MSc. FINANCE AND STRATEGIC MANAGEMENT

MASTER'S THESIS

POTENTIAL MERGERS IN THE NORWEGIAN ELECTRICITY DISTRIBUTION INDUSTRY

A DEA – Approach to Measure Efficiency

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Abstract

Electricity is a utility, by many seen as a given. A contributing party in making this achievable is the distribution system operators (DSOs) of the electric grid. Following statements regarding too many and too small Norwegian grid operators, this thesis will explore how size affects performance and how efficiencies could be influenced by mergers, through three research questions:

Research Question 1: How are the firm sizes of the DSOs in the Norwegian electricity industry affecting their performances?

Research Question 2: What are the potential efficiency gains from mergers in the Norwegian electricity industry?

Research Question 3: What are the most promising potential combinations of mergers, and what do the results imply?

Data Envelopment Analysis (DEA), is utilized as a benchmarking tool to make an optimal efficiency frontier for the electricity distributors in Norway. The study is of a quantitative nature, analyzing detailed data consisting of costs, assets, and descriptions of the operating environment. Continuing, to estimate the most promising potential merger combinations, the 99 DSOs were restricted to county borders, before being combined in pairs, making 431 potential mergers. Moving forward, these merger gains were then decomposed into learning, harmony, and size effects. The 25 most promising mergers were presented.

The efficiency findings from the DEA showed there are dubious reasons to believe that the performance is dependent on firm size. However, there are also found firm-specific potential for economies of scale among the smaller companies. Overall efficiency experienced a slight decrease post-merger, but the median overall efficiency rose, indicating that smaller firms benefits the most from a merger. The two latter effects are spread, but on overall deemed too low to recommend industry consolidation. Learning effect is the strongest driver for the overall merger potential. These effects can however be obtained by applying best practice from the fully efficient firms from the DEA. Therefore, the most promising mergers are sorted by pure merger gains, i.e. harmony and size effect. Further, this study finds that there are more pure merger gains from merging small companies than large.

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Acronyms

CRS Constant Return to Scale

DEA Data Envelopment Analysis

DMU Decision Making Units

DRS Decreasing Return to Scale

DSO Distribution System Operator

FDH Free Disposability Hull

FRH Free Replicability Hull

HV High-voltage

IRS Increasing Return to Scale

LV Low-voltage

NVE Norges vassdrags- og energidirektorat (Norwegian Water Resources and Energy Directorate)

OLS Ordinary Least Square

O&M Operation and Maintenance

SD Standard Deviation

SE Scale Efficiency

SFA Stochastic Frontier Analysis

SFDA Stochastic Frontier Data Analysis

StoNED Stochastic Non-Parametric Envelopment of Data

TE Technical Efficiency

TSO Transmission System Operator

VRS Variable Return to Scale

WACC Weighted Average Cost of Capital

1. Introduction

Norway is a country of elongated nature, with distinct and varied geography. Its population is wide-ranging, living both scattered in uncanny places and centralized in cities. The access to electricity, despite of this, has been seen as a given for almost a century (Johannessen, 2015). The parties responsible for ensuring electricity consumption are the electricity producers, the distribution system operators (DSO) and the electricity retailers.

The Norwegian electricity market is a complex market. Firstly, the markets for production and retail are both deregulated and open for competition and private ownership. On the other hand, the distribution of electricity is considered a natural monopoly. Natural monopolies are considered generally undesirable for the public welfare (Posner, 1968). The companies in charge of the distribution, the DSOs, therefore, have explicit societal objectives to follow:

- Secure and stabile power supply to the customers without interruptions or other quality deviations.
- Connect both new production and new consumption to the power grid, as well as adjusting the capacity to customers when needed.

(Reiten & Al, 2014)

To ensure that the DSOs are following these societal objectives, they are therefore regulated by the government through The Norwegian Water Resources and Energy Directorate (NVE). The regulations have been a subject for debate since the "Energy Act" made its arrival in 1990, ensuring that all production, distribution, and sales will serve the for the better of the Norwegian society (Ministry of Petroleum and Energy, 1990).

From 2007 there was an update to the regulation, having even clearer emphasis on incentivizing efficient operations and optimizing deliverance quality of electricity. Since then, the NVE has been setting a maximum limit to what the DSOs can demand from their customers, which in practice means setting a revenue cap. In turn, this will make it necessary for the DSOs to increase efficiency in order to gain profits. Further revision in 2013 improved the model by introducing a better method for adjusting for differences in the operating environments, and removing disincentives that may have previously prevented mergers (Kumbhakar, Amundsveen, Kvile, & Lien, 2015).

Furthermore, in 2014, a group of experts were hired by the Ministry of Petroleum and Energy to evaluate the performance and the organization of the electricity distribution industry. Among the conclusions their report came to were that there has been a case of underinvestment the last decades and many small, inefficient DSOs may experience lack of capital to renew the power grid (Reiten & Al, 2014).

The electricity industry in general is experiencing severe changes. The Norwegian electricity market is, and will still be in the future, dominated by hydropower. However, the demand for environmentally friendly renewable energy sources is increasing and planned projects for intermittent sources of energy are coming ever closer. Wind farms are increasing, both in size and count, households are installing their own solar power. Additionally, the demand for electricity in general is increasing, as further markets, among them transportation, are getting electrified. These trends in the will lead to more demanding environments for the DSOs and expensive investments may have to happen in the near future (Kuhn, Huber, Dorfner, & Hamacher, 2016).

What caught the authors' attention to this subject was how NVE had evaluated the industry further and found how there could be a yearly public savings for over 2,6 billion Norwegian Kroner by extensive mergers in the industry (Heltne, 2019). By discovering this, along with the exploration of the industry and specifically the "Reiten Report," the interest in quantification of the potential economies of scale and the potential merger gains and combinations among the DSOs rose.

1.2. Research Questions

Following the claims of too many small operators to operate efficiently in the Norwegian electricity distribution market, this thesis will focus on both industry and firm specific scale of economies, size effects and effects of mergers. This will be performed by using a Data Envelopment Analysis (DEA), presented by Charnes, Cooper and Rhodes (1978). This is the same benchmarking model used by the NVE when they regulate the DSOs. The thesis' first research question is the following:

Research Question 1: How are the firm sizes of the DSOs in the Norwegian electricity industry affecting their performances?

The analysis of the scale economies, size effects and the performance of the firms will be used further in the merger analysis. The approach for analyzing mergers is proposed by Bogetoft and Wang (2005). The analyses from this approach will show the potential for merger gains ex-ante to identify eventual differences in efficiency before and after merger. The model will make it possible to decompose the potential merger gains. Continuing, the thesis will answer following research questions:

Research Question 2: What are the potential efficiency gains from mergers in the Norwegian electricity industry? What are the likely effects of the merger?

Research Question 3: What are the most promising potential combinations of mergers, and what do the results imply?

Finishing the subject, the perspective of the authors is to understand how the efficiency in the industry can improve, and in what context mergers can benefit the performances and at the same time hopefully provide companies with advice on what potential mergers to further examine.

1.2. Delimitations

This thesis is delimited to evaluate the electricity distribution only, even though the firms often are within the same concern as production or retailing of electricity.

Further, the cut-off date is set to 31.12.2019. The authors of this thesis are aware of mergers that took place after the given date, but this is not included in the analysis since the updated data on the DSO operations are still to be published when this thesis was submitted.

In the benchmarking literature, there are other models that can be used to assess efficiency measures. This thesis is utilizing the non-parametric Data Envelopment Analysis (DEA) as the framework for evaluating the efficiency development in the Norwegian electricity industry. This is the same practice that the Norwegian regulator, NVE, is using. However, as this thesis is not meant to be of a comparative nature, it will not include other frontier models than DEA.

The thesis will propose potential mergers for the Norwegian electricity industry. The financial and strategic complications of such an operation are complex and severe. Some of these consequences will not be considered in the applied models.

1.3. Structure

The thesis is divided into 8 chapters that describes the theories utilized, the data sets and the empirical results based on the analyses performed on the data sets. Chapter 2 gives the reader insight in the choices taken to investigate the research problems, and in what way the data is collected and analyzed. This part is inspired by Saunders et al. (2009) and their research onion. Chapter 3 will give the reader further insight about previous literature written about the subjects as well as understanding of some the principles utilized. Continuing, chapter 4 will further explain in detail what analytical frameworks will be applied, why they are relevant for this paper, and how they will be applied. Chapter 5 will provide an overview of the complex industry that is electricity distribution. Chapter 6 will prove thorough explanation of the data set, with an overview of the different companies, their costs and more. Using this data set, chapter 7 will display the results of the analyses discussed previously, before the results will be discussed in chapter 8. Chapter 9 will offer conclusions and recommendations on the subject at hand.

2. Methodology

Research is defined by Saunders et al. (2009) as "something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge". In the attempts to resolve the research questions, extensive research needs to be completed. When undertaking a research project there are several elements that needs to be addressed. The abovementioned definition describes firstly how there is a need for a systematic approach when undertaking research. A systematic approach entails that one can determine the viability of a procedure built on repeatable steps and valuation of results and the necessity for methodology when researching (Siddaway, Wood, & Hedges, 2019). Secondly, the need to "find out things" is an essential part of a research project. When researching there is a need for a clear purpose or purposes that needs to be resolved (Saunders, Lewis, & Thornhill, 2009). This thesis will try to explain in what methods this will be done in the following chapter.

The structure of the methodology chapter is based on Saunders et al.'s (2009) various layers of methodology, often referred to as the "research onion", and describes the philosophies, approaches, strategies, choices, time horizons, techniques and procedures behind this research project.

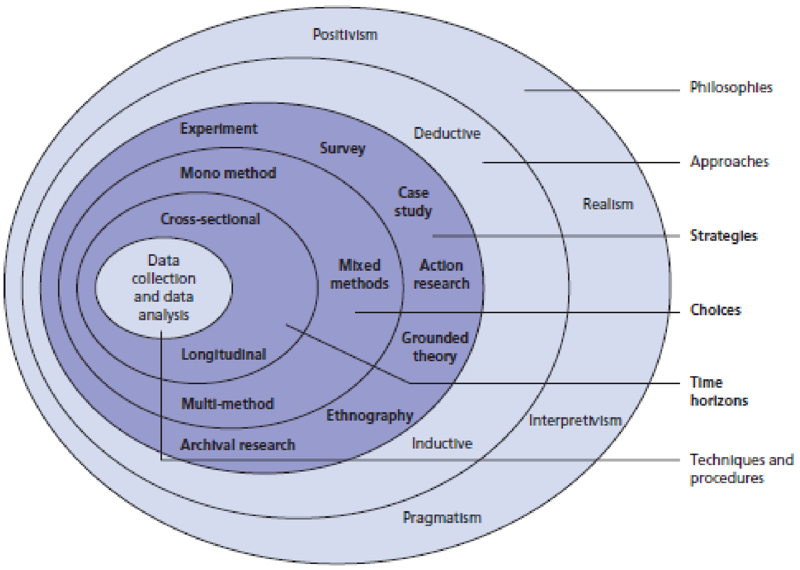

Figure 1: Research Onion. Source: Saunders et al. (2009)

2.1. Philosophies

The research philosophy is the outermost layer of the research onion. It is a belief about how data about the inquiring phenomenon is gathered, analyzed, and used (Saunders et al. 2009). Philosophies of science is not to be used to generate new facts, but rather contribute with additional reflections and acceptable knowledges within that reality. There are mainly four different philosophies: positivism, realism, interpretivism and pragmatism. These philosophies have different degrees of two different point of views, namely objectivism and subjectivism (Saunders et al. 2009). Objectivism represents a stance that social units exist in an external reality to social actors (Saunders et al., 2009). Furthermore, it maintains that reality is an absolute, and facts are considered to be the truth, regardless of personal feelings or aspirations (Biddle, 2014). Critics claim that objectivism will not be successful in social science research, mainly due to it does not capture the complex nature of human beings (Holden & Lynch, 2004). Subjectivism, on the other hand, explains how individuals have differences in preferences, knowledge, expectations and actions must begin to be explained by the mental state of the relevant individuals and take the differences into account (Foss, et al., 2006). In addition, it describes how the decision-making of the human mind are not rigidly determined by external events (O'Driscoll, Rizzo, & Garrison, 1996). In order to correctly assess the thesis' research philosophy, it is important to distinguish between the ontology, epistemology, and axiology of the research (Saunders et al. 2009).

