy due to transmission constraints, however the price difference has been gradually decreasing in recent years.

[11] The data is from 22nd of March 2019. The average system price for the day was 40,33€/MWh.

Table 2. Difference in the Finnish area prices and Nordic system price in 2015-2018 (Fingrid, 2018; 2019a).

	2018	**2017**	**2016**	**2015**
Day-ahead system price €/MWh	43.99	29.41	26.91	20.98
Area price in Finland, average €/MWh	46.80	33.19	32.45	29.66
Difference (Area price/system price)	106.39%	112.85%	120.59%	141.37%

This chapter has provided a comprehensive examination on the Finnish electricity market and how the price of the electricity is formed for the Finnish customers. In the next chapter we define and briefly review the options that households face when they choose their distribution and electricity contracts.

3 ELECTRICITY CONTRACTS IN FINLAND

This chapter of the thesis focuses on the different contracts that electricity companies currently offer to the Finnish residential customers. Because the thesis' empirical questions concentrates on matters around Finnish households' electricity contracts. This chapter will focus more on this topic and only briefly introduce the distribution side of the electricity contracts.

3.1 Network services

In Finland, the transmission system is handled by a single operator called Fingrid Oyj. The company takes care of the nation-wide high-voltage grid, which is the aorta of the Finnish electricity network. Its main task is to transmit electricity continuously from the generating sites to distribution network companies and industrial companies. Fingrid also takes care of the cross-border connections, which connect Finnish transmission network to its neighbour countries, hence enabling Finnish consumers to participate in the Nordic common power markets. (Fingrid, 2019a.)

The distribution companies are natural monopolies that base their operations on a permit that defines the primary geographical responsibility area of the company. (Kopsakangas-Savolainen, 2002). The companies are regulated by the law, and the supervision is carried out by the Finnish energy authority. The law dictates that the distribution system operators (DSOs) are obligated to supply households and other small customers in the area at reasonable prices. All suppliers are required to send their offered prices to the online price comparison service[12] that is maintained by the regulator. (Annala, Viljainen & Tuunanen, 2013.)

The reasonableness of the prices are calculated by using weighted average cost of capital (WACC) model that is updated annually (Energy authority, 2015). For the year 2019, Energy authority has determined that the WACC yields as a reasonable rate of return for network services is 6.20% for the distribution and 5.36% for the

[12] Website for the online price comparison service is: www.sahkonhinta.fi.

transmission services. (Energy authority, 2019b.) In Finland, the deregulation of the electricity markets did not include privatization, hence many of the DSOs are still locally owned, often by municipalities. (Annala et al., 2013.)

However, over the recent years some of the largest energy companies in Finland, for instance Fortum and Vattenfall, have sold their electricity distribution networks to domestic and international investors (Annala, 2015). These investor led distribution companies have been investing heavily into underground cabling, and by doing so gradually replacing the overhead lines that are prone to be vulnerable for extreme weather conditions (Ala-Kokko, 2018). These events have drastically changed the landscape of the Finnish distribution networks, since the investments have been funded by increasing the distribution prices significantly over the past few years. According to the Energy authority's online price comparison service, the domestic distribution tariffs for regular homeowner[13] has increased over 28 percent in five years from 4.56 c/kWh in January 2014 to the price of 5.87 c/kWh in the first of April 2019. (Energy authority, 2019a.) There are substantial regional variations that can significantly increase or decrease the total price of electricity for the household. For instance, the average distribution price in the first day of April 2019, was 4.44 c/kWh in Northern Finland, while simultaneously the average distribution price in Eastern Finland was 8.32 c/kWh. This means that in regional level the increased distribution tariffs may exceed or be lower than the 28 percent level of increase. (Energy authority, 2019a.)

The rapid surges in distribution prices and increased differences between different regions has led to increased participation of the regulating authorities. The final push for the demand of more active regulator came through the public uproar that followed after a DSO Caruna[14] proposed over sudden 20 percent increases in the electricity tariffs in 2016. This led to the amendment of the electricity market legislation, which currently restricts DSO's and TSO's right to increase network

[13] Consumer's annual consumption 5000 kWh, average distribution tariff for the whole country.
[14] Caruna currently operates distribution network that was sold by Fortum in 2014. It has the largest share of the distribution markets in Finland.

tariffs by maximum 15 percent during rolling period of 12 months. (Energy authority, 2018b; Electricity Market Act (4:26a §).)

Even though homeowners in Finland cannot compete their DSOs, they can still choose between different contract types or tariffs that the distribution companies offer. The three most common tariffs that are offered are: fixed-rate tariff, two-rate (i.e. time-of-day) tariff and seasonal tariff. The basic pricing structure for all of these three tariffs are the same: monthly basic charge (€/month) and an energy charge (c/kWh). (Ruokamo, Kopsakangas-Savolainen, Meriläinen & Svento, 2018.)

Fixed-rate tariff operates in a pretty straight forward fashion. The charge (c/kWh) of the electricity is constant for every hour of the year. The two-rate tariff and seasonal tariffs are so called time of use tariffs that have varying prices according to the load. In two-rate tariff the charge varies for days and nights, lower charge during the night-time load and vice versa. In the seasonal tariff the structure is the same, however the change variable is the season of the year rather than time of day. Energy charge is higher when the system load is higher, mainly during winter workdays, and cheaper in other times. These time of use tariffs encourage customers to plan their electricity usage and possibly ease the burden of the system during peak load times, however they do not necessarily provide flexibility to the markets when it is required. As an option for this problem a new alternative dynamic load-based tariff has been proposed, called power-based tariff (PBT). This tariff charges consumers based on their utilized peak power capacity, which would create an incentive for households to smoothen their consumption profile and limit their peak power usage. (Ruokamo et al., 2018.) Variations of PBT has already been taken gradually into use by three pioneering companies in Finland (Happonen, 2019).

3.2 Electricity contracts

The Finnish electricity retail market can be deemed as fairly competitive. The market consists of 72 retail suppliers, of which 55 offered their products nation-wide in Finland. The market concentration in the Finnish electricity retail market is around 600 to 700 in Herfindahl-Hirschman index (HHI). (Energy authority, 2019c.) The index takes into account the relative size distribution of the firms in the market. The maximum value of the index is 10 000, which would mean that the market is controlled by a single firm. On the contrary when a market is occupied by a large number of firms of relatively equal size value of the index approaches to zero. (U.S. Department of Justice, 2018.)

Finnish customers' participation in the retail market can be evaluated in two categories, signing a new contract and switching a supplier. Finnish consumers seem to be relatively active to compete their electricity contracts, but switching the supplier is fairly scarce. According to Nordic Energy Regulators study (2019), approximately 87 percent of the Finnish customers' state that they have signed a new contract with an electricity supplier, which was the highest rate among the Nordic countries. Out of these customers 39 percent state that they signed a new contract during the last 12 months, which again was the highest amount compared to Sweden, Norway and Denmark. However, according to Finnish energy authority's latest national report (2019c), the percentage number of household customers that has switched a supplier during a calendar year, has been around 10 to 12 percent for the past few years. These numbers indicate that Finnish households are relatively active in competing their electricity agreements, however they seem to be loyal for their current suppliers. The information of supplier switch rate is presented in detail in Table 3.

Table 3. The share of Finnish electricity customers who have changed the supplier in 2013-2018 (Adapted from Energy authority, 2019c).

	Households and other permanent dwellings	
Year	<10 000 kWh/a	>10 000 kWh/a
2013	10.2 %	12.7 %
2014	11.8 %	11.2 %
2015	12.5 %	13.1 %
2016[15]	12.4 %	
2017	11.3 %	
2018	11.1%	

[15] Since 2016 grouping used in data collection was changed. Data has been divided into two groups: household customers and other customers.

The retail market of electricity has been opened for competition more than two decades in Finland. The fairly stable supplier switch rates shown in Table 3 represent quite adequately the stagnant development in the consumer behaviour in supplier switching. Two decades is also a long time for the technological developments in the electricity infrastructure. In fact, Finland has been globally in a forefront in the installation of the smart meters[16] to nearly all of the energy consumers (Energy authority, 2019c). This is a part of smart grid deployment that is seen as a significant opportunity to reduce carbon emissions at all levels and gain comparative advantage in the clean technology markets in a global scale. (Zhou & Brown, 2016.) The comprehensive roll out of these devices, which detect the use of hourly measured consumption data has made it possible for electricity suppliers to offer all customers dynamic electricity contracts, where the price reflects the price at the Nord Pool spot market. These contracts are known as real-time pricing (RTP) contracts, or more commonly spot pricing contracts. (Ruokamo et al., 2018.)

Finland has sufficient technology in place that enable customers to choose and switch their electricity contracts freely and according to latest trends. Finland's electricity network infrastructure enables electricity suppliers to offer various types of electricity contracts. However, a rough division can be made depending on the pricing schemes of the contracts. This means that the contracts are divided into either fixed rates or dynamic rates.