Ontology focuses on the individual's subjective view of the nature of reality (Johannesson & Perjons, 2014). Differences in culture and environment will for example be a decisive, explanatory factor to the views of reality. The view of reality will have a pivotal role in forming the research to be done, as it may lead to differences in methods, results, and discussions (Saunders et al. 2009). It could be argued that this thesis utilizes the most objectivist nature of reality, positivism. It could be deemed the more fitting, because it will not elaborate on social differences within the different companies' management, culture etc. A positivist view on ontology will only consider the hard and quantitative results of the analysis.

Epistemology, on the other hand, concerns what is considered acceptable knowledge in a field of study (Johannesson & Perjons, 2014). Continuing, in the positivist manner, this thesis will make use of this approach to the epistemology. The observable phenomena will in some ways be transformed into simpler elements, but the paper will in some contexts be explanatory and try to find explanations to the phenomena. When we are talking about the axiology, the researchers view of the role of values are being discussed. The role taken in this thesis is value free, and the authors have an independent and objective stance on the research (Saunders et al. 2009).

2.2. Approaches

The different approaches destined by Saunders et al. (2009) is the deductive and the inductive approach. The dominant approach in natural science is the deductive approach. It is used to explore relationships between different variables by testing of the theory and requires independence from researcher from what is being researched (Saunders et al. 2009). In order for the deductive research to have increased significance, it is important to reach generalization. In deductive case studies generalizations are made by formulating a hypothesis, and testable consequences are derived by deduction (Johansson, 2003). To reach that goal, concepts needs to be measured quantitively. To further maintain reliability, a deductive approach needs to use a structured method, and therefore, making replication a viable option for checking reliability (Saunders, Lewis, & Thornhill, 2009; Gill & Johnson, 2002). Looking back at what was discussed during the research philosophies chapter, there are strong links from the philosophy of positivism to the deductive approach.

Inductive research approach, however, is a contradiction to the deductive. Social science is a research field closer to induction. Where deductive research test theories, inductive research approach will develop theory, not test them, often through concentrating on qualitative studies. In general, one could argue how inductive research will aim to understand the phenomenon, rather than discovering relationships between theory and variables (Saunders et al., 2009).

The research question is outlined to understand the firm size relative to performance in the electricity distribution industry, as well as exploring the potential merger combinations. This will be done in a way that allows us to measure results quantitatively. The estimates of the analysis point to specific results, rather than developing theories as to how it occurred. The aim is to understand the factors leading up to the results, however, it is not the main objective of the study. Hence, the deductive approach is a viable option for this thesis. Furthermore, the highly quantitative nature of the data available from the industry and the natural path to the DEA and benchmarking theory ensures the deductive approach moving forward.

2.3. Strategies

Following the choice of the deductive approach, there is a need to turn the attention to the research strategies that is going to be employed. The choosing of the approach naturally filters out some strategies that are clearly intended for inductive research approach, but labelling every strategy to one approach might be too simplistic (Saunders et al. 2009). The research strategies relevant to utilize throughout this thesis are either a case study or archival research.

A case study is a research strategy that involves empirical investigation of a particular phenomenon within its real-life context using numerous sources of evidence (Robson, 2002). It is particularly useful when there is a need to obtain an in depth understanding of the issue (Crowe, et al., 2011). However, the choice of a case study limits the ability to explore and understand a bigger context, because of the number of variables that can be collected are not complete (Saunders et al. 2009). While inducing a case study, an in depth understanding of the electricity distributing market will be gained. The regulation of the market is being done with the aid of DEA. This thesis will also utilize DEA framework, a framework often used for benchmarking various industries, and will thus gain a comprehensive understanding of this, as well as other applications of it.

Archival research takes into consideration where the data is collected from. In archival research, the data is primarily collected from administrative records and documents (Saunders et al. 2009). It could both be recent and historical documents (Bryman, 1989). The ability to answer the research questions might be limited by the intended use of the data, missing data, censorship or similar. Before deciding to use an archival strategy for research it is therefore necessary to establish how much data is available and design the research to maximize it (Saunders et al. 2009). The data collected is from the database of NVE. The use of the archival research in this study will improve the quality of the data, due to the companies themselves submit the data to receive a correctly calculated revenue cap. More information about the collection and validity of the data is presented in chapter 2.6. While case studies can utilize many different methods, Welch (2000) argues to use archival research as a tool to enhance the results in a case study. Going forward, this thesis will apply that strategy.

2.4. Choices

When discussing the previous layers of methodology, it has become quite clear how the data analysis in this thesis will mainly be of a quantitative nature. That entails that it will focus on the numerical types of data, rather than the non-numeric. Following the framework set by Saunders et al. (2009), the mono method quantitative study is the choice of design for this thesis. Within this choice of method, the data is collected will be analyzed in a quantitative manner. A simply quantitative research design, much like this one, have received critique in the past.

Bryman (2012) identified criticisms against purely quantitative methods. One of the critics identified is quantitative social researchers will treat the social world as they do the natural world and ignore how people react different to the world around them than what the object of natural sciences does (Schutz, 1962). Furthermore, there are arguments for how the causal relationships between the phenomena developed by social scientists are assumed, rather than actual phenomena seen in the world today (Cicourel, 1964). Adding to this, a third critique assessed by Bryman (2012), is how the isolating of variables done in quantitative research, will create a static world, not representing the complexity and dynamics of the real world's processes (Blumer, 1956). By researching in this manner, however, the results will be presented in an objective way, not affected by the researcher's beliefs (Bryman, 2012).

2.5. Time Horizons

When pondering upon what time horizons to take into account when doing the research, it depends on whether the phenomenon should be looked at as a "snapshot" at a specific time, as a cross-sectional study, or if it should be analyzed over a period of time, as a longitudinal study (Saunders et al. 2009). The data collected for the thesis has a definitive cut-off date at 1st of January 2020. The size relative to performance and thereafter merger potentials will be looked at from the data available up until that specific time. It is however not to be looked at as a cross-sectional study, but rather a longitudinal study as the data is an average over a five year period. Thus, the thesis will be minimizing the possibilities of disruptions from irregular activities, that could happen on a yearly basis. This will be more thoroughly discussed under chapter 6, data.

2.6. Data Collection

When collecting data for a study, there are two methods to choose from. One method is when researching for a study new data is being collected, specifically for the purpose of answering the research questions. This is known as primary data. The second way of collecting data is to collect already existing data and then reanalyze it for a different purpose, considering the study's research questions. This is known as secondary data and does provide a useful source to answer the research questions (Saunders et al. 2009).

As mentioned previously, to correctly calculate the revenue cap, the NVE collects extensive data from the DSOs. These data contain various information about the costs, assets, and daily operations. The data obtained by the NVE is classified as survey-based secondary data (Saunders et al. 2009). As a governmental agency, the data is collected using a survey strategy called continuous censuses, which often gets carried out by governmental foundation, and is considered differential to regular surveys, because participation is obligatory (Hakim, 2000). By continuous, it is happening at a regularly interval. In this particular case, the censuses are to be answered on a yearly basis (NVE, 2019a). When the data is collected repetitively on a yearly basis, it makes a foundation for it to be a multiple source secondary data, in this case specified as a time series of data. These types of data enquiries from the government are normally clearly defined, documented well and high quality (Saunders et al. 2009). With respect to the NVE choosing to undergo these censuses every year, the use of the secondary data makes it more feasible to undergo a longitudinal comparative study.

Gaining access to these types of data could often prove exceedingly difficult, often due to time constraints for employees or documents determined as confidential (Saunders et al. 2009). This was not an issue seeing that NVE publishes these types of document, making it available for the public on the organization websites. It is presented in an excel matrix, with compiled data that has received processing in form of categorizing and selection.

2.6.1 Evaluating the Secondary Data

To evaluate secondary data, the overall suitability of data to the research question must follow two criteria's, namely measurement validity and coverage. Further, for ensuring precise suitability of data for the analysis it is important to pay particular attention to validity, reliability and measurement bias that arise.

An important criterion for overall suitability of the secondary data is the measurement validity (Saunders et al. 2009). Data that does not provide the information needed to answer the research questions will lead to invalid answers (Kervin, 1999). Additionally, one will often discover how secondary data does not match the measures needed to answer the research question (Jacob, 1994). The data will be applied in the same type of framework that it was originally intended to be utilized, so the measures of the secondary data will fit the research question.

A second important criterion is coverage. When undergoing the study of these types of large quantitative datasets it is important that the secondary data covers the population about the data needed, for the specific time period, as well as the data variables required to answer the research questions (Saunders et al. 2009). In practice it means that one needs to ensure that unwanted data can be excluded and sufficient data to complete the analyses planned after the exclusion of the unwanted data (Hakim, 2000). The foremost has been executed in this analysis on several cases, both for excluding companies that did not have electricity distribution as their primary source of income and when firms lacked the required data to be measured. For full explanation check chapter 6, Data.

Precise suitability

The reliability and validity of the secondary data are concerned upon how the data is collected and from which source. Survey data from government organizations tend to be a reliable source (Saunders et al. 2009). A detailed assessment of validity and reliability of secondary data will involve an assessment of methods utilized to collect the original data (Dale, Arber, & Procter, 1988). NVE's method of acquiring data is described earlier in this chapter. As a governmental organization, the data should be considered a reliable source (Saunders et al. 2009)

An important note to consider regarding the regulation of the electricity distribution industry is how there is bound to exist an information asymmetry between the regulator and the firms (Kopsakangas-Savolainen & Svento, 2010). For optimal validity of the secondary data, it would be best if the regulators had superior information, thus enabling 100% correct datasets. This is not considered feasible, due to the number of DSOs in the industry. As a result of the informational asymmetry, there could be a case of misrepresentation from the managers or employees. Measurement bias, for example, can occur when there are changes in the way data is collected or deliberate or intentional distortion of data (Kervin, 1999).

The NVE is responsible for deciding what the DSOs can receive from their customers. They do so by measuring several inputs and outputs. If some of these measurements were devaluated, the NVE would allow them to gain more money. As a result, there might be an incentive for the management to misrepresent their own costs. Deliberate distortion is unfortunately difficult to detect (Saunders et al. 2009). One possibility to check if deliberate distortion is occurring is to triangulate the data in relation to other sources. This has been done by checking their costs through other online sources, mainly ”proff.no”. This is a Norwegian service that delivers detailed and updated information on Norwegian businesses, and is considered a reliable source (Proff, 2020).

Furthermore, NVE has consistent checks of the books and are correcting the distribution fees paid by the customers every year. This paper therefore assumes that the data submitted by the DSOs to NVE are correct and without major flaws and will continue this study using the data retrieved from NVE.

2.7. Summary

This thesis now has described in which manner the research will be approached, by using Saunders et al. (2009)'s framework for research methodology. This thesis will in its focus mainly on the quantitative measures to the electricity distribution industry. Thus, it will be natural for the thesis employ a view on which lays emphasis on the objectivist side of the research philosophy. However, the different research paradigms could represent a different stance than what the other represent. Therefore, the ontology of the paper will best be represented by positivism, the epistemology will be viewed in context of realism and the axiology will take the optimism perspective.

Following the strong links from the research philosophies of optimism and realism, the quantitative nature of the paper will further make a mark on the research approaches. The deductive approach has therefore been chosen, duly because the thesis will lay its emphasis on the whether or not the phenomena occur, or should occur, not the implications or consequences of the phenomena. Because of the particular interest in the phenomenon of the Norwegian electricity industry, the thesis will utilize a case study approach, while it also involves parts of an archival study, where it uses archives of the NVE to enhance the research of the phenomena further.

Building on the previous discussions about the layers of the research onion, the choices of research methods has been set as mono method, due to the ability to acquire objective results. Continuing, to eliminate disruptions from potential irregular capital expenditures or similar, the time horizon of the research will be a longitudinal one.

The data that is collected is of a survey-based secondary nature. The data is collected by the NVE through surveys, where the companies are to report their costs and income. It is then presented to the public in an excel matrix. This is a yearly census, meaning a longitudinal study is feasible. When discussing the suitability of the secondary data, necessary measures will be taken to exclude unwanted data. Check chapter 7: Data, for more information on this subject. There could be some validity problems regarding information asymmetry between the regulators and the DSOs. It has undergone some triangulation and will be utilized throughout this thesis.

3. Literature Review

The purpose of this section is to pinpoint this thesis in comparison with the existing literature and to detect useful tools. Benchmarking is often used as a measure for economic regulation in utilities, and will therefore be starting point for this chapter. After reviewing the literature for benchmarking in electricity distribution, the electricity industry structure will be further explored. As this paper will eventually look at mergers in the Norwegian distribution industry, a detailed review of mergers, potential motives for mergers, and finally, horizontal mergers within DSOs.

3.1. Benchmarking Research for Network Operators

Benchmarking is often used as technique for management purposes, often to identify efficiency outliers as a part of a possible problem resolution (Shuttleworth & Graham, 2005). Inspired by agency theory, benchmarking is now used as to effectively regulate natural monopolies (Joskow P. L., 2008). As said in the introduction, the electricity distribution sector is a good application for economic regulation. There is a wide variety of benchmarking methods uses across the world, but best practice in electricity network regulation is determined by size and geographical venues (Haney & Pollitt, 2011). With this in mind, Joskow (2008) examines developments of incentive regulation for electricity distribution and transmission network with a focus on price-cap regulation. Coelli et al. (2013) provide regulators with useful benchmarking tools to evaluate the efficiency of different actors in the electricity industry. In their research, frontier-based methods turned out to be useful tools to evaluate the efficiency of the distribution sector. A cornerstone of existing studies of efficiency in the electricity distribution sector, using frontier-based methods, is proposed by Jamas & Pollitt (2003).

	Deterministic	*Stochastic*
Parametric	Corrected Ordinary Least Squares (COLS) (Aigner & Chu, 1968) (Fried, Schmidt, & Lovell, 1993) (Greene, 1990) (Greene, 2008)	Stochastic Frontier Analysis (SFA) (Aigner, Lovell, & Schmidt, 1977) (Battese & Coelli, 1992) (Coelli T. , 1998)
Non-parametric	Data Envelopment Analysis (DEA) (Charnes, Cooper, & Rhodes, 1978) (Deprins, 1984)	Stochastic Data Envelopment Analysis (SDEA) (Nagin & Land, 1993) (Olesen & Petersen, 1995) (Fethi, Jackson, & Weyman-Jones, 2001)

Table 1: Frontier models. Source: (Agrell, Bogetoft, & Grammeltvedt, 2015)

Since the development of the DEA and SFA there has been debates regarding which method entails the better suitability for regulatory purposes. Few doubts remain however, that they are the most popular of the frontier benchmarking models (Agrell, Bogetoft, & Grammeltvedt, 2015). Mortimer and Peacock's (2002) literature review showed how no empirical results proved either better than the other. As of yet, there is still no consensus to which is superior (Kuosmanen, Saastamoinen, & Sipiläinen, 2013). Kuosmanen, Saastamoinen, & Sipiläinen (2013) compared the DEA and SFA methods with consideration to the regulation of electricity distribution. They concluded that the choice of method had significant economic effects, and when explicit statistical noise was available SFA methods were preferable. This further backs the argument of choosing SFA if such statistics are easily available (Jacobs, 2000). By using the DEA model however, there is no need to specifically know the true underlying technology "*T*" (Bogetoft, 2012).

Scandinavian countries are some of the precursors of the restructuring in the electricity market. Thus, numerous literature is focused on the efficiency and productivity of the electricity network. Agrell, Bogetoft & Tind (2005) introduced a regulation scheme based on dynamic DEA yardsticks as an alternative to the widespread CPI-X revenue cap regulation. Førsund & Edvardsen (2003) use a fictive grid network based on distribution utilities from Norway, Denmark, Sweden, Finland & Netherlands to compare efficiency of the different countries and their respective peer operators. With access to the same data as this thesis, Amundsveen & Kvile (2016) underlined the need to capture heterogeneity in a sample analyzing the 107 Norwegian DSOs through a classification model. Still using data provided by NVE, Bjørndal et al. (2010) investigated the robustness in best-practice regulation through different models. This paper is relying on the DEA framework from Bogetoft & Otto (2011), and will discuss this further under Chapter 4: Analytical Framework.

3.2. Electricity Distribution Industry Structure and Mergers

The industry structure of electricity distributors has been rigorously studied previously. Many have been focused on economies of scale, and several researchers found potential for economies of scale for smaller companies and diseconomies of scale for larger companies across the world (Kwoka, 2005; Filippini, 1996; Kumbhakar & Hjalmarsson, 1998). In the Norwegian industry however, the reports provided have differing conclusions on economies of scale. In a productivity analysis, the productivity among the smallest companies were considered poor by Førsund and Kittelsen (1998). Growitsch, Jamasb & Pollit (2009) found by using an SFA model, that there was potential for scale economies for companies at all sizes. Kumbhakar et al. (2015) discovered the technical efficiency indicated higher potential for economies of scale for the small companies. Salvanes and Tjøtta (1994) used similar methods to data from 1998, and found no evidence of economies of scale. In a quantile regression study, Mydland, Haugom and Lien (2018a), supported the findings of Kumbhakar et al, (2015). However, in this study only a two-output method was used. Using several inputs and outputs, Førsund and Hjalmarsson (2004) found that the industry was characterized by optimal scale and size for all company sizes, and Miguéis et al. (2011) found no significant size effect on the efficiency levels of the DSOs. Reiten et al. (2014), however, highlighted how there are several technical innovations that require extensive investments. With that in mind, they suggested that there were too many and too small DSOs to perform at optimal efficiency.

Following the discussions on optimal size and scale this thesis will discuss the potential for mergers in the Norwegian electricity distribution industry. The mergers in the general electricity distribution industry in have been studied extensively.

The analysis of horizontal mergers and their potential efficiency gains have been an important topic among researchers (Röller, Stennek, & Verboven, 2000). It has been heavily debated whether a horizontal merger results in gains or losses for the merging company (Farrell & Shapiro, 1990) (Perry & Porter, 1985). There is evidence of efficiency enhancements in both production plants and in horizontal mergers in general after ownership changes (Lichtenberg & Siegel, 1987) (Shahrur, 2005). Where there is potential for economies for scale, this can be used as an indicator for potential efficiency gains from mergers, and it is often used as an argument to defend a proposed merger (Zschille, 2012). An example of efficiency enhancement in horizontal mergers could be removal of inefficient management from one of the merging party (Asquith, 1983). Nevertheless, mergers are not the only way to achieve operating economies, and it is possible to achieve diseconomies of scale as well (Gaughan, 2011).

Mergers' effects can be measured in two ways (Resti, 1998). The effects of market value, financial performance and shareholder value or the effects on the productive efficiency (Röller, Stennek, & Verboven, 2000). Since the DSOs are considered public entities, the focus has been on productive efficiency. This is because maximizing financial performance is rarely the main objective of public service providers. Earlier literature from Bagdadioglu et al. (2007), Kwoka & Pollitt (2010) and Çelen (2013) have analyzed the potential efficiency effects of mergers of DSOs. Kwoka & Pollitt (2010) did not find significant merger gains in the US, while Bagdadioglu et al. (2007) and Çelen (2013) do find gains within the Turkish distribution sector. In the electricity distribution sector, the market structure is not generally shaped by the normal entry and exit but rather through merger activity between DSOs (Agrell, Bogetoft, & Grammeltvedt, 2015). Agrell, Bogetoft & Gammeltvedt (2015) examined the realized merger gains in the Norwegian electricity distribution sector during the period 1995 – 2004. They found small gains and assigned most of the improvement potential to the internal efficiency increases within companies. Bogetoft and Gammeltvedt (2006) found limited potential cost gains, but some improved efficiency. Further, they discovered newly merged companies had accelerated technology progress. This could be interesting to look at in light of Reiten et al's (2014) on the non-optimal size of the companies in the industry.

The importance of modeling choices in regulatory models has also been highlighted in previous literature (Kuosmanen, Saastamoinen, & Sipiläinen, 2013). First, as Bogetoft & Otto (2011) point out, the results of merger analysis can vary if different frontier estimators are used. Many of the above-mentioned studies only apply one estimator. Second, as this paper is investigating further, there are signs that scale inefficiencies are present in the Norwegian DSO sector (Heien, Melvær, Nibstad, Sergieva, & Sliwinski, 2018; Kumbhakar, Amundsveen, Kvile, & Lien, 2015). Thus, the assumption of return to scale can alter the regulatory outcome significantly (Bjørndal, Bjørndal, & Fange, 2010). Third, it is acknowledged that the operating environment of firms should be taken into account when assessing the efficiency of firms (Kuosmanen, Saastamoinen, & Sipiläinen, 2013; Growitsch, Jamasb, & Wetzel, 2012; Johnson & Kuosmanen, 2012; Wang & Schmidt, 2002). This thesis will utilize the DEA framework portrayed by Bogetoft and Wang (2005) and Bogetoft and Otto (2011) to examine the efficiency of the Norwegian electricity distribution industry and further assess the potential mergers in the industry and will be discussed further under analytical framework. Further, it will also calculate the efficiencies with difference return to scale assumptions, to highlight how the results are sensitive to this choice.

4. Analytical Framework

The chapter that follows will give further insight in what theories and methods are used to understand and analyze the forthcoming data. Firstly, benchmarking is further elaborated upon. Secondly, frontier models are presented to select the appropriate model for the upcoming analysis. Following this choice, the DEA model and its features will be discussed.

4.1. Benchmarking

Benchmarking has proved to be a useful tool for the regulator in the electricity distribution sector. Relative performance evaluations, or benchmarking, is the systematic comparison of the performance of one firm against the other (Bogetoft & Otto, 2011). The idea is that entities who transform the same type of resources to the same type of products and services is compared. The production entities can be firms, organizations, divisions, industries, projects, decision making units (DMUs), or individuals. This study entails comparison of DMUs, and will be referred to as firms throughout this thesis.

Benchmarking can be used in several settings. Most often, it is used to make *inter-organizational* comparisons (Bogetoft & Otto, 2011). For instance, a regulator (NVE) seeking to induce cost-efficiency or to avoid the misuse of monopoly power among a set of firms (DSOs) enjoying natural monopoly rights in different regions. It is worthwhile mentioning that the use of benchmarking is not restricted to *for-profit* organizations. In public organizations such as Norwegian DSOs, there is no single objective or success criterion like profit maximization due to a revenue cap (Bjørndal, Bjørndal, & Fange, 2010). To be efficient, they rather have to focus on minimizing costs to sustain efficiency.

The objectives of benchmarking can be related to the basic issues in any economic system, namely learning, coordination and motivation (Bogetoft & Otto, 2011). In other words, benchmarking can be used to facilitate decision making (learning and coordination) and control (motivation).

4.1.1. Learning

The objective of most benchmarking studies is to learn or get insight per see (Bogetoft & Otto, 2011). This applies to scientific studies where researchers examine the relative efficiency of firms in an industry. It is also the objective in industry applications where several firms compare their performance. Nonparametric approaches, such as DEA, provide particular strengths were the peers or the dominant firms provide valuable and concrete information for performance improvement targets. Further, the various decompositions of the overall efficiency can point towards more specific means to improve efficiency, e.g. to change the scale of operation or the mix of resources used if scale or allocative efficiency is low (Bogetoft & Otto, 2011). Competition may limit sharing of information about best practices in an industry.

Recent advances in benchmarking is an attempt to push the learning perspective by allowing individual firms in a benchmarking exercise to define the comparison basis (potential mergers), the objective (cost-efficiency), etc. of the evaluations. It has typically been used in industries where firms do not compete directly, but see themselves as colleagues, e.g. among distribution system operators in electricity networks (Bogetoft & Otto, 2011).

4.1.2. Coordination

Among firms and industries, benchmarking is used extensively to coordinate operations at optimal cost and performance. However, some coordination requires more advanced benchmarking models to evaluate the structural efficiency of a set of entities. This may necessitate calculations in networks of individual benchmarking models (Bogetoft & Otto, 2011). In example, methods to evaluate structural efficiency of whole industries and the possible gains from mergers, as is evaluated in this paper. It has also been used to decompose inefficiencies in terms of scale, scope and learning among the industry players. An interesting finding in such studies is that a better coordination may be just as valuable as the learning of best practices (Agrell, Bogetoft, & Grammeltvedt, 2015). This is relevant since it may be optimistic to assume that all firms can adopt best practices.