3.2.1 Fixed rate

Fixed rate contracts are straightforward from the customer's point of view. On top of possible monthly fees, customer pays a fixed rate (c/kWh) for the used electricity no matter when or how much of the electricity is used. It is a simple contract for the consumer, since the price does not change and the only way of having any influence on the electricity bill is to simply adjust the usage of the electricity.

[16] By the end of 2018, more than 99 percent of consumption places in Finland had installed a smart meter.

Even though the fundamental idea of the fixed rate contract is really simple. The range of different kinds of fixed rate products that suppliers offer to households is quite vast. Basically, when a consumer compares different fixed rate contracts, she has four comparable and interchangeable categories, which together form the product.

First category is the basic fee of the contract. This charge is either monthly or yearly fee that is added on top of the consumption of the electricity. The basic fee covers retailers fixed costs and is charged regardless of the consumption (Sähkönvertailu, 2019). Basic fees in Finnish energy bills typically range between zero and five euros per month. This means that during months of lower consumption the unit price of the electricity is higher than during months of higher consumption.

The second category is the production method of the electricity. The importance of this category has arguably increased within the last few years due to the increased awareness of environmental issues and strong public demand towards more sustainable options also in electricity contracts. For instance, households' willingness to pay a premium for green energy have been widely shown in academic studies (see e.g. Sundt & Rehdanz, 2015; Kaenzig, Heinzle & Wüstenhagen, 2013). This can also be seen in the contracts that the electricity companies offer to consumers. For instance, Vattenfall offers contracts that have same prices and terms but different production methods. Depending on the preference of the customer she can choose contract that ensures the electricity is generated either by wind, hydro, solar or nuclear (Vattenfall, 2019.) Oulun Energia also offers its customers the option to choose a responsible production method, with a principle that the higher the price, the more sustainable the generation method is (Oulun Energia, 2019).[17]

Third category is the duration of the contract. According to the Finnish energy authority's national report (2019c), in 2018 the most common type of supply contract was open-ended contract with indefinite validity. The contract may be terminated with two weeks' notice. It was chosen by about 49 percent of retail customers.

[17] Biomass and hydro: 1€/month, Wind: 2€/month and Solar: 3€/month.

Second most popular contract type was the fixed term contract that was chosen by 41 percent of customers. Typically, the duration of the fixed term is between one or two years and during this period the price of the electricity is fixed. The rest nine percent of the retail customers had dynamic electricity price contracts. This distribution illustrates how popular fixed term contracts are compared to dynamic alternatives.

The last category is the price of the energy. Retailers offer prices that are close to the area price that is formed in the Nord Pool Elspot marketplace. On top of this the retailers add their own margins that typically reflect the so-called ingredients of the contract. Traditional and still by far the most common way of pricing the energy is cents per kilowatt hours (c/kWh), which means that the energy is charged depending on the used amounts of energy. However, retail companies, such as Fortum, Imatran Seudun Sähkö and Oulun Energia, have recently started to offer contracts which have fixed price per month for a certain quota and extra costs for the exceeding usage. For instance, Imatran Seudun Sähkö offers small, medium and large "packages" depending on the household's annual consumption. The small contract, that is targeted for the households that have annual consumption of 3000 kWh's, includes basic monthly charge and fixed price of 11.90€/month. This enables the customer to use 250kWh/month. If the usage exceeds this amount the customer pays quarterly changing fixed rate for every extra kWh[18]. (Imatran Seudun Sähkö, 2019.) This type of contract is similar to mobile phone bills. For the electricity market point of view this contract type proposes issues that are somewhat polarized. On the other hand, the customer is motivated to obey the consumption quotas. However, this can mean that there can be significant peaks in demand at the end of each month, because the customer is incentivized to use all the possible excess electricity that is left in the quota. The fit of these contracts in Finnish environment is questionable since the demand of electricity is strongly correlated with the need for residential space heating. In 2017 space heating corresponded 68% of the total energy consumption in households (OSF, 2018). The need for space heating obviously varies a lot depending on the weather. A household's monthly electricity usage during summer

[18] The price for the extra electricity varies according to market prices.

months tend to be vastly lower than during winter months. Having same quotas for electricity use every month is therefore arguably a problematic solution in Finland.

3.2.2 Dynamic pricing

According to Borenstein (2013) there is a consensus that dynamic, or time-varying, retail pricing for electricity would improve the efficiency of electricity systems and would lower the total cost of meeting electricity demand. Borenstein suggests that the primary benefit in dynamic pricing schemes is that it allows the retail power supplier to give consumers an incentive to reduce consumption at peak times, when the system is strained and shift the consumption toward lower demand times when supply is ample. The most dynamic contract type is real-time pricing (RTP), which reflects the scarcity in the power system by having, typically, hourly varying prices depending on the state of the power system. RTP program is widely considered to have significant potential to increase flexibility in the demand side of the power markets. (Ruokamo et al., 2018.) In fact, academic studies have shown that dynamic pricing does have an affect on households' consumption behaviour. For instance, study made by Allcott (2011) showed that consumers that had RTP contracts conserved energy during peak hours and did not increase their average consumption during off-peak times. When there are plenty of households that participate in demand response, this could mean smoothened demand peaks, therefore more efficiently operating electricity markets.

Similarly to fixed rate contracts, there are also variations in the contract terms for dynamic priced contracts. Dynamic pricing schemes in Finland can be categorized either to time-varying or load based programs. In time-varying programs, the rate depends on when electricity is demanded, whereas in load-based programs the rate is determined by the current power load level of the household. (Ruokamo et al., 2018.) Other forms of dynamic electricity pricing schemes that are used abroad are for instance block pricing and critical peak pricing. In block pricing scheme the marginal price of electricity increases according to total quantity consumed. In critical peak pricing scheme consumers pay most of the time a standard rate, but on occasional high price days they pay higher prices or receive rebates for energy conservation. These kind of contracts are also called peak-time rebate contracts. (Allcott, 2011.)

In Finland, RTP contracts follow the Nord Pool's day-ahead spot market that has hourly changing prices for the electricity. Retailers then add their premiums to the spot price and sell it to the customers. Premiums vary between the retailers and sometimes retailer can offer different contracts on the basis of the generation method. For instance, Vattenfall (2019) currently offers normal RTP contract with premium of 0.29 c/kWh, as well as so called EKO contract, which is ten cents more expensive, but the electricity is fully generated by wind power.

RTP contracts are typically valid indefinitely, which means that the contract is binding as long as the customer is satisfied. Spot market-based contracts are suitable for households that are interested in the development of the electricity market prices as well as able and willing to shape their consumption behaviour according to the spot prices. Household can follow the hourly varying price online or via mobile applications and plan the individual energy consumption pattern accordingly. (Karjalainen, 2018.)

From the customer's point of view, spot market-based contracts enable consumers to always pay the market price for the used electricity. This means that the consumers face volatility risks in their contracts but can also obtain more savings in their electricity bills by simply shifting consumption from high demand peaks to low demand. During low demand hours, the price of the electricity is cheaper, hence RTP contracts are suitable option for informed consumers that can easily affect their consumption for instance via smart appliances or automated home heating systems.

As established earlier in this thesis, according to Finnish energy authority (2019c), the share of retail customers that had dynamic contracts was 9 percent in the year 2018. These contracts include RTP as well as other dynamic contracts that have prices varying in different degree, i.e. on monthly basis. Even though this is a relatively low share of the total users, the trend is growing. In 2016 the share of households that had dynamic contracts was roughly seven percent. The increase of two percentage points signals the increasing demand for these types of contracts. (Energy authority, 2017; 2019c.)

This chapter has explained the different alternatives from which the customer chooses her electricity contract. It should be noted that even though money seems to be the most important factor that guides households, it is not the only thing that matters when the contract is chosen. Other factors that customers consider important are for instance environmental issues and support for local suppliers. Customers are inclined to pay a premium on their electricity, if the electricity is generated by using sustainable and renewable energy sources or if the electricity company is a local operator. (Nordic Energy Regulators, 2019.) Table 4 summarizes the different options that households in Finland have when they make the decision on their electricity contracts.

Table 4. Households' options in electricity contracts and factors that cannot be influenced.

Components	Decisions for households	Factors that cannot be influenced
Distribution	- Tariff [a]	- Distribution company - Distribution prices - Contract length
Energy	- Retail company - Production method - Pricing scheme of the contract [b] - Duration of the contract [c]	- Area price [d]
Taxes	-	- VAT - Energy tax - Sales tax

a: i.e. Fixed-rate or two-rate, for instance day-night or seasonal

b: i.e. Fixed price for electricity, RTP contract, fixed monthly fee, time-of-day, seasonal

c: Valid indefinitely or Fixed term, typically between one to two years

d: Area price for Finland is given by the Nord Pool day-ahead market, and acts as a base for the retailer's offered price

4 THEORETICAL FRAMEWORK AND METHODOLOGY

In this chapter we introduce the theoretical framework and empirical approach of this thesis. The theoretical framework comes from discrete choice theory. The empirical part utilize discrete choice binary logit (BL) model.