4.1.3. Motivation

The last general application of benchmarking is to facilitate incentive provision. By establishing the performance of an employee, a manager or a firm, it is possible to better target the incentives (Bogetoft & Otto, 2011).

There are usual two aspects of this. One is the pre-contractual asymmetric information of making it possible for better informed agents to extract information rent by claiming too high costs. It can be limited with benchmarking by extracting information about an agent's (firm) type from past behavior. The other, and perhaps more relevant, is post-contractual moral hazard problem arising for the inability of a principal (NVE) to precise monitor if an agent (DMU) pursues private objectives and perhaps shirks. By announcing ex-ante that performance-based payments in the coming period will depend on the outcome of a benchmarking study (or a DEA) to be done ex post, can limit moral hazard (Bogetoft & Otto, 2011).

In Norway, a series of DEA models have been developed for these purposes since 1997 (Amundsveen & Kvile, 2016). Effectively it means that real competition is substituted by benchmarking; instead of competing directly, the DSOs compete via a benchmarking model.

4.1.4. Performance evaluations

As previously mentioned, benchmarking is a relative performance of one firm against another. In example, a firm has produced certain outputs using certain costs as indicated by the output-cost diagram below.

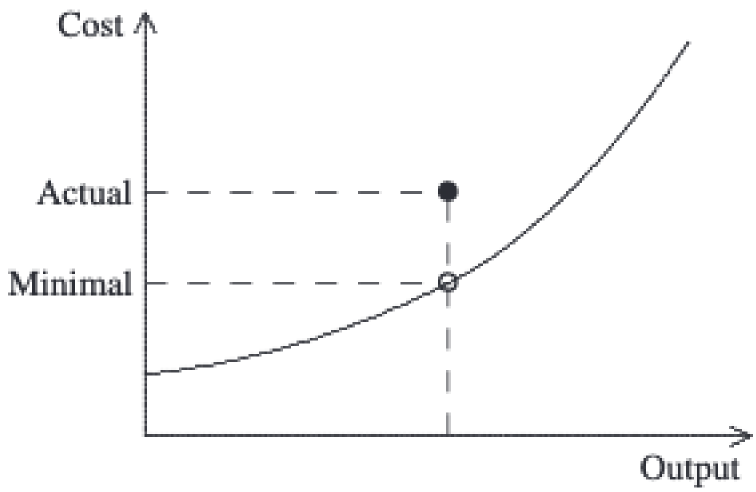

Figure 2: Performance evaluations. Source: Bogetoft & Otto (2011)

The performance is evaluated using a cost function. It shows the smallest possible cost of providing different output levels. If the cost function is as illustrated above, the firm has been inefficient. Thus, it is possible to produce the same outputs with less cost, or more output with the same cost. The excessive cost of the firm measured by the vertical distance between the actual cost level and the minimum cost of the firm is an absolute measure of inefficiency. The relative inefficiency could therefore be measure by

$$InEfficiency = \frac{Actual\ cost - Minimal\ cost}{Actual\ cost}$$

The smaller the inefficiency, the better performance (Bogetoft & Otto, 2011).

Likewise, the relative efficiency is measured directly as the ratio of minimal cost to actual costs

$$Efficiency = \frac{Minimal\ cost}{Actual\ cost} = 1 - InEfficiency$$

The higher the efficiency, the better performance (Bogetoft & Otto, 2011).

4.2. Frontier Models

An increasingly common approach in modern benchmarking is to use best practice, or frontier, analysis methods. One practical aspect of this is that it is often more interesting to learn from the best than to imitate mediocre performance (Cooper, Seiford, & Zhu, 2004). The idea is to model the frontier of the technology rather than to model the average use of the technological possibilities (Bogetoft & Otto, 2011).

A frontier-based model will determine a technology set and a best practice frontier. The function the model derives are defined on the basis of the performance of the most efficient actors, which will be the reference for the comparisons with the different firms on the panel. From this, the efficiency of the firms on the panel will be determined. This kind of frontier models will provide reference to the other operators by determining the most efficient ones.

As in traditional statistical literature, a benchmarking model distinguish between parametric and nonparametric, and deterministic or stochastic, approaches. In short, a parametric model are characterized by being defined a priori through several parameters (Bogetoft & Otto, 2011). Non-parametric models are on the other hand much less restricted a priori from the beginning. In stochastic models, one will assume that the data has possibly been influenced by random noice and the model will account for it. On the contrary, a deterministic model refers to one which does not include any noise (Bogetoft & Otto, 2011).

There exist four types of frontier-based models. Those models are shown in the figure below. The DEA model was first introduced by Charnes et al. (1978), and is characterized as deterministic and non-parametric. In order to estimate the technology, DEA uses the minimum extrapolation principle based on different assumptions on the data set. SFA (Aigner, Lovell, & Schmidt, 1977; Battese & Coelli, 1992) includes the presense of noise and thus, draws a technology set which does not contain all the initial data. The technology set is a parametric model and computes a priori, in most cases due to the maximum-likelihood approximation. COLS (Aigner & Chu, 1968; Fried, Schmidt, & Lovell, 1993) can be summed up by the idea of adapting a regression model to enclose all the firms in the technology set through shifting the estimated line. The STOned, or SDEA, is more recent and aims at combining the relevant characteristics of DEA and SFA.

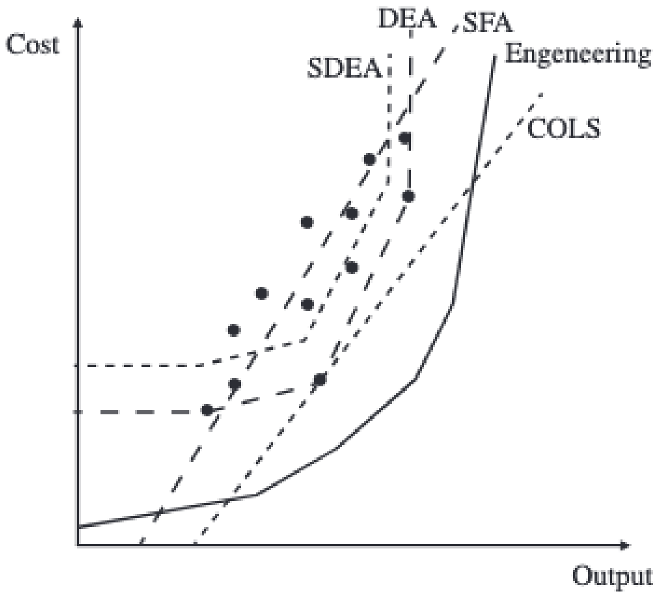

Figure 3: DEA, SFA, SDEA, COLS and Engineering. Source: Bogetoft & Otto (2011)

When choosing between the frontier-based models one must question whether flexibility in the mean structure or precision in the noise separation is wanted (Bogetoft & Otto, 2011). Despite the relevance of the approaches, this thesis will only use DEA. It is clearly a choice of convenience given that DEA is the method applied by the Norwegian regulator and, thus, easier to implement. On one hand, this method will provide qualities in terms of flexibility and in the sense that its mean structure is easily able to adapt to data. On the other hand, DEA do not consider random noise and results need to be interpreted with caution (Bogetoft & Otto, 2011). This is one of the main criticisms addressed to regulation using DEA.

4.3. Data Envelopment Analysis

A short definition from Bogetoft & Otto (2011) of the DEA is that it "provides a mathematical programming method of estimating best practice production frontiers and evaluating the relative efficiency of different entities." Charnes et al. (1978) introduced the basic DEA, which is originally a tool for efficiency analysis of public sector entities.

DEA combines the estimation of the technology with the measurement of performance as related to this technology. It thereby integrates the two basic problems of a) defining a performance standard, the technology, and b) evaluating achievements against the established standard (Bogetoft & Otto, 2011).

4.3.1. DEA technologies

The basic DEA models mainly differ in the assumptions that they make about the technology *T.* The four assumptions are presented below.

4.3.1.1. Assumption 1: Free disposability

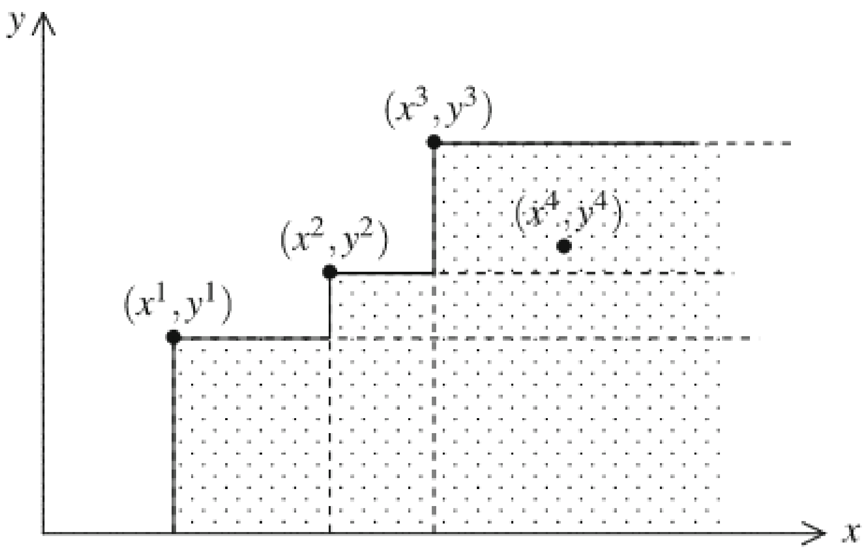

Figure 4: Free Disposability. Source: Bogetoft & Otto (2012)

The first of the assumptions is the possibility to freely discard unnecessary input and unwanted outputs. In short, produce less with more; that is

$((x, y) \in T \;,\; x' \geq x$, and $y' \leq y \rightarrow (x', y') \in T$ (Bogetoft, 2012).

In general, firms would not pursue this, but it remains a technological possibility. It is a useful assumption when a firm wants to reduce unattractive output. In DEA literature, a technology based on free disposability on a set of observations is called Free Disposable Hull (FDH). The technology set of free disposability is shown in figure 5, where the dots are four different production plans. The feasible input-output combination are inside the shaded area, and the (x^4, y^4) production plan is on possible due to the free disposability assumption (Bogetoft, 2012).

4.3.1.2. Assumption 2: Convexity

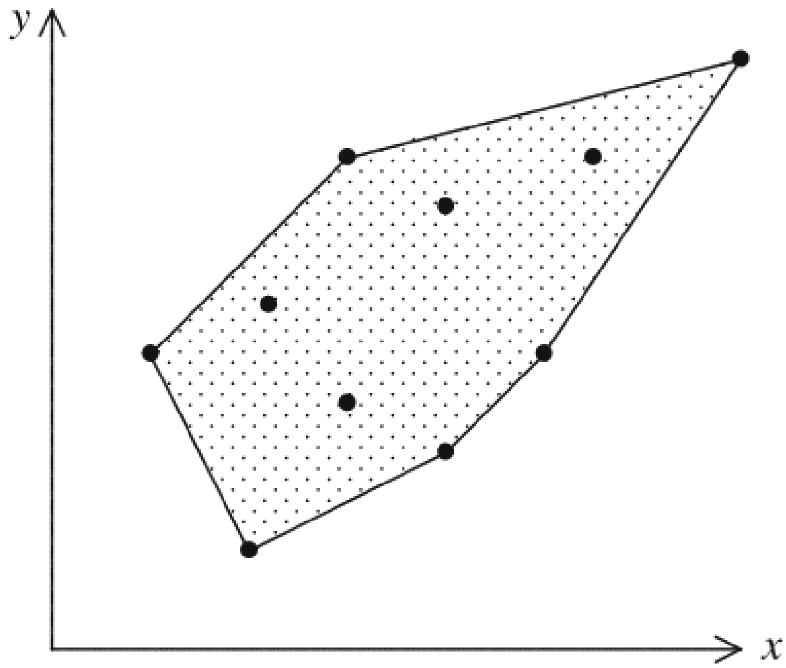

Figure 5: Convexity. Source: Bogetoft & Otto (2012)

Convexity is a way to enlarge the technology in an analysis with few observations. The assumption is in all classical DEA models. Any weighted average of feasible production plans (x, y) is feasible as well:

$\in T, (x', y') \in T, \alpha \in [0, 1] => \alpha(x, y) + (1 - \alpha)(x', y') \in T$ (Bogetoft, 2012).

The convexity assumption makes it possible to rely on fewer observations, and still be able to conclude whether a firm is fully efficient (Bogetoft, 2012). In figure 6, the convexity enhance the shaded area and thereby also the possible input-output combinations. Still, convexity is not an "innocent" assumption, though many attempts have been made within the DEA literature to use weaker-convexity assumptions (Bogetoft, 2012). The large potential impact of convexity has been subject to debate among researchers, as it does not take into account any potential economies of scope or scale. In addition, convexity requires divisibility that might not be reasonable to assume when set-up times and switching costs is considered (Bogetoft, 2012). Variable returns-to-scale (VRS) combines the free disposability and convexity assumptions.

4.3.1.3. Assumption 3: Returns to Scale

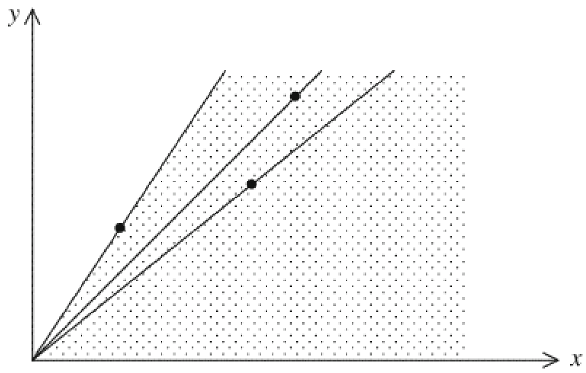

Figure 6: Constant returns to scale. Source: Bogetoft (2012)

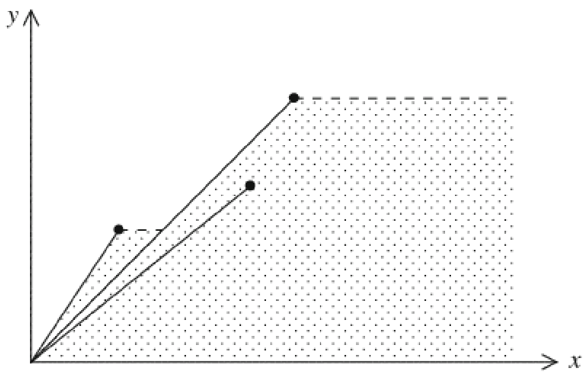

Figure 7: Decreasing returns to scale. Source: Bogetoft (2012)

The assumption of scaling is divided into three returns to scale models. These are constant returns to scale (CRS), decreasing returns to scale (DRS) and increasing returns to scale (IRS). Under this assumption, production can be scaled with any of a given set of factors (x, y):

$$(x, y) \in T, \kappa \in \Gamma(\gamma) => \kappa * (x, y) \in T$$

The *return to scale* assumptions suggest that some rescaling is possible. The weakest assumption is that there is no rescaling possible, $\gamma = 1$, and the strongest is that there are constant returns to scale, $\gamma \geq 0$. No rescaling is also called variable return to scale (VRS). In between these assumptions, any degree of downscaling is possible but not any degree of upscaling, $\gamma \leq 1$. This means that it cannot be disadvantageous to be small but that it may be disadvantageous to be large. I.e. there may be decreasing return to scale (DRS). The last and less commonly used assumption (Bogetoft & Otto, 2011), is that of increasing returns to scale (IRS), $\gamma \geq 1$. Here, it cannot be a disadvantage to be large, but that it may possibly be a disadvantage to be small.

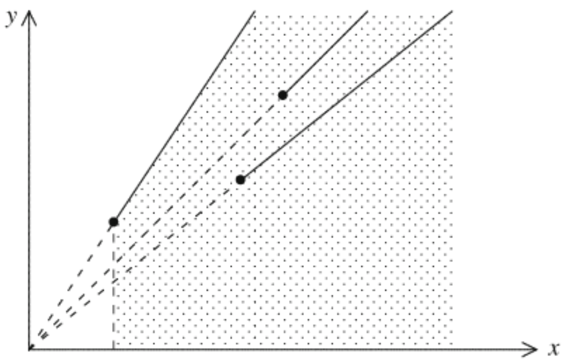

Figure 8: Increasing rerturns to scale. Source: Bogetoft (2012)

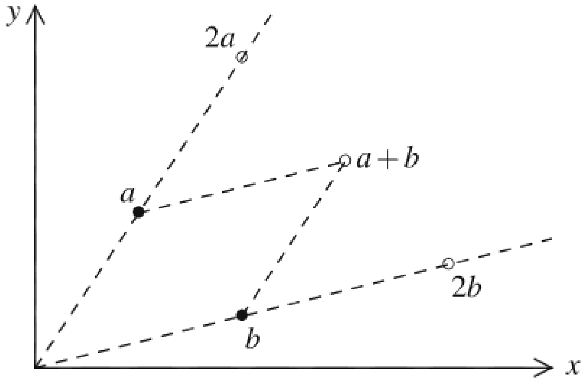

Figure 9: Additivity. Source: Bogetoft (2012)

4.3.1.4. Assumption 4: Additivity

The final assumption under DEA technology is additivity, where two production plans are combined into one. The sum of any two feasible production plans is feasible as:

$$(x, y) \in T, (x', y') \in T => (x + x', y + y') \in T$$

At last, the *additivity* assumption stipulates that when we have possible production plans, their sum will be possible as well. By using the original inputs, it should therefore be able to produce the same output, and the firm should be able to produce the ultimate sum. Unfortunately, additivity is a difficult assumption to work with and is therefore the least common of the mentioned assumption (Bogetoft & Otto, 2011).

4.3.2. DEA Models

Based on the free disposability, convexity, scaling and additivity assumptions, six different DEA models are presented in table 1. The mentioned models only differentiate in the applied assumptions.

MODEL	A1 FREE DISPOSABILITY	A2 CONVEXITY	A3 γ RETURN (SCALING)	A4 ADDITIVITY
FDH	X			
VRS	X	X		
DRS	X	X	$\kappa \leq 1\ (Down)$	
IRS	X	X	$\kappa \geq 1\ (Up)$	
CRS	X	X	$\kappa \geq 0\ (Any)$	
FRH	X			X

Table 2: Assumptions of the DEA models. Source: Bogetoft & Otto (2011)

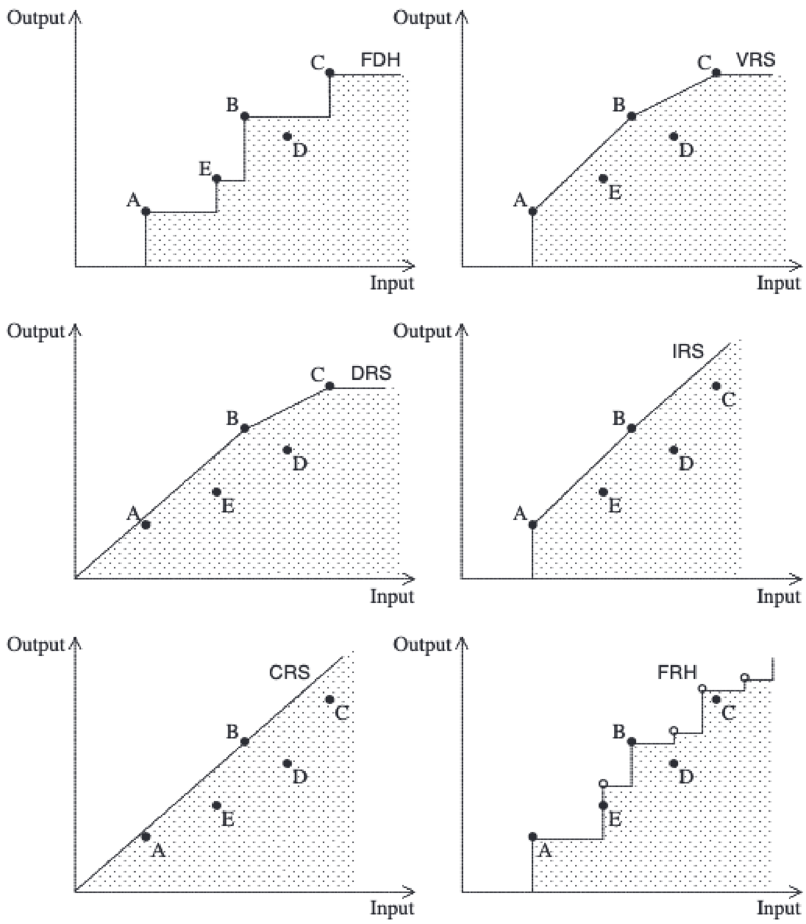

Figure 10: FDH, VRS, DRS, IRS, CRS and FRH models. Source: Bogetoft & Otto (2011)

The original constant return to scale (CRS) model; the decreasing (DRS), increasing (IRS) and varying/variable return to scale (VRS); and the free disposability and free replicability hull

(FDH, FRH) models. The latter two are not always called DEA models, but share the conceptual idea of minimal extrapolation (Bogetoft & Otto, 2011). The idea of minimal extrapolation is to use smallest possible set to ensure that the firms are evaluated more cautiously. In some cases, it results in unrealistic estimates of the technology, the *T**, which would make the firms look more inefficient than they realistically are (Bogetoft & Otto, 2011).

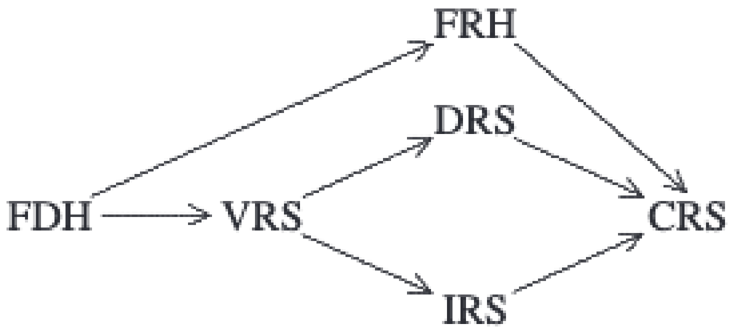

Figure 11: Size of the six technologies. Source: Bogetoft & Otto (2011)

As shown in figure 12, the VRS model is marginally larger than the FDH model because "the holes are filled out" with the convexity assumption (Bogetoft & Otto, 2011). By allowing some scaling enlarges the technology set of the DRS and IRS model. Lastly, by allowing full rescaling and convexity, CRS is the largest of the DEA models. As seen from the figure above, the FRH is somewhat less comparable to the others, but is ultimately larger than FDH and smaller than CRS.

These different relationships are interesting because they suggest systematic differences between the outcomes of benchmarking exercises depending on the assumptions that is made a priori (Bogetoft & Otto, 2011). The small models will therefore be more optimistic in the estimates of the improvement potential of a firm. The negative side is that the firms look less efficient in the larger models. Ideally, then, the choice of assumption shall be carefully argued for, and if possible, tested (Bogetoft & Otto, 2011). With this in mind, this thesis tests all models to achieve the outmost accurate overview of firm-specific efficiency.

4.3.3. Scale Efficiencies

The DEA model is able to estimate if the inefficiency of firms is due to scale. The results suggest how far the firm is from the most productive scale size (Bogetoft & Otto, 2011). The scale efficiency *SE* is calculated by,

$$SE = \frac{E(CRS)}{E(VRS)}$$ (Bogetoft & Otto, 2011).

The higher value for scale efficiencies, the closer the firms is to the most optimal scale size. To further examine if these DSOs are below or above optimal size, the following statement is tested:

$$E(VRS) - E(DRS) < 0{,}0001$$

(Bogetoft & Otto, 2011)

If this test is false, the firms are below optimal scale. Likewise, if the test is true, the firms are above optimal scale size. If the firm is fully efficient in both the CRS and VRS model, the result will be at optimal scale (Bogetoft & Otto, 2011).