4.1 Discrete choice theory

When studying the microeconomic activity where decision maker evaluates so called all-or-nothing alternatives, we are talking about discrete events. Either something is or is not. Discrete choice framework investigates choices made by the individuals among finite set of alternatives. Fundamentally discrete choice is about modelling discrete outcomes and responses to survey questions about the strength of preferences or about self-assessed health or well-being. In these cases, the dependent variable is not a quantitative measure of an economic outcome, instead it is an indicator of the occurrence of some outcome. In other words, discrete choice is about modelling probabilities and using econometric tools to make probabilistic statements about the occurrence of these events. (Greene, 2012.)

Discrete choice framework has three common features that typically arise in all discrete choice models. First feature is the choice set that depicts the set of alternative options that the decision maker has. Simply put, choice set represents the set of alternatives of which the decision-making unit chooses the preferred option. To fit within a discrete choice framework the choice set has to meet three requirements. First, choosing one alternative inevitably means that none of the other alternatives can be chosen, i.e. alternatives must be mutually exclusive. Second, all possible alternatives need to be included, meaning the decision-making unit chooses inevitably one of the alternatives, i.e. alternatives are collectively exhaustive. Lastly, the choice set must contain finite number of alternatives, so that the researcher can count the alternatives and therefore be finished with counting at some point. (Train, 2009.)

For the purposes of this study we can make a fair assumption that a household must have one electricity contract, and the marginal utility of acquiring a second contract is zero, since dwelling's electricity needs are always fulfilled with a single contract. Having two simultaneous electricity contracts in one address is in fact not possible. This means that a Finnish household has to choose one electricity contract in order to obtain electricity. Choosing one contract means that no other contracts can be chosen. And the retail market for electricity contains finite number of companies and contracts. This means that the choice set of electricity contracts for Finnish households fulfils all three requirements that discrete choice framework requires.

Second feature in the discrete choice theory is the determination of utility for different alternatives in the choice set. It is a common practice that economists do when they try to model and describe the benefit that a consumer receives when she consumes a product or service or makes purchase decisions. Utility can be considered as somewhat arbitrary concept since it does not have no natural level or scale. (Train, 2009.) This does not diminish the concepts value for researchers; however, it does mean that direct comparisons between utility levels of different studies is obsolete.

According to neoclassical economics, the economy is portrayed as interactions between a collection of profit maximizing firms and utility-maximizing households that operate in perfectly competitive markets. The idea that households or "rational economic entity" maximizes her utility or self-interest is often referred by economists as rationality axiom. (Boerger, 2016.) People may not actively think about their utility levels during their everyday life but through their actions and decisions, for instance when they make purchase decisions, they do provide signals of their utility levels towards certain products or services. In discrete choice models the usual assumption is that decision maker chooses the alternative that maximizes her utility. This is also called the decision rule assumption. (Train, 2009.)

The previously mentioned axioms provide the basis for this thesis' research surroundings. From the researchers' point of view, it is important to define the utility levels correctly to be able to interpret the results properly. However, no matter how comprehensive the survey or other data gathering method is, there will always be at least some level of stochastic elements that are specific to and known only by the individual, but not by the researcher. In order to interpret the data on individual choices, economists use random utility models (RUMs). (Greene, 2012.)

RUMs are derived on the basis of early work done by Thurstone (1927), Marschak (1959) and McFadden (1974). In these models, the decision maker is assumed to operate in utility-maximizing manner, albeit it does not preclude the other forms of behaviour. (Train, 2009.) Mathematically RUMs are derived in the following manner. A decision maker, labelled as n, has to make a choice among alternatives, labelled as J. All of the alternatives provide a certain level of utility, labelled as U, for the decision maker. In mathematical formula, this can be denoted as: $U_{nJ} > 0 \ \forall J$. The utility that decision maker receives from different alternatives, for instance alternative j, can be denoted as: $U_{nj}, j = 1,\dots,J$. This level of utility is known by the decision maker, however not by the researcher. According to decision rule, the alternative that is chosen by the decision maker provides the highest level of utility. In the context of this example, the decision maker will choose alternative i over alternative j, if and only if $U_{ni} > U_{nj} \ \forall j \neq i$. (Train, 2009.)

The RUM framework takes into account that the researcher is not able to observe all characteristics of utility. Hence the utility equation is often represented with a formula that includes the so-called random term that is typically denoted with epsilon, ε. (Greene, 2012.) The actual formula for RUM can be portrayed concisely in the following manner:

$$U_{nJ} = V_{nJ} + \varepsilon_{nJ}. \tag{1}$$

And since the researcher is not able to observe all the characteristics of utility, the utility is then divided into two components that represent the observable and unobservable factors. In the equation (1), V denotes the observable factors and is often called representative utility. These observable factors can include various measurable characteristics or attributes, but for the sake of simplicity in this formula V is used to denote them all. If the researcher would be able to observe all the factors that affect to utility, the formula would simply be: $U_{nJ} = V_{nJ}$. However, RUM framework acknowledges the fact that the researcher is unable to observe and measure all the factors, therefore the formula also includes ε to denote the stochastic factors that cannot be observed by the researcher, but still affect to the utility. This breakdown is fully general, since ε_{nJ} is defined as the difference between the true utility and the representative utility, seen in equation (2) below: (Train, 2009; Greene, 2012.)

$$U_{nJ} - V_{nJ} = \varepsilon_{nJ}. \quad (2)$$

With carefully designed surveys the share of the unobserved attributes can be diminished, making the research outcomes more reliable.

Third common feature in the discrete choice theory is defining choice probabilities for particular alternatives in the choice set. The process of defining choice probabilities is closely linked with the utility determination, since through different levels of utility researcher can assess what alternative in the choice set is the preferred option for the studied decision-maker. (Train, 2009.) For purposes of studying behaviour of individual people, we will form models that link the decision or outcome to a set of factors, at least in the spirit of regression. The general framework of probability models is:

$$P(event\ j\ occurs) = P(Y = j) = F[relevant\ effects, parameters]. \quad (3)$$

The “event” is an individual’s choice among two or more alternatives. The study of qualitative choice for the probabilities of these events focuses on appropriate specification, estimation and usage of models. (Greene, 2012.)

Defining choice probabilities is the part of discrete choice models that specifies a certain probability for a decision maker to choose different alternatives. This probability is expressed as a function of observed variables that relate to the alternatives in the choice set and to the decision maker. The researcher can make a general probabilistic statement that a decision maker chooses alternative i over alternatives J in a following RUM environment: (Train, 2009.)

$$
\begin{aligned}
P_{nj} &= Prob(U_{ni} > U_{nj}\ \forall\, j \neq i) \\
&= Prob(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\ \forall\, j \neq i) \\
&= Prob(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}\ \forall\, j \neq i). \qquad (4)
\end{aligned}
$$

This equation is the basis of choice probabilities in RUM environment.

Standard microeconomic theory suggests that a consumer always acts rationally and maximizes her utility. However, at the forefront of behaviour economics, Simon (1982) challenges the traditional line of thought and suggests that rationality is bounded due to limitations on our thinking capacity, available information and time. This bounded rationality can be seen in discrete choice theory for instance through default effects, meaning that when a decision-maker is confronted by a choice with a default option, they often are predisposed to accept the default choice (Fowlie, Wolfram, Spurlock, Todd, Baylis & Cappers, 2017). It is estimated by Annala et al. (2013) that in the Finnish electricity market, approximately 60 to 70 percent of residential customers purchase their electricity from their local supplier with default contracts. They also studied that majority of these customers could have saved money, if they had competed and switched their supplier contracts. Hence, it is reasonable to assume that the two phenomena: default effects and bounded rationality, are present in the electricity markets.

4.2 Empirical model

In this thesis, the discrete regression model that we use is logit, which is considered the easiest and hence most widely used discrete choice model. Arguably the popularity of logit model stems from the fact that the formula for the choice probabilities takes a closed form and is readily interpretable. Logit models assume that the unobserved factors, i.e. εs does not correlate with each other alternatives and have the same variance between each other. However, it should be noted that this assumption of independence can be inappropriate in some situations. (Train, 2009.)