4.3.4. Peer Units

Based on the estimated efficiency scores, it is possible to analyze the peer weights under the different technologies. Peer weights gives an indication of the peer units for inefficient firms. In theory, the inefficient firms should look towards their peer units for a more efficient production plan. The peer units are situated at the efficient frontier that the evaluated firm is projected onto (Bogetoft & Otto, 2011). The efficiency level E of the firm k are used to estimate the peer weights, λ^k.

Peer units = $\{k \in \{1, \ldots, K\} | \lambda^k > 0\}$ (Bogetoft & Otto, 2011).

The inefficient firms often times have more than one peer units. Where n is the number of inputs, and m is the number of outputs, the maximum number of peer units are restricted to $n + m$. This is not the case for the CRS model, however, which generally have one less peer unit because there is a slack in the solution (Bogetoft & Otto, 2011).

4.3.5. Bootstrapping

Efron (1986) introduced the bootstrap method, which is later applied to DEA. This paper apply the bootstrap method for bias-correcting DEA analysis presented by Bogetoft & Otto (2011). The bootstrap serves as a statistical method to set up a "random" data sample based on the observations in the original data sample. Similar, the new data sample consists of the same number of observations n as the original data sample, and is utilized to derive the necessary statistics, e.g. median of the bootstrap sample. These are called replicates, and the process is repeated to create a sufficient sample of replicates.

The number of bootstrap replicates B used in an analysis will have influence on the results. Bogetoft & Otto (2011) use the standard error of the median to discover an optimal number of bootstrap replicates. The outcome of the median values varies less the higher the number of replicates. In the general benchmarking practice, a number of replicates between 50 and 200 is a good standard error estimator. Bogetoft & Otto (2011) states that is not enough when utilizing the bootstrap method in DEA.

4.3.5.1. Bias-correcting

The purpose of including bootstrapping in this study is to derive bias-corrected efficiency scores for the analysis. As DEA tend to be upward biased the estimated efficiencies might be higher than the true efficiencies (Bogetoft & Otto, 2011). Therefore, to obtain the bias the bias-corrected efficiencies are defined for firm, *k,* as

$bias^k = \hat{\theta}^k - \theta^k$, where $\hat{\theta}^k$ is the estimated DEA efficiency and θ^k is the true efficiency.

As θ^k is unknown, it is necessary to use bootstrapping to find $bias^k$. A bootstrap estimate of bias is found by

$$bias^{k*} = \frac{1}{B}\sum_{b=1}^{B} \theta^{kb} - \hat{\theta}^k = \bar{\theta}^{k*} - \hat{\theta}^k.$$

The bias-corrected estimator θ^k is then

$\tilde{\theta}^k = \hat{\theta}^k - bias^{k*} = \hat{\theta}^k - \bar{\theta}^{k*} + \hat{\theta}^k = 2\hat{\theta}^k - \bar{\theta}^{k*}$

(Bogetoft & Otto, 2011).

As the bootstraps are created based on the original data sample there is a certain chance of spikes in the distribution if the data sample is small (Bogetoft & Otto, 2011). To avoid these spikes, smoothing are introduced to the distribution. A smoothed sample is used instead of replicating the observations in the original data sample. As mentioned, the R software package Benchmarking is utilized to estimate the bias-corrected efficiencies of the Norwegian distribution system operators.

4.3.6. Second-Stage Analysis

After the initial efficiency analysis from the DEA is completed, it is important to understand under what circumstances the different DMUs operate. In an analysis like this, the environmental conditions are deemed important, because exogenous circumstances might have a great impact on performance, and lead to inefficiency among companies (Zschille, 2012). The former analysis will not consider the different environmental circumstances in which they operate and is one of the critiques of DEA. Therefore, a second-stage DEA analysis will seek to model the first-stage efficiency scores in a manner that allows for exogenous variables to be taken into account (Hoff, 2007).

There are several ways to adjust for the environmental values in as a second-stage method. The two-limit Tobit model is a popular choice for benchmarking and used in numerous benchmarking studies. However, it is argued that an ordinary least squares (OLS) regression can handle large sample tests in an equally satisfactory fashion (McDonald, 2009). Hoff (2007) as well, argues that an OLS will in many cases replace the Tobit-method due to its unbiased analysis.

An OLS linear regression model is mathematically proposed as:

$$E = a_1 z_1 + a_2 z_2 + \cdots + a_q z_q + \varepsilon$$

Where:

$E \;=\; Independent\ variable$

$a = coeffisient$

$z = Dependent\ variable$

$\varepsilon = Random\ error\ reflecting\ unexplanatory\ levels\ of\ regression$

(Bogetoft & Otto, 2011)

The results for the regression are thus being implanted to adjust the input variable from the first-stage DEA analysis. The input will now reflect the environmental factors of which the DMUs operate in.

4.4. Merger Effects

As this thesis is delving into the effects of mergers in the Norwegian electricity distribution, it is highly beneficial to decompose the overall efficiency into learning, harmony and size effects. Furthermore, pure merger effects will be presented as a function of harmony and size effects.

4.4.1 Total Economic Effects

As mentioned in the introduction, a main focus for DSOs is to lower the costs to be efficient. In the DEA model utilized by the industry regulator, total costs is the input factor. Likewise, the focus on a horizontal merger is to produce an output using the minimal amount of input. Bogetoft (2012) defines E in a merger between F1 (Firm 1) and F2 (Firm 2) as,

E = Smallest E such that $E(x^1 + x^2)$ can produce output $y^1 + y^2$.

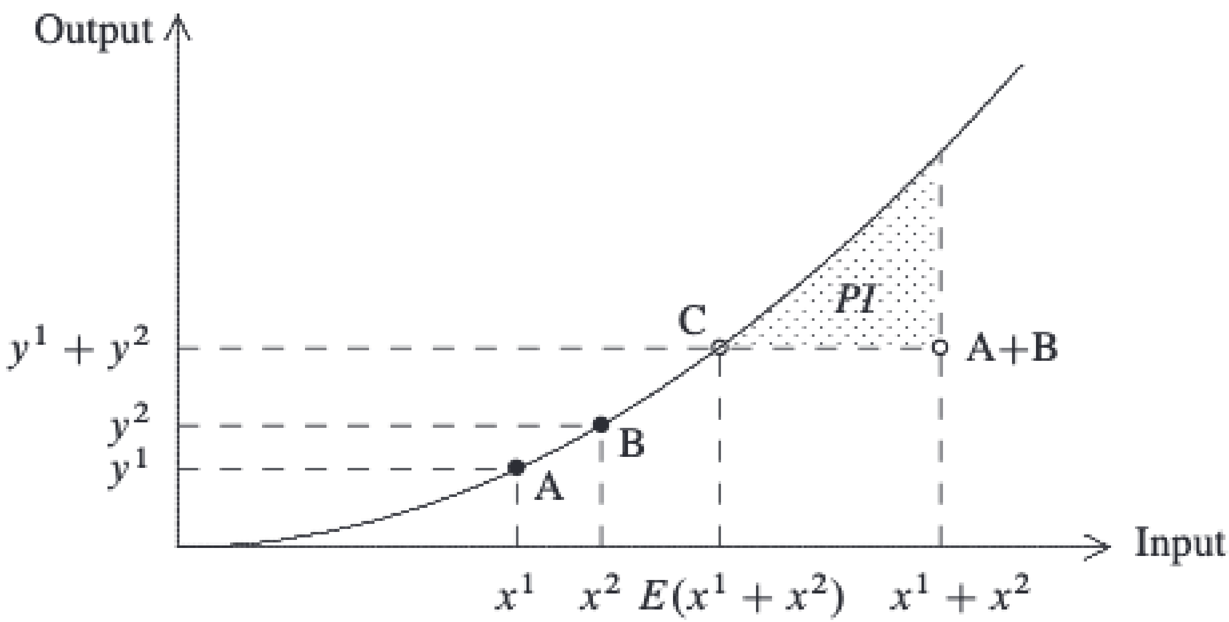

Figure 12: Total Economic Effect, E. Source: Bogetoft & Otto (2011)

The minimization of E is shown in the figure above. Production plan A of F1 and production plan B of F2 indicate that the two firms are not fully efficiency before the merger as they find themselves below the efficient frontier T. However, the post-merger production plan $A + B$ has a larger efficiency potential. Production plan C is the most efficient of the three production plans, where $E(x^1 + x^2)$ can produce output $y^1 + y^2$. This fundamental idea also applies to distribution system operators. A merger (H) between two DSOs (J) can be defined as

$$E^H = \frac{c(\sum_{j\in j} y^j)}{\sum_{J\in J} x^J}$$

A score of $E^H < 1$ indicate potential cost reductions resulting from the merger, while a score of $E^H > 1$ indicate that the merger will increase the costs for the two DSOs. Thus, it is necessary to analyse if the total economic effects are due to learning effects, harmony effects or size effects. These effects are introduced next.

4.5.3.2 Learning effects

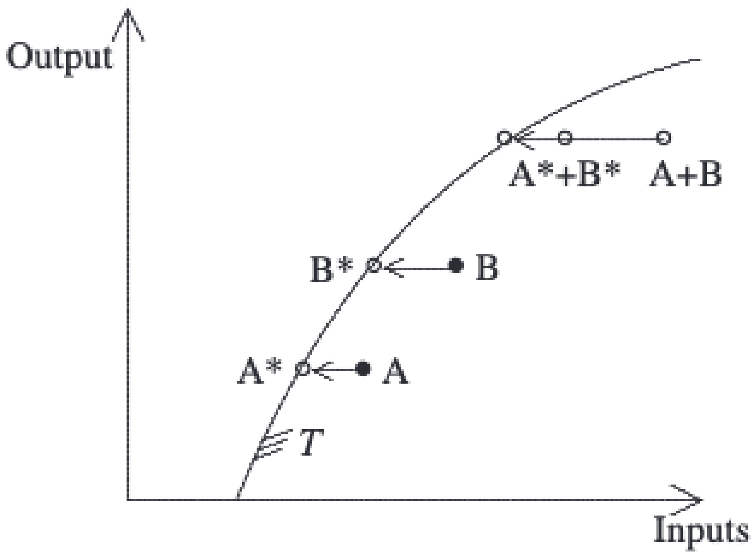

Figure 13:Learning effects, LE. Source: Bogetoft & Otto (2011)

The learning effects, or technical efficiency, is defined as the potential gains from applying best practice. Firms that are not fully efficient before a merger could utilize high gains from applying best practice rather than merging. However, as shown in figure 4 a merger adds to the potential gain from applying best practice. By optimizing the production plan of Firm 1, A becomes A^*. Same applies to Firm 2, where $B \rightarrow B^*$. The two production plans A^* and B^* is now at the efficient frontier. Nonetheless, if Firm 1 and Firm 2 merger, additional efficiency gains could be achieved as the production plan $A^* + B^*$ is not fully efficient. Bogetoft (2012) define the learning effects of the merger between two DSOS J as

$$LE^J = \frac{\sum_{j\in J} c(y^j)}{\sum_{j\in J} x^j}$$

As with the total economic effects, a score of $LE^J < 1$ indicate a potential gain from the merger, while a score of $LE^J > 1$ will result in increasing costs due to learning effects.

4.4.2. Harmony Effects

The harmony effects, or scope effects, measure the optimal economic gains from reallocating the production plans in a merger. Harmony effects are estimated as the possibility of reducing the average cost of producing an average output. To gain harmony effects from a merger more than one input or one output is needed. The data sample in this study consist of one input and three outputs, which is introduced in section 6.

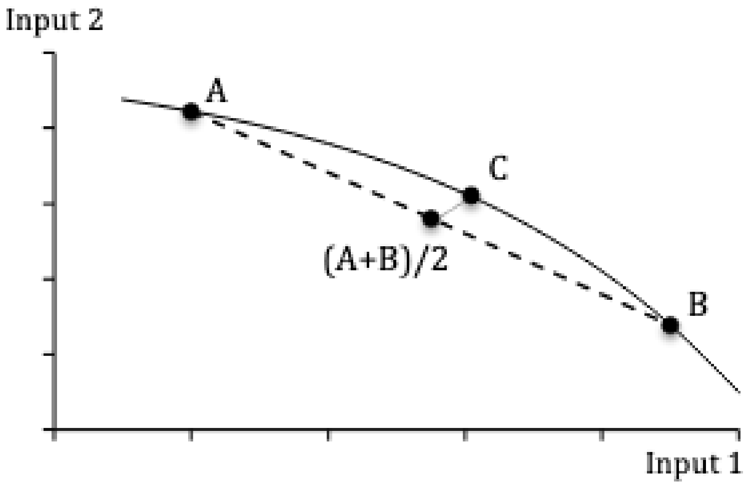

Figure 14: Harmony effects, HA. Source: Bogetoft (2012)

Figure 5 illustrates the harmony effects of a merger of two firms producing two outputs. In an output-maximizing merger, C would be the optimal production plan without increasing the input (Bogetoft, 2012). The focus of this study is input minimization, but the potential reallocation of outputs is needed to estimate the harmony effects of mergers between DSOs. Harmony effect is defined as

$$HA^J = \frac{c(|J|^{-1}\sum_{j\in J} y^j)}{|J|^{-1}\sum_{j\in J} c(y^j)}$$

A score of $HA^J < 1$ indicate that the merger realize potential gains from reallocating the three outputs.

4.4.3 Size Effects

The size effects, or scale efficiencies, compare the cost of operating at full scale to the cost of average scale. Figure 6 shows that Firm 1 and Firm 2 have fully efficient production plans, *A* and *B*, respectively. The production plan of the merged firms´ *A + B* is not fully efficient and economic gains can be realized by changing to production plan *C* instead (Bogetoft, 2012). The firm can produce the same output with a lower amount of input.

$$SI^J = c(\sum_{j \in J} y^j) \, / \, |J| c(|J|^{-1} \sum_{j \in J} y^j)$$

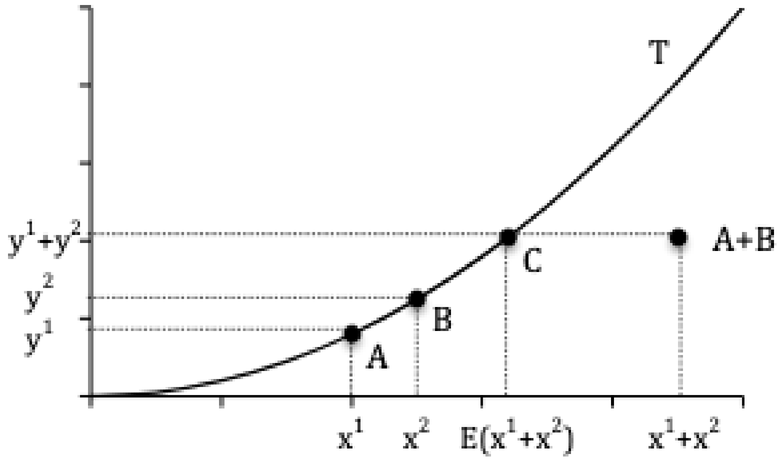

Figure 15: Size effects, SI. Source: Bogetoft (2012)

4.4.4. Pure Merger Effects

The correlation between harmony effects and size effects is the pure merger effects, *E*.*

$$E^{*J} = HA^J * SI^J$$

As mentioned, learning effects can be realized without a merger, but to realize the pure merger effects a full-scale merger is needed.

Henceforth, the total economic effects are a function of learning effects, harmony effects and size effects. The overall economic effects are defined as

$$E^J = LE^J * E^{*J} = LE^J * HA^J * SI^J$$

(Bogetoft, 2012)

5. Industry Overview

The market for electricity is a complex market. Electricity cannot be stored in the same ways as other goods can be stored, and there must therefore always be an exact balance between producing and consumption of power (Norwegian Ministry of Petroleum and Energy, 2020). To ensure stability and provide an effective market, there has been made extensive restructures and changes in the Norwegian electricity market. It is now divided into three sections to fulfil the specific needs of the industry: Electricity producers, distribution system operators (DSOs), and retailers. Electricity producers generates the power, while the retailers sell the power to private households through various agreements. The DSOs are responsible for physically distributing the electricity from the different power plants to consumers, as well as maintaining the power grid (Norwegian Ministry of Petroleum and Energy, 2019).

The customers are connected to different levels of the power grid, determined by the size and demand for power. Energy intensive companies will be connected to the central or regional grid, while households are connected to the distributional grid. The central grid is operated by the Norwegian state, through Statnett SF. The regional and the distributional grid are operated by regional and local DSOs (Reiten & Al, 2014).

Currently, there are 102 DSOs in Norway, with sizes varying from the biggest operator Hafslund Nett AS, having over 720 000 subscribers, to Modalen Kraftlag SA, having just 420 (NVE, 2019). The industry is characterized by how the 9 biggest companies have 63% of the market, while 93 DSOs share the remaining 37%. This can be explained by how the companies are in charge of specific areas, and more rural areas have less subscribers than the companies in urban areas. There is a clear tendency for less companies in the industry now, compared to earlier. This is illustrated by how in 2005, it was 135 DSOS, compared to 100 DSOs in 2019 (NTB, 2019).

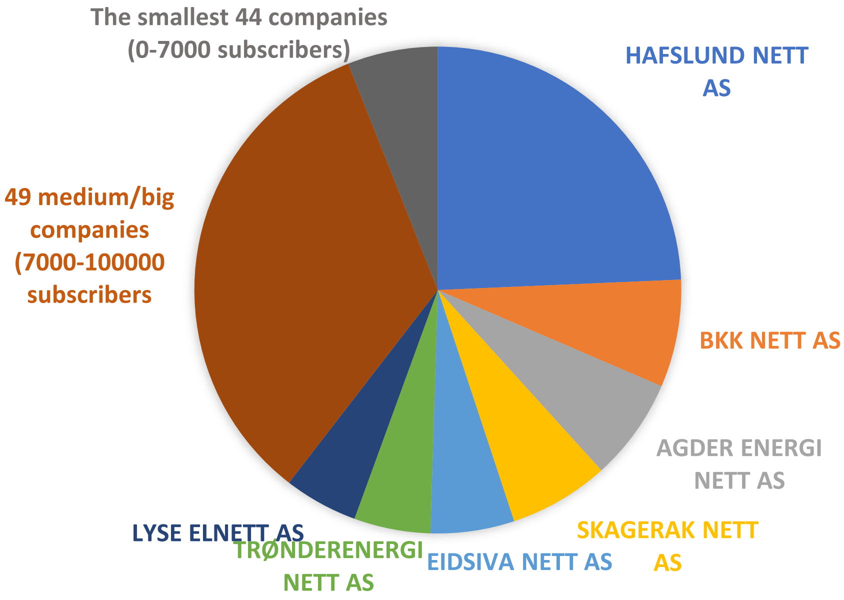

Figure 16: Market shares of subscribers in 2019: Data source: NVE, 2019. Own depiction.

DSOs are very often vertically integrated with an electricity-producing company, but typically they also offer other services, such as internet or telephone services (Reiten & Al, 2014). The income from these extra services varies from company to company, but according to Reiten & Al. (2014), the extra income is on average about 50% of the total income. To ensure better organization and increase cost-effectiveness, and at the same time help the consumers understand the market better, the different units of business must however be under different legal names. This thesis will only study the electricity distribution, and not any side operations the firms might have.

5.1. The Industry Regulation

An industry has a characteristic of a natural monopoly if one firm can produce the market demand at lower cost and with a greater efficiency compared to the efficiency of other firms in the industry (Greer, 2012). To distribute electricity there are several barriers to entry. There has to be made substantial irreversible investments, such as grid lines. Infrastructure is one of the most typical entry barriers for causing a natural monopoly (von der Fehr, Hagen, & Hope, 2002). If there were to be competition in the distributive part of the electricity industry, it would raise the average cost of production and the customer would consequently pay more (Taylor & Greenlaw, 2016). It will not make sense to build parallel grid lines, when the consumer is indifferent to who distributes the power. Thus, the electricity distribution is considered a natural monopoly and competing in a natural monopoly would not prove socio-economically beneficial. To be able to understand the industry of electricity distribution it is important to understand how some parts of their business-model is considered competitive, while other parts are not. The sales of internet and telephone subscriptions are an example of this. The distribution of power, however, is not accounted for as a part of a competitive industry and is what this thesis will analyze.

Figure 17: Area of distribution concessions in Norway (NVE, 2020).

In competitive market environments the corporations have strong incentives to minimize the production costs, as they will be replaced by competitors that will supply at efficient production cost if they choose not to (Joskow, 2007). Companies that lies within this description of a natural monopoly, have the possibility to exploit the benefits by restructuring goods or inflate prices for the disadvantage of the consumers. The NVE has therefore chosen to regulate this market with several methods.

Firstly, they limit the number of competitors in geographical areas by assigning a concession to build and operate power grid lines within that area. Following this concession, there is also an obligation to supply every household and company with power. Furthermore, it has also chosen to legislate a revenue cap. It is based off a law stating that the DSOs will “over time, their costs for operation and maintenance will be covered, and at the same time earn a reasonable return of their investments” (NVE, 2019). The revenue cap is designed in a way that it determines how much revenue the DSOs are allowed to accumulate from their customers.

The revenue cap is calculated in this manner:

$$TI_t = IR_t + E_t + KON_t + FoU_t - KILE_t + TE_t$$

(NVE, 2019b)

Where:

E_t: Property Tax. This cost is impossible for the DSOs to influence, so it can be collected in entirety from their customers.

KON_t: Costs to other level power grids.

FoU_t: Research and development costs. The R&D projects has to be preapproved by the NVE.

$KILE_t$: Costs of not delivered electricity. Every power outage’s cost is measured by their length and type of customer affected. The KILE cost incentives the DSOs to avoid power outages.

TE_t: Adjustment for time lag for investments.

IR_t : Individual revenue frame for each firm. It is split up in two parts. The first part is their cost foundation, based on their actual costs the two previous years weighted with 40%. The second part is the *cost norm*, weighted with 60%.

$$\mathrm{IR}_t = 0{,}4 * \mathrm{K}_t + 0{,}6 * \mathrm{K}_t^*$$

Where:

K_t: The cost foundation

K_t^*: The cost norm

(NVE, 2019b)

The cost norm is determined by NVE. It is intended to reflect the costs of an imagined company, with average cost-effectiveness. The cost norm is meant to show what the costs of the specified company should have been, given average efficiency in operation, maintenance, and power grid exploitation. It is calculated by multiplate the cost foundation with an effectiveness score. The effectiveness score is determined in a Data Envelopment Analysis (DEA) model. It measures companies against each other and will in term determine an average efficiency score for the companies (NVE, 2019b)

With these measures the NVE claims to have managed to increase competition within the natural monopoly. If not to increase revenue, but to become the most cost-efficient, thus relishing the opportunity to gain more profit.

Adding to this, in 2013 it also introduced a merger scheme to further incentivize merger among the DSOs. The former regulation did somewhat penalize merging of firms by granting the merged company a smaller revenue cap, than the two individual entities combined, When entering a merger, the NVE will pay out the 10-year NPV of the harmony effect discussed in chapter 4.4.2. (NVE, 2015).

6. Data

In this chapter, the reader will get acquainted with the dataset analyzed in the efficiency research and merger gains. The input and output variables are described and the alterations to the original data sample is elaborated upon. The data sample consists of operational costs and capital costs. Furthermore, in the second stage analysis, additional output data is introduced, as environmental variables are used to adjust efficiency scores for geographical factors. This data is included to ensure more accurate input variables since DSOs have different geographical obstacles to comprehend. Full data samples are found in appendix, while this section will present descriptive statistics of the data samples.

The overall data includes 100 Norwegian DSOs during the period 2014 – 2018 which were still in operation in by the year-end of 2019. These companies cover the whole of Norway. The data is averaged over the whole period, thus the final sample includes 100 observations. Instead of using yearly data, there are two compelling reasons why it is averaged. Firstly, averaging reduces the effects of noise, such as unexpected cost shocks (Kuosmanen, Saastamoinen, & Sipiläinen, 2013). It is more reasonable to study cost efficiencies where all parties operate on their usual input/output profile rather than on some exceptional level caused by exogenous shocks. Nevertheless, the actual Norwegian regulatory model also uses averaged data of the past to achieve a more stable cost frontier against which firms´ cost efficiency is assessed on a yearly basis (Amundsveen & Kvile, 2016). Secondly, except for some exogenous shocks, the distribution industry is relatively stable with little variation in demand over the years.