The biggest differentiative factor between logistic regression models and linear regression models is the fact that the outcome variable in logistic regressions is dichotomous or binary. This difference is reflected both in the choice of a parametric model and in the assumptions. The estimation of binary choice models is usually based on the method of maximum likelihood rather than minimizing the sum of squared errors. When these differences are taken into account, the methods that are used in the analysis using logistic regression follow the same general principles that are also used in linear regression. (Hosmer & Lemeshow, 2000; Greene, 2012.)

Train (2009) states three arguments that clarifies the power and limitations of logit models' abilities to represent choice behaviour. These three arguments are: taste variation, substitution patterns and repeated choices over time. Concisely the first argument means that logit can represent systematic taste variations that relates to observed characteristics of the decision maker, but not random taste variation. This means that the tastes cannot be linked to observed characteristics. The second argument means that the logit model indicates corresponding substitution across alternatives, given the researcher's definition of representative utility. Other models are needed to acquire more flexible forms of substitution. And the third topic means that logit works well when the unobserved factors are independent over time in repeated choice situations. However, if the unobserved factors are correlated over time, logit cannot handle these situations well. (Train, 2009.) This means that the researches abilities to pinpoint the important information is highlighted. For instance, in the context of this research, a household may state that environmental issues are always close to heart when making consumption decisions. However, the same household may exclude the arguably environmentally friendlier alternative in electricity contracts, due to lack of knowledge of the dimensions of different contracts.

According to Train (2009), the logit model has evolved from the origins of Luce (1959) through the completion of the formula by McFadden (1974). Using the same notations as in earlier equations in chapter 4.1. and adding a specific distribution for unobserved utility, the logit model can be derived. We again have the same setting as in equation (1)[19]. By assuming that each ε_{nj} is independently and identically

[19] $U_{nj} = V_{nj} + \varepsilon_{nj} \forall J$.

distributed (iid) extreme value, we can obtain the logit model. For each unobserved component of the utility the density is:

$$f(\varepsilon_{nJ}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}}, \tag{5}$$

and the cumulative distribution is:

$$F(\varepsilon_{nJ}) = e^{-e^{-\varepsilon_{nj}}}. \tag{6}$$

Train (2009) reminds that the key assumption in logit models is not so much to focus on the distribution of error terms, but rather on the statement that the errors are independent of each other. He also states that the independence assumption is not as restrictive as it may seem. For a well-specified model, the independence can be interpreted as a natural outcome. The ultimate goal for the researcher is to specify the observed variables V_{nj} sufficiently enough, so that the unobserved portion, ε, of the utility is essentially redundant, or as Train put it: “white noise”. Therefore, the goal is to specify utility well enough that a logit model is appropriate. (Train, 2009.) This description about logit models works as a basis for this thesis modelling framework.

The data will be analysed through three logistic regressions. The scope of these regressions is to find the best fitting, yet reasonable model to describe the relationship between dependent variable and a set of explanatory variables. The regressions generate coefficients, including standard errors and significance levels, of a formula in order to predict a logit transformation of the probability of presence of the characteristic of interest. (Medcalc, 2019). For instance, the formula for a probability for a respondent that is willing to acquire electricity contract that includes electricity consumption control would be:

$$logit(p)_{WILLDR} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n. \tag{7}$$

where p denotes the probability that a respondent either accepts or rejects the dependent variable, in this case *WILLDR*. β_o denotes the intercept and other β’s represent the coefficients and *X’s* represent the explanatory variables.

The value calculated for p denotes whether the respondent is willing to acquire electricity contract that includes electricity consumption control. In this research if the p receives a value that is $0 < p \leq 0.49$, the respondent would not be willing to acquire the aforementioned contract, whereas if the value is $0.50 \leq p \leq 1$, the response would be yes. Therefore, we can say that p_{WILLDR} is the representative utility for the willingness to acquire demand response contracts.

This thesis' dependent variables are all dichotomous that fulfil the discrete choice theory's choice set requirements. All three dependent variables will be analysed through three separate regressions that are all done according Binary Logit (BL) models, a framework that was completed by McFadden (1974). In the used BL models the choice probability is of the form:

$$P_n(j = 1) = \frac{exp(\beta_1 X_n)}{1+exp(\beta_1 X_n)}. \tag{8}$$

In this equation β_1 is the vector of estimated parameters for a choice j and X_n is the corresponding vector of explanatory variables.

5 DATA

In this chapter, the empirical data of this thesis is presented. Moreover, we describe the dependent and explanatory variables.

5.1 Data description

The empirical data of this thesis is obtained from a survey that was conducted in 2016 by a group of researchers from University of Oulu and Finnish Environment Institute (SYKE). The survey was designed on the basis of two thorough pilot studies that tested the quantitative and qualitive features of the study. The pilot studies were conducted in order to make sure that the survey is both understandable and credible to the respondents. (Ruokamo et al., 2018.)

The first pilot was qualitative study that was done in the fall of 2015. In this study the final survey was pretested by interviewing small group of Finns. The focus was on presenting the questions to the respondents in the most understandable manner. The second pilot was quantitative and broader study that was carried out with an internet survey in Webropol. This pilot focused more on the empirical aspects of the final survey. (Ruokamo et al., 2018.)

The final survey was conducted in October 2016. Based on the second pilot, the researchers selected homeowners as a target group for the survey since their response rate was significantly higher than individuals who lived in rental flats or houses. The survey was done via mail invitations that included instructions on how to answer the internet survey. The instructions were sent to four thousand homeowners that were randomly picked from the civil registry, i.e. Population Information System of Finland. The age range of the target population was limited to $24 - 75$ years old to exclude individuals that still live with their parents or presumably have short period of home ownership. (Ruokamo et al., 2018.)

The number of received responses was 380, which results in response rate of 9,5%. It is acknowledged that the response rate is relatively low, therefore the collected sample may suffer in some degree from non-response bias. Due to time and budget constraints, the group were not able to send reminder letter that likely would have had positive impacts on the overall response rate. Other possible reasons for the low response rate could be the selected survey mode, in this case the internet survey, as well as the difficulty of the subject matter and general lack of interest toward energy issues among households. For the exclusion of selection bias, the respondents were also asked if their profession has any links to energy industry or electricity markets. Only 6.8 percent of the respondents reported that they work is related to energy sector indicating that there is no significant bias towards having more than expected "professionals" among the respondents. (Ruokamo et al., 2018.) Also, it should be noted that the survey was conducted briefly after the DSO Caruna raised distribution costs for its customers that caused a nationwide discussion about the state of Finnish distribution system[20]. This may have caused some reporting bias among the respondents, however due to the fact that this research is more interested in the energy contracts rather than distribution contracts, this should not propose an issue in this research.

Table 5 displays the descriptive statistics of the respondents' socio-demographic characteristics and the corresponding statistics of either national average or the survey averages. The sample consists of homeowners that are more educated and somewhat older than the average Finnish homeowners. Also, the amount of men respondents were slightly higher than women. The similar distribution patterns concerning sex and age distribution have been also observed in two Swedish energy-related studies (Broberg & Persson, 2016; Ek & Söderholm, 2010). We can speculate that these findings can be explained by the increased overall interest toward energy issues among this group. Due to aforementioned reasons, the overall results of the survey should be fairly valid, however not fully generalizable for all Finnish homeowners. (Ruokamo et al., 2018.)

[20] Briefly discussed in the chapter 3.1 of this thesis.

Table 5. Descriptive statistics of the respondents (N=380) (Adapted from Ruokamo et al., 2018).

	Respondents	**Corresponding statistics**
Socio-demographic characteristics		
	Average	Average
Age (years)	56.4	52.1[a]
Household size	2.4	2.2[b]
	Percent	Percent
Gender		
Female	43.2	50.0[a]
Male	56.8	50.0[a]
Household's income (gross, €/month) (N=374)		
<4 000	31.8	N/A
4 000-5 999	31.0	N/A
6 000-7 999	18.4	N/A
8 000-9 999	9.4	N/A
>10 000	9.4	N/A
Education (N=379)		
Polytechnic or university degree	56.2	24.0[c]
Living environment		
City	59.7	N/A
Town, sparsely populated area or small population center	40.3	N/A
Dwelling type		
Detached or semi-detached house	67.4	64.5[d]
Terraced house	11.8	13.3[d]
Apartment building	20.8	22.2[d]

N/A: Not available

a: Corresponding statistics of the original sample of 4 000 homeowners

b: Corresponding statistics of Finnish homeowners (OSF, 2016b).

c: Corresponding statistics of Finnish population aged 20-74 (OSF, 2016a).

d: Corresponding statistics of Finnish dwellings (Energy authority, 2017).

The survey consisted of over hundred questions. For this thesis the most important questions that the survey contained were the following three:

1. Do you have a fixed rate electricity contract?

2. Have you considered a spot price contract where the price of electricity varies hourly?
3. Are you willing to acquire a contract that includes electricity consumption control where your consumption is shifted from peak hours to off peak hours?

Based on these questions, three dependent variables are created for the regressions. The response distributions for these three questions are visually demonstrated in Figure 5.

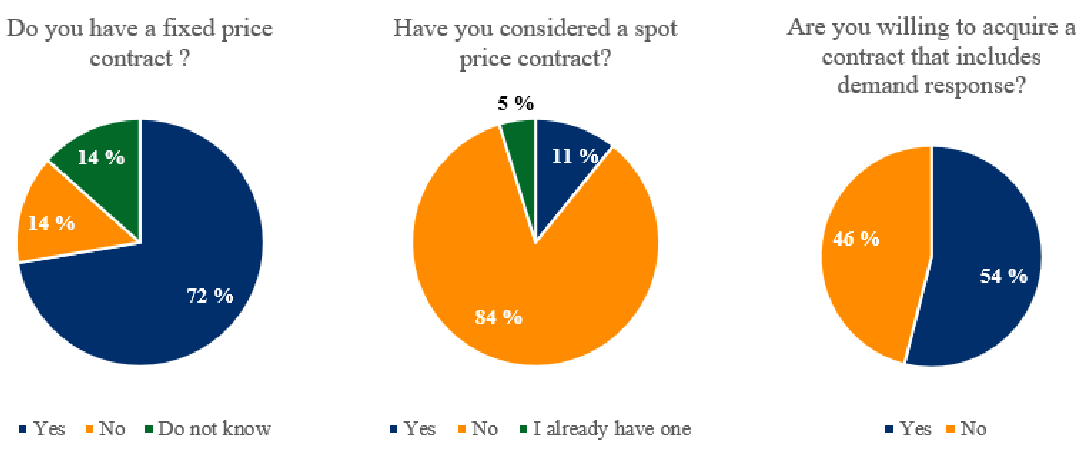

Figure 5. Respondents' electricity contracts and readiness for demand response (N=380).

5.2 Dependent and explanatory variables

Table 6 presents concisely the dependent variables as well as the means of the variables. Each variable will be examined more thoroughly in the following paragraphs.

Table 6. Dependent variables and response distribution in the regressions (N=380).

Dependent variable	Definition	Yes*	No*
DNK (1 if yes)	I do not know if I have a fixed rate electricity contract	13.4	86.6
RTP (1 if yes)	I have considered acquiring a spot price contract or I already have one	15.5	84.5
WILLDR (1 if yes)	I am willing to acquire electricity contract that includes demand response (electricity consumption control)	54.0	46.0

*: Values in percentages

The variable *DNK* represents the share of respondents who did not know whether their electricity contract is fixed rate or not. Surprisingly many respondents were unable to state what kind of electricity contract they have. This result is somewhat in line with the results from the latest consumer behaviour research in the Nordic electricity market which stated that 87 percent of the Finnish household can name their electricity supplier. This means that 13 percent of the respondents do not know which company is sending them electricity bills, and also, that they are unaware of how much and in what terms they are paying for their electricity. (Nordic Energy Regulators, 2019.) This further embraces the need to gain more information about the consumer knowledge on the electricity market, to better understand and enhance the structure of demand side of the market. It should also be noted that in the survey fixed rate contracts and spot price contracts are distinctively explained just before the question is presented. This assures that the respondents are fully aware what is asked and that they do not confuse the energy contracts with distribution contracts. Hence, the 13.4 percent of respondents that do not know their electricity contract type can be seen as a credible share.

The second variable *RTP* represents the share of respondents who either have RTP contract, or then have considered of acquiring one. Earlier on chapter 3.2.2. we discussed about the benefits of RTP contracts. Therefore, studying people's attitudes towards RTP contracts is well-grounded. There are number of academic studies made about how RTP contracts enhance electricity markets. According to Kopsakangas-Savolainen and Svento (2010), RTP contracts diminishes the need for total production capacity even with inelastic demand. They also state that as the share of the RTP customers increase or demand becomes more price elastic, the price of the peak demand hour clearly lowers. For other researches, see for instance Huuki, Kopsakangas-Savolainen and Svento (2014), Borenstein (2013) and Ruokamo et al. (2018).

We argue that the benefits from widespread adoption of RTP contracts comes from the fact that if electricity users would adjust their consumption according to time-varying electricity prices, or other signals about the state of the power system, it would enable more efficient use of generation and network assets. For instance, our environment would benefit vastly from this, due to facilitation of matching intermittent generation of renewable energy with electricity demand. (Annala, 2015.) Therefore, researching people's willingness and unwillingness to acquire RTP contracts is valid to gain more perspective on the reasons that deters people from acquiring these contracts.

The last variable *WILLDR* measures consumers' willingness to take more active role in the electricity markets. In the survey, the respondent's willingness to adjust their electricity consumption, or demand response, was asked. Roughly 54 percent of the respondents answered yes to this question. The consumer segment that chooses RTP contracts is relatively small, however over half of the respondents accept that their consumption could be controlled in so called extreme or necessary cases.

Next, we describe the explanatory variables that are used in the regressions of this research. Most of the survey's questions provide non-linear responses, hence most of the variables are created by dummy-coding them so that the variables represent a distinct group of respondents.

The independent variables were roughly divided into three categories to model the research problem. These categories represent respondents: socio-demographic, attitude and consumer behaviour aspects. Table 7 presents the definition of most frequently used variables.

Table 7. Description of explanatory variables.

Socio-demographic variables	**Definition**	**Mean**
age (metric)	Respondent's age	0.564
city (1 if yes)	Respondent lives in urban area	0.597
female (1 if yes)	Respondent is female	0.432
hhsize (metric)	Number of individuals living in the household	0.238
high educ (1 if yes)	Respondent has either polytechnic or university degree	0.562
income (metric)	Monthly gross income of the household (from 1<2000€, 2=2000€-3999€, 3=4000€-5999€ … 8>14 000€	0.336
apartment (1 if yes)	Respondent lives in apartment or loft building	0.208
daywork (1 if yes)	Respondent has "traditional" 8:00-16:00 working days	0.482
ftworker (1 if yes)	Respondent is employed fulltime	0.462

Attitude variables	Definition	Mean
default (1 if yes)	In the choice experiment, did you always choose the default option	0.147
*diffcomp (1 if yes)**	I feel that it is difficult to compare electricity contracts	0.574
ener counter (1 if yes)	I am familiar with some energy counter that enables user to evaluate own energy consumption	0.202
entrain (1 if yes)	I have attended to training/event where the topic was energy efficiency	0.141
*follow ener use (1 if yes)**	I would be interested to follow own energy use with some device, if it would come without additional costs	0.811
*int ener use (1 if yes)***	I am interested in to receive more information on my energy usage	0.840
*int spot price (1 if yes)***	I am interested in to receive hourly information about spot prices of electricity	0.79
*low consumption (1 if yes)**	It is not possible to reduce my electricity usage, because it is already at low level	0.412
*unable timing usage (1 if yes)**	My daily rhythm does not enable me to schedule my electricity usage	0.384
*volatility ok (1 if yes)**	I do not mind if the size of the electricity bill varies a lot	0.164
Consumer behaviour variables	**Definition**	**Mean**
*active cons (1 if yes)**	I would like to have more effect on my electricity bill	0.786
*conservative cons (1 if yes)**	I prefer to buy products and services that are used by others as well	0.466
*environ cons (1 if yes)**	When purchasing, I always pay attention on the products and services environmental effects	0.508
fr (1 if yes)	Respondent has a fixed rate electricity contract	0.724
*innov cons (1 if yes)**	Testing new devices is interesting	0.526

*: The survey question is based on a 5-point Likert scale that ranges from “1” = “Strongly disagree” to “5” = “Strongly agree”. The answer is yes, if respondent has replied 4 or 5.

**: The survey question is based on a 5-point Likert scale that ranges from “0”=”I can not say, “1”=”Not at all interested” to “4”=”Extremely interested”. The answer is yes if respondent has replied 3 or 4.

As it can be seen from the Table 7, all but three variables are dummy-coded or binary yes and no questions. Only parameters *age, income* and *hhsize* were left in the metric form, basically because there was no significant benefit of dummy coding them.[21] The first six socio-demographic variables were included in all three regressions. These variables covered the respondent's age, gender, income, education level, household size and whether the respondent lives in a city or not. Other variables were used according to their fit in the model on the basis of both statistical and descriptive nature.

Variables that are inspected more in-depth are *default* and *fr.* The survey included a choice experiment section where the respondents were asked to choose from different flexibility scenarios their preferred option. Ruokamo et al. (2018) state that the main goal of this stated preference method was to determine how individuals form their preferences for demand side flexibility. This was done by identifying which attributes are substantial for individual's choice, how these attributes are ranked and what is the marginal willingness to pay for a change in particular attribute. There were six scenarios to choose from. *Default* variable is yes if the respondent always chose the default option without any flexibility characteristics in the choice experiment. The share of respondents that fall into this category was 14.7 percent. This is interesting result considering the bounded rationality and previous studies in default effects that was discussed in chapter 4.1. Also, it should be mentioned that since the variable *default* consists somewhat similar information as dependent variables, endogeneity is a likely problem.

Other highlighted variable *fr* is drawn from the same question as dependent variable *DNK*. The respondents were asked if they have fixed rate electricity contracts. Variable *fr* represents the one's that answered yes to that question, whereas *DNK* represents the ones that answered I do not know for the same question. It is likely that most of the respondents who did not know their contract type actually have fixed rate contracts rather than RTP or other type of dynamic contract, due to general lack of interest toward their own electricity contracts.

[21] For instance, *INCOME* was dummy coded to low income (respondents that were part of groups 1, 2 and 3) however, there were no significant results in the results, hence the variable was left in the current form.

6 RESULTS AND DISCUSSION

This chapter presents the results and has discussion on the research outcomes. The chapter is divided into three subchapters, one for each regression. The estimations were conducted with R, which is open source-based program and environment for statistical computing and graphics (r-project, 2019). The regressions utilize the generalized linear model (GLM) function. All three regressions were done by using binary logit (BL) model. Over thirty different explanatory variables were fitted into these models, however the best fit was achieved with fewer variables in each of the models.

Each model's fit is evaluated with log likelihood, null loglikelihood, McFadden Pseudo R^2 and Akaike information criterion (AIC). The coefficient results shown in all the following chapters are presented in estimated means of the slope. These coefficients provide information whether an explanatory variable has positive or negative effect on the probability to choose the dependent variable. The magnitudes of these coefficients also provide signals about how significant the effects are.

6.1 Determinants of not knowing contract type

The first regression concentrates on studying what factors are common for people who do not know the type of their electricity contract. Knowledge and awareness appear to be important for the acceptance of different demand response programs. For instance, Dütschke and Paetz (2013) found that consumers were more open to accept dynamic pricing programs, when they were given a chance to experience in practice how these can be managed in everyday life.

The results of the first BL model are presented in Table 8. To interpret the results correctly it should be underlined that the positive coefficients signal that the variable increases the probability that a respondent is unaware of her contract type and negative coefficients indicate the opposite.

Table 8. Results of the first binary logit model.

Dependent variable: Respondent does not know her electricity contract type		
Variable	**Estimate**	**Standard error**
age	-0.0811***	0.0186
city	0.6851*	0.4082
female	1.1258***	0.4122
hhsize	-0.3630*	0.2043
high educ	-0.4868	0.4281
income	0.0345	0.1281
ft worker	-0.4931	0.4906
default	-1.8470***	0.6720
ener counter	-1.9114**	0.7982
entrain	0.1432	0.6180
int ener use	-0.8778*	0.4769
int spot price	1.4954**	0.7230
active cons	-0.3535	0.4438
conservative cons	-0.6907*	0.4059
innovative cons	-0.6858*	0.4059
willdr	-1.3140***	0.4311
Model fit		Fit statistics
LL		-98.09
LL(0)		-133.9
McFadden Pseudo R^2		0.27
AIC		230.18
N		380
k (# of parameters)		16

***, **, * = statistical significance at 1%, 5% and 10% level respectively.

The results of this regression provide three statistically significant variables that indicate positive correlation with the dependent variable. Out of these three variables, the first two represent socio-demographic features of the respondents. These two variables are *city* (0.685*) and *female* (1.126***). Living in an urban area increases the probability of not knowing the contract type. The latter outcome is in line with the previous researches on electricity issues in Nordic countries. Higher probability of not knowing the contract type among females can be arguably explained through the observation that females are generally less interested in electricity issues than men. This phenomena is seen in the latest Nordic customer survey[22], where women prove to be less aware of electricity issues in majority of the survey questions. (Nordic Energy Regulators, 2019.) Also, Ruokamo et al. (2018) noted that men tend to be overrepresented in the survey results of energy-related studies. This can be explained by increased interest in energy issues within this group.

Interestingly, respondents who are *interested* in receiving hourly information about *spot prices* of electricity are more likely to not knowing their current electricity contract type (1.495**). This may be an anomaly in the model since only 7.9 percent of the respondents were interested in receiving the spot price information. Nonetheless, the result is interesting. Typically, one could assume that if an individual is willing to receive updated information about electricity prices, she would also be interested in her own electricity issues.

This model had plenty of explanatory variables that proved to be statistically significant and resulted with negative coefficients. Starting with the socio-demographic variables and *age* of the respondents. Our results indicate that as the respondent gets older by the year, the probability that she does not know her electricity contract decreases (-0.081***). The variable *household size* indicates that when the size of the household is increased by one unit, the probability of not knowing the contract type decreases (-0.363*). This could be explained by the fact that electricity bills tend to increase as the number of inhabitants in the household increases. Higher expenditures are likely to make electricity contracts more topical for households. Interestingly though, *income*, *apartment* and *higher education* variables did not provide any statistically significant results on this matter.

As for the attitudinal variables, it comes to no surprise that respondents who show interest in their households’ energy issues have higher probability of knowing their

[22] This survey concentrated on the presence and participation of Nordic electricity customers. As well as their attitudes towards electricity markets. The survey included responses from Denmark, Finland, Norway and Sweden.

contract types. The parameters that measure this interest are: *ener counter* (-1.911**) and *int ener use* (-0.878*). Similarly, people who are willing to allow some levels of consumption control (*willdr* -1.314***) are also more likely to know their contract type, as well as the respondents that always chose *default* option in the survey's choice experiment section (-1.847***). The *entrain* was the only attitudinal variable that did not have statistical significance in the model.

Parameters that measure consumer behaviour, excluding *active consumers*, provide results that all had statistical significances and negative values. Meaning that they all improve the possibility of knowing the electricity contract. Interestingly though *conservative consumers* (-0.691*), people who prefer to purchase products and services that are generally used by others, as well as *innovative consumers* (-0.690*), both had similar coefficient levels, as well as same statistical significance in the model. This is interesting result since in a way these characteristics are mirror images of each other. Perhaps the key takeaway is that people who tend to pay attention on their consuming behaviour also know what they are buying.

6.2 Determinants of RTP contract selection

The second regression concentrated on studying what factors are common for people who either already have acquired RTP electricity contract or have considered acquiring one. The number of respondents that have RTP contracts is 18 and the number of respondents that have considered the contract is 41. In this research we are interested in the characteristics of these respondents, since they have stated their interest toward this contract type. Hence, these respondents are pooled together and compared to the ones that have not shown interest. Together these two groups of respondents represent 16 percent of the survey's respondents. The results of the second BL model are shown in Table 9.

Table 9. Results of the second binary logit model.

Dependent variable: Respondent either have or is willing to acquire an RTP contract		
Variable	**Estimate**	**Standard error**
age	-0.0434**	0.0178
city	-0.1207	0.3585
female	-0.3076	0.3512
hhsize	-0.0939	0.1600
high educ	0.2258	0.3655
income	-0.0401	0.1147
apartment	-1.1817*	0.6197
ft worker	-0.4304	0.4485
diffcomp	-0.2031	0.3388
unable timing usage	-0.2729	0.3553
volatility ok	0.8460**	0.3866
conservative cons	-0.6932**	0.3415
environmental cons	0.7031**	0.3410
fr	-1.8461***	0.3694
dnk	-2.3264***	0.6595
Model fit		**Fit statistics**
LL		-128.8
LL(0)		-160.5
McFadden Pseudo R^2		0.20
AIC		289.6
N		380
k (# of parameters)		15

***, **, * = statistical significance at 1%, 5% and 10% level respectively.

The results from this regression provided two explanatory variables that had positive correlation with the dependent variable and statistical significance. These two variables were *volatility ok* (0.846**) and *environmental cons* (0.703**). It is understandable that individuals who do not have problems with a possibility of having a lot of *volatility* in their electricity bills are also more likely to acquire RTP contracts. After all, varying electricity prices are essential part of RTP contracts.

Perhaps the most interesting result is the indication that individuals who always pay attention on the environmental effects of products and services are more likely to acquire RTP contracts. This supports the general claim[23] that RTP contracts are seen as a factor that not only increase market effectiveness, but also boost environmental friendliness of the markets. However, it should be noted that even academics do not consider RTP as a shortcut or automation for environmental friendliness. For instance, Huuki et al. (2014) highlight that the original structure of the production system determines the final effects on environment. If the generation mix of electricity relies on generation methods that are powered by fossil fuels, the high level of adoption of RTP contracts may even increase the amount of greenhouse gases[24]. Still, this result signals positive correlation between environmental awareness and RTP electricity contracts.

The explanatory variables that provided statistically significant results and negative coefficients presented issues that can be speculated in various ways. First, it is understandable that respondents who showed moderate lack of interest toward electricity issues also had negative coefficients. For instance, respondents who *did not know* their *contract type* (-2.326***) and also the ones that had opted the simple *fixed rate contract* (-1.846***) both had negative coefficients. It should be mentioned that there is endogeneity bias, since variables *fr* and *dnk* represent features that are similar to dependent variable.

Perhaps a bit more intriguing result is the negative coefficient for living in an *apartment* (-1.182%*). We can speculate that this result is linked with arguably lower level of electricity consumption in apartment buildings. As for the consumption profile of apartment residents, according to official statistics of Finland (OSF, 2018) space heating amounted approximately 48% of the total consumed electricity in a household. Apartment residents tend to have lack of ability to influence or time the households heating options. This is because apartment buildings in Finland are typically heated with district heating. Meanwhile district heating is an efficient heating method, it restricts the individual resident's possibility

[23] See for instance Borenstein (2013).
[24] In the study, researchers tested RTP adoption levels of 33.3%, 66.7% and 99.9%.

of timing the consumption. (Motiva, 2012.) On top of these factors apartment buildings typically have more or less formal codes of conducts that tend to restrict the use of some energy intensive and noisy household appliances during night-time. These rules may not be mandatory by law, but most of the people follow them to avoid disturbing their neighbours. All of these factors restrict the resident’s possibilities to acquire savings via RTP contract, because the large portion of consumption is harder to time to cheaper electricity hours.

Age (-0.043**) has a negative coefficient on the matter. This result indicates that younger individuals are more likely to acquire RTP contracts. This is an interesting insight, especially for people who are keen on promoting RTP contracts. The average age of the respondents of this survey was 56.4 and the share of pensioners was 39%. The reason why this is highlighted is the fact that pensioners typically do not have to oblige the regular daily work schedules. This means that informed pensioners could, at least in theory, easily take advantage on the daily electricity price variations by timing some of their own electricity consumption from general peak hours, i.e. high pricing hours, to low demand, low cost hours. Perhaps pensioners in general should be more informed about the mechanics of RTP contracts.

The result for *conservative consumers* (-0.693**) indicates that they are less likely to adopt RTP contracts. One reason for this result could be the fact that majority of people have not acquired these contracts, making RTP contracts unlikely choice for people who acquire products that are used mainly by others. We can speculate however, what would happen if enough of trendsetting customers switched from fixed rate contracts to dynamic contracts. This change could eventually make the RTP contracts the most popular contract type for the masses. In economics, rate of adoption measures the relative speed with which an innovation is adopted by members of social system. This rate of adoption is a numerical indicant of the steepness of the adoption curve for an innovation. Theoretically, once the opinion leaders adopt a certain innovation, the adoption curve shoots upwards in a self-generating fashion. (Rogers, 1982.) Applying this theory of diffusion of innovations, we can speculate that *conservative consumers* would follow opinion leaders and also shift to RTP contracts when they do. This is interesting consideration, since this parameter represents 47 percent of the total sample, which is almost the same as the share of Finnish households that currently have chosen the fixed rate contracts.

6.3 Determinants of demand response contracts

The third regression examined respondent's willingness to acquire contracts which include electricity consumption control, i.e. demand response during peak demand periods. 54 percent of the respondents stated that they would be willing to acquire the contract. This is relatively high share, especially when compared with the share of people who are willing to acquire RTP contracts. The high number of respondents that accept demand response contracts signals that individuals are willing to adapt their consumption when needed or properly incentivised. The respondents were also asked: what kind of consumption control would you be willing to participate? The possible answers were:

1. "Electricity consumption can be controlled automatically according to contracts terms"
2. "The customer will be informed about forthcoming consumption control; the customer can refuse but without refusal the control will happen"
3. "The customer will be asked if the forthcoming consumption control is okay; if the customer agrees the consumption control takes place, in other cases it will not"

The responses were distributed almost evenly, being 37%, 25% and 38% respectively. It is interesting that the distribution of the answers were almost even. It is difficult to distinguish what makes alternatives one and three slightly more appealing than alternative 2. We can speculate that this could be because in alternative 2, the customer is forced to either silently accept or then register refusal. This creates psychological conundrum for the customer, either go along or refuse. Perhaps people prefer to feel that they are in charge, either by agreeing with contract terms or by having the final say in the matter.

The results of the third BL model are shown in Table 10.

Table 10. Results of the third binary logit model.

Dependent variable: Respondent is willing to acquire a contract that includes demand response		
Variable	**Estimate**	**Standard error**
age	-0.0369**	0.0153
city	0.0126	0.2899
female	-0.2669	0.2876
hhsize	-0.2624*	0.1398
high educ	0.0013	0.3068
income	0.0798	0.1024
daywork	-0.8235**	0.3370
ftworker	-0.2453	0.3864
default	-3.6828***	0.6467
diffcomp	-0.4239	0.2870
ener counter	-0.8013**	0.3631
entrain	1.2610***	0.4467
follow ener use	1.6359***	0.4006
int spot price	1.7615***	0.6576
conservative cons	0.5118*	0.2776
environmental cons	0.6949**	0.2828
innovative cons	-0.4601	0.3040
fr	-0.7160*	0.4194
dnk	-2.1896***	0.5861
Model fit		**Fit statistics**
LL		-170
LL(0)		-238.2
McFadden Pseudo R^2		0.29
AIC		380
N		380
k (# of parameters)		19

***, **, * = statistical significance at 1%, 5% and 10% level respectively

Interestingly, almost all sociodemographic parameters proved to be statistically insignificant to explain the dependent variable, including *high education*, *income* and *city*. The three sociodemographic parameters that does present statistically significant results are: *age* (-0.037**), *household size* (-0.262*) and *daywork* (-0.824**). All of these parameters suggest decreased probability to participate in demand response. These results clearly indicate that younger people are more likely to accept demand response. However, in broader sense willingness for demand response is not driven by sociodemographic characteristics.

Other parameters that decreased the probability of acquiring demand response contract were *energy counter* (-0.801**), *default* (-3.683***), *fixed rate contract* (-0.716*) and *dnk* (-2.190***). The negative effects of *fr, dnk* and *default are* not surprising, since they describe people who are obviously not too interested about monitoring and altering their electricity consumption behaviour. Perhaps a bit surprising is that the parameter *energy counter* also decreased the probability of demand response. This result contradicts other results from parameters that represent improved knowledge about energy markets. Then again, the parameter measures whether or not a respondent is familiar with some counter. It does not measure the usage of any counter.

The parameters that increase the probability for demand response represent mainly behavioural aspects of the respondents. It is surprising that *conservative consumers* (0.512*) are more likely to acquire these contracts. Then again, a narrow majority of the respondents are willing to acquire these contracts. Therefore, this can explain why people who prefer purchasing same products and services as others do, are also more willing to acquire these contracts.

Similarly with RTP contracts, *environmental consumers* (0.695**) are more willing to acquire demand response contracts. Annala et al. (2018) state that the reduction of environmental impacts of electricity use and shift into renewable power generation crucially depends on demand response. The result from this regression suggests that people who feel strongly about environmental issues accept this notion. Annala et al. (2014) reviewed previous studies on acceptability of residential demand response programs. They stated that price and security of supply are bigger motives to change consumption behaviour than environmental issues. We argue that our result represents, if not paradigm shift, at least increased significance of environmental issues in the acceptance of demand response.

Another set of parameters that also increased the probability of demand response contracts were *energy trained* (1.261***), *follow energy use* (1.636***) and *interest in spot price* (1.762***). All of these parameters represent respondents that clearly show interest toward energy issues; hence these results are not surprising. In general, these results indicate that there is a clear division between people's preferences surrounding this matter. It seems that people who are perhaps more aware of the consequences of their consumption behaviour and generally interested in their electricity issues are also more willing to provide demand response.

Six variables did not provide any direct statistical significance in any of the regressions. Perhaps surprising socio-demographic variables, such as *income* and *high education*, were among these six variables. We argue that the result related to *income* underlines that electricity issues tend to be uninteresting topic, since the price of the electricity is still relatively cheap.

If we compare the results of this thesis with previous academic research, we see that the general knowledge about electricity issues is needed to successfully implement demand response programs. Dütschke and Paetz (2013) state that consumers are open to dynamic pricing but prefer simple programs over complex and highly dynamic ones. They state that consumers are not able to grasp the individual and societal advantages of dynamic pricing contracts. Therefore, roll-out of dynamic contracts should be accompanied with convincing communication and information campaigns in order to make sure that the advantages of these contracts will be perceived.

Previous studies also show that consumers seem to favour simple price structures that remain in a constant level for a long period over more dynamic options (see e.g. Annala et al., 2014; Dütschke & Paetz, 2013). Annala et al. (2013) state that about 60 to 70 percent of residential customers in Finland acquire electricity from their local supplier under a default contract. These contracts are seldom the cheapest available in the markets even though people state that price and saving money are the most important attributes in electricity contracts (Nordic energy regulators, 2019; Kaenzig et al., 2013). Therefore, we argue that residential consumers in electricity market are prone to constraints of default effects and bounded rationality.

Other academic studies have shown that choosing RTP or dynamically priced contracts will result in at least some level of consumer surplus. Allcott (2011) reported that price elastic households in the US that have RTP contracts can save two percent annually in electricity costs compared to “normal” fixed rate contracts. Implementation of RTP contracts in Finnish markets have also been found to have positive welfare effects (Kopsakangas-Savolainen & Svento, 2010). Campillo, Dahlquist, Wallin and Vassileva (2016) have even researched the effects of RTP contracts without enabling consumer demand-side management. The research used hourly consumption data of 7-year period in Sweden. The results state that RTP electricity contracts offer potential of considerable economic savings even without consumers changing their electricity usage profile. All these studies indicate that consumers would be monetarily better off with RTP contracts, yet people still prefer fixed rate contracts.

On these bases we argue that money seems to be a poor or at least inefficient motivator for residential consumers to switch to RTP contracts. Moreover, the results of this thesis indicate that consumer acceptance of demand response programs could be better achieved by highlighting environmental aspects. Appealing to environmental aspects is not a new idea. Kaenzig et al. (2013) found out that in 2009 German electricity customers were willing to pay 16% premium for electricity that is produced with renewable energy sources. This result indicated that the German default electricity mix did not correspond to customer preferences. In other words, German customers would have been willing to pay extra for more sustainable option.

The survey that was used in this thesis was conducted in late 2016. It showed that people who consider environmental issues important when consuming are also more willing to acquire demand response contracts. Since then the Intergovernmental Panel on Climate Change (IPCC) has released a report about global warming and climate change that is drastically accelerated due to man-made activities. A prime example of this is the greenhouse gas emissions that is released in the atmosphere when electricity is generated with fossil fuels. This report has been one of the main catalyst that has accelerated people’s willingness to act more sustainable and reconsider their daily choices. (IPCC, 2018.)

Currently "eco-anxiety" is a term that describe people reacting emotionally and mentally to environmental conditions and knowledge about them. Often this anxiety and sorrow is exacerbated due to the feeling of being powerless to influence one's own future. (Pihkala, 2018). Hence, there is a need to educate consumers on their possibilities to have an effect on environment through their electricity usage profiles. Based on these issues we claim that environmental factors could better motivate people to adopt RTP and demand response rather than monetary factors.

7 CONCLUSION

Electricity markets with rigid demand side is prone to operate inefficiently. With this setting the market can face significant demand peaks that require matching supply capacity[25]. Rigid demand side is also problematic when the supply side is becoming more and more dependable on renewable energy sources, such as wind and solar power. These energy generation methods are difficult to predict without uncertainties. Hence, the power system could be needing some level of demand response to balance these uncertainties.

In Finland industry and commercial customers take roughly half of the nation's total energy consumption. This leaves the other half of the total energy consumption to Finnish services, public consumption and to housing and agriculture. The focus of this study was to research the behavioural tendencies of Finnish homeowners and their willingness and readiness to acquire electricity contracts that make residential consumers more active in the energy markets. The electricity usage of this segment represented 28 percent of the total annual consumption in year 2018.

Homeowners in Finland have a variety of options to make when they choose the electricity contract for their home. Choosing electricity contract is a discrete choice for a household. Therefore, the empirical part of this thesis was done with discrete regression model. Overall there were total of three regressions. The data used was collected with a consumer survey that was executed in October of 2016. All three regressions studied different aspects of consumer behaviour in the electricity markets. The first studied the reasons why households do not know what type of electricity contracts they currently have. The second and third focused on demand response by studying homeowner's willingness to become more active consumers. The second studied the respondent's willingness to acquire a dynamic RTP contract and the third researched respondent's attitudes toward demand response contracts.

[25] This combined with the fact that technology for electricity storage is still inefficient to provide sufficient assistance.

The results of the first regression indicate that the awareness of one's own electricity contract tend to be increased among individuals who are well informed about their own consumption behaviour. No matter if a person is actively seeking new solutions for old "problems" or just satisfied with having similar things as the masses have in general. Factors that tend to demonstrate higher electricity consumption amounts, for instance bigger household size, seem to increase the interest toward electricity issues. Straight forward interpretation of this deduction is that as the expenditures of certain product or service increases the interest towards the source of said expense also increases. According to the sample data, not knowing one's own electricity contract type is more common among females and people that live in a city. The latter finding may be related to the lower electricity consumption levels in the cities that may reduce interest towards electricity issues. The former finding may be linked with general lack of interest toward electricity issues among females compared to men.

The results from the second and third regressions provide information about the respondents' attitudes toward demand response. The results of the second regression show that people seem generally unwilling to choose RTP contracts, even though they could be financially better off with this contract. This can be explained by consumers' general lack of understanding or awareness of the features of RTP contracts. These contracts reward people for acting differently than masses. Timing household's energy usage for the periods of lower demand means that the price of the electricity tends to be cheaper. One could think that group of people, such as pensioners would be able to utilise this feature in their daily lives. The share of pensioners in the sample was around 40 percent, but *age* proved to be negative factor for the acceptance of these contracts. This indicates that with better marketing, electricity companies could attract more consumers to change to RTP contracts. Generally, the share of dynamic contracts in Finnish households have been slowly increasing. However, this thesis shows that the fixed rate contract is still by far the most favourable contract.

The third model focuses on whether respondents are willing to adapt their consumption if needed. The results from the third regression suggest that there is pretty steep difference between people who are willing to accept some levels of demand response in their contract and people who are not. The respondents who are older or have somewhat established daily routines seem to be less likely to participate in demand response. People who express general interest in electricity issues and their consumption behaviour are more likely to accept demand response contracts. It is interesting that roughly 84 percent of the respondents had not considered a dynamic RTP contract, a contract which basically provides monetary benefits when the consumption behaviour is adaptive. At the same time, almost 54 percent state that they are willing to have demand response in their contracts. In a way, these two contract types can be seen as product differentiation for different target groups. RTP contracts represent arguably the most dynamic contract type, hence the share of people who consider it as a viable option is substantially low. Whereas the other contract maps out people who are willing to accept demand response, but with more moderate level of dynamism. Based on this thesis, a narrow majority of respondents seem to accept some levels of demand response in their electricity contracts.

Generally, it was interesting that neither *high education* nor *income* provided any statistically significant results in any of the regressions. This indicates that the general lack of interest toward residential electricity issues cannot be explained through education or income levels. One can argue that this could be due to the overall well-functioning power system and relatively moderate prices of the electricity.

According to many studies that were covered in this paper, RTP contracts and demand response programs can disrupt the fundamental problems of electricity market's demand side[26]. This disruption will arguably provide benefits for both supply and demand side of the power market that will also benefit the environment substantially. This leads to so called "win-win-win" situation, where companies, customers and the environment are all better off.

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[26] The demand side is difficult to forecast and almost completely insensitive to price fluctuations, while the supply side faces limiting constraints at peak times, and storing the electricity is prohibitively costly.

Previous studies in this field have concentrated mainly on the monetary benefits that customers can achieve with RTP contracts. Even though these studies have shown that residential consumers would have smaller electricity bills if they would acquire these contracts, most consumers still tend to choose simpler fixed rate options. Based on our findings we argue that raising awareness of individual and more importantly societal advantages is the key to achieve better demand side management of power markets. The results indicate that invoking on environmental aspects of these concepts will improve the overall acceptance substantially. Overall, we argue that people should be more informed about electricity matters. Knowledge about the impacts of one's decisions seem to be good catalyst for people to re-evaluate their choices.

As for the limitations of this research, the low response rate (9.5%) may cause some bias. The survey was done in late 2016, after what the general discussion around electricity prices and environmental issues have increased in some degree in Finland. Hence, the study results may not represent the views of today's homeowners. Especially after the IPCC released their report on climate change, more and more people are becoming interested in environmental issues. The survey was exclusively sent to people who own their homes. This means that there may be some selection bias, since people who live in rented houses or apartments are excluded from the sample.

Finally, the survey was done during the distribution company Caruna's first wave of price increases. Since then, distribution of electricity and electricity issues in general have been publicly discussed by many authorities. For future researches, it would be interesting to study how these discussions have influenced on the awareness and behaviour of residential electricity consumers. Also, arguably environmental issues are daily topic in the lives of modern people. Therefore, as a follow up research we would like to conduct more in-depth study about people's preferences for environmental versus monetary benefits from demand response contracts.

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