6.1 Data collection and preparation

The data is collected by the Norwegian regulator (NVE) and provides precise information on the assets and costs of the different Norwegian distribution companies for the period 2014 – 2018 (NVE, 2019c). A first step was to remove operators that did not have a distribution system as its core business. These were typically production-oriented companies in the three-way Norwegian electricity market. Besides, operators which were not represented in all years or with unrealistic information were removed. To further ensure measurement validity, , a second step was to balance the panel, namely through completing the mergers which took place in 2019. These mergers have been realized by consolidating the different inputs and outputs of the acquired company to the acquirer´s data. At the end of the data preparation, the dataset consisted of a sample of 400 observations depicting the main characteristics of 100 operators for 2014-2018.

6.2 Data model

The applied DEA model comprises one input and three outputs, measured as the average over the last five years (2014-2018). The model is mimicking as closely as possible the current model applied by the NVE. A strength of the model is that it includes the main costs faced by the operators. This gives a response to the critics addressed towards DEA concerning its lack of consideration of the whole cost-efficiency (Cooper, Seiford, & Zhu, 2004).

6.2.1. Input

The input is total cost (TOTEX), comprising operating and maintenance costs (O&M), cost of power losses, costs of energy not supplies (CENS) and capital costs. For all input values, check appendix B and C.

Input 1: Operating costs. The operating and maintenance costs (O&M) is adjusted for inflation by applying a consumer price index for services with wage as a dominant price factor. The cost of power losses is measured as the average physical losses in MWh multiplied with the Elspot price for the relevant price area at NordPool Spot. CENS is adjusted for inflation by applying a standard CPI and express the customers´ costs in the event of power outages, and is included in the model in a way that is consistent with the overall model for economic regulation of the DSO´s. Operating cost can be written as:

$$Operating\ costs\ =\ O\&M\ +\ Cost\ of\ power\ losses\ +\ CENS$$

Input 2: Capital costs consists of depreciation and a reasonable return on assets (RoA) determined by the NVE. The RoA is calculated as the book value of tangible assets plus one percent for working capital, multiplied with same WACC (weighted average cost of capital) as of the NVE is using (Langset & Syvertsen, 2015). Using these capital cost measures in DEA impose bias in the yardsticks due to differences in the age of the DSOs assets (Amundsveen, Kordahl, Kvile, & Langset, 2014). This is dealt with in the overall model for economic regulation of the DSOs. It can be written as:

$$Capital\ costs\ =\ RoA\ +\ Depreciation\ costs$$

Thus, total costs (TOTEX) equals:

$$TOTEX\ =\ Operating\ costs\ +\ Capital\ costs$$

6.2.2. Output

The output variables are the number of customers, the length of the high voltage (HV) network expressed in kilometers and the number of substations. These outputs relates to network structure and demand, and is the main cost drivers that are common for all DSOs regardless of geographical location.

Output 1: Number of customers is a volume measure, which is very highly correlated with "energy supplied" that is new in the two-stage DEA model applied in Norway from 2013 (Amundsveen, Kordahl, Kvile, & Langset, 2014).

Output 2: Length of HV network is a proxy for the transport distance, which is probably the strongest single cost driver.

Output 3: Number of substations, transforming power from HV to low voltage (LV) lines, is mostly a structural variable taking care of the differences in population density. In densely populated areas, you can serve many customers through one single substation, whilst in the least populated areas the DSOs may have only customer in a substation.

6.2.3. Descriptive Statistics of First-Stage DEA Model.

This section will display the descriptive statistics of the dataset. This is done by showing tables and figures that will illustrate the dataset and compare the different inputs and outputs.

The table below shows the maximum, minimum, average, standard deviation, and median values for the inputs and outputs described earlier in the chapter. This is done to give the reader insight on how the different variables are in terms of size and deviations.

Statistical Measure	TOTEX (NOK) in thousands	Number of customers	Length of HV network (KM)	Number of substations
Min	3.348	425	13	9
Max	2.679.064	701.125	4.759	17.837
Average	177.937	30.210	583	1.285
Median	55.362	7.501	240	412
Std.dev	361.600,09	80.424,73	892,68	2.459,67

Table 3: Descriptive Statistics for input and output variables. Source: Own calculations from dataset

The table displays the minimum and maximum values for the companies that average the highest or lowest value over the computing period combined. The average DSO serves about 30.210 customers. They do differ greatly, however, showed by how the standard deviation holds a value of 80.424. The great variation among the DSOs is further highlighted by how the company with the highest number of substations is operating over 1938,8 times as many substations as the DSO operating the fewest.

The average of every variable is constantly displaying values of over the twice the size of the median variables. This can be explained by how a few dominant DSOs are significantly larger than the many of the small DSOs, that will in turn affect the average significantly.

6.2.3 Environmental variables

This chapter will describe the data included to give the reader a better overview over what environmental challenges the DSOs are operating in, and what variables are included in the second-stage DEA.

This thesis has chosen to utilize the same variables for this matter as the NVE has. This choice is made for two reasons. Firstly, NVE as an organization has a lot of responsibility considering environmental issues in Norway, for example preventing different climate occurrences like flooding and avalanches. This require extensive information about the geography of Norway, and NVE will therefore have superior information the average environment in which the DSOs operate. Facilitating variables for own use would not be beneficial and would simplify the results, rather than increase the value of the study. Secondly, the use of different variables for this matter would decrease the generalization potential for the paper. This choice is also backed by recent research in the area (Agrell, Bogetoft, & Grammeltvedt, 2015) (Mydland, Kumbhakar, Lien, Amundsveen, & Kvile, 2018b).

NVE has collected the data based on a geographic information system (GIS) analysis, where the geographical areas of Norway are split up in parts, describing the environmental factors, such as amount of snow and terrain, for every area. Continuing, the GIS analysis further describes what type of asset and equipment the DSOs have in every area (Amundsveen, et al., 2013). The GIS-analysis surmounts to a considerable amount of data for every company. The data from the analysis will then be utilized in a Principal Component Analysis to include variables that exploit the variation between them and excludes the variables with a high degree of correlation (NVE, 2020). Following these analyses, a variety of environmental variables are selected. This thesis has been granted access to the results of these analyses and will utilize them as the environmental variables for the second stage DEA. Continuing the selected variables will be presented. All explanations are from NVE (2020).

Z1: Shares of overhead of how many kilometers of underground cables compared to total amount of kilometers of cable.

Z2: A measure of high-voltage (HV) lines through coniferous forest.

The three upcoming Z-variables that are going to be included in the second-stage analysis are "GEO-indexes", consisting of three or four variables, constructed by the abovementioned GIS-analysis and PCA.

Z3: *"Geo 1"*: The first variable in Geo 1 is the average incline in the areas the DSOs operate in. The second variable in Geo 1, not unlike Z2, describes a measure of how much of the overhead HV-lines run through a deciduous forest. The last part of Geo 1 is a measure of how many small power outages the DSOs has installed in their areas of concession, downscaled by the cost norm. The cost norm is calculated by multiplying the bootstrapped efficiency scores with the average 5-year total costs.

Z4: *"Geo 2"*: The first variable is made to account for the distance to coast the DSOs experience throughout their operations and the average wind speed they encounter. The second variable is the number of islands, more than 1 km away from shore, the DSOs has provided. This is also downscaled in the same way as the small power outages from Geo 1. The final variable that is included in Geo 2, is the share of underwater cables they employ.

Z5: *"Geo 3":* This index will try to account for harsh weather conditions. It contains of average snow fallen in the areas, amount of ice affecting the constructions and the average temperature. Northern parts of Norway experience polar nights at certain parts of the winter months. The extra months of darkness will reduce the operational flexibility in some parts of the grid network. The last variable of Geo 2 is designed to consider this, and the DSOs that operate north of the latitude 65,9° will receive higher values of this variable.

To provide further insights on the environmental variables, a table of descriptive statistics will be presented.

Statistical Measures	Z1	Z2	Z3: Geo 1	Z4: Geo 2	Z5: Geo 3
Min	0,077464789	0	-1,989872533	-0,703278713	-2,548191238
Max	0,903654485	0,391628899	4,060136304	11,91057718	6,158798146
Average	0,38222585	0,118940665	-0,036961118	0,013094957	0,028449189
Median	0,358014594	0,121617752	-0,528532575	-0,456358919	-0,227145671
Std.Dev	0,171420001	0,099380793	1,499552621	1,546318633	1,677303768

Figure 18: Descriptive Statistics from Environmental Variables. Datasource: Own Calculation from appendix J.

As mentioned earlier, Norway has a varied geographical venue. Some places are flat while other have steep hills and mountains. This is, to some degree, represented by the variation in how the environmental variables' value.

The variable «Geo 3» will be affected, amongst other things, by the temperature and how far north they operate. Not surprisingly, the DSOs that receive the most advantages from this are situated far north, or up in the mountains. Geo 2 clearly favors companies near the shore, and disfavors DSOs inshore, while geo 1 supports the DSOs near the fjords.

6.2.4 Final model

To summarize and try to give the reader a better overview, the model described in the chapters above is graphically designed.

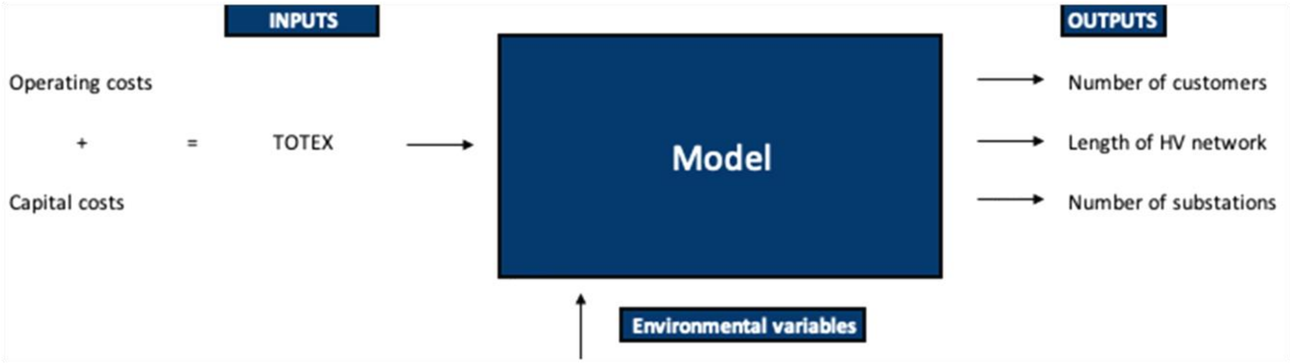

Figure 19: Graphic explanation of variables. Source: Own depiction

7. Results

In this section, results from the analysis will be presented. Firstly, efficiency scores from a standard DEA to evaluate the performance of Norwegian DSOs is calculated. Individual efficiency scores under six different technologies are estimated, as well as the firms' scale efficiency. An additional feature of DEA is the estimation of each DSOs´ peer units. Peer units are the reference unit for the firm, setting an example of which firms it should emulate to improve (Johnes & Yu, 2008). To remove potential biases from the analysis, bootstrapping is introduced to ensure a more accurate estimation of the efficiency scores.

As mentioned in section 6, environmental variables are introduced in the second stage of this analysis. Some companies may operate in areas with dense forests and steep terrain, while others operate in exposed areas with strong winds, or very cold temperatures. The DSOs are obliged to operate in the area of where they have received its concessions. To account for the variations in demanding exogenous circumstances, the environmental variables will in turn adjust the input from the original model. This will be done by utilizing an ordinary least squares (OLS) regression.

Lastly, the environmentally adjusted results are used to estimate total economic effects, learning effects, harmony effects and size effects of potential mergers between DSOs. The merger combinations are delimited to the county of which the DSOs operate in.

To determine the efficiency frontier, as well as the inferred merger effects, the R software package Benchmarking from Bogetoft & Otto (2011) is utilized. The full extent of the statistical computations of efficiency scores, bootstrapping and merger effects are found in Appendix L.

7.1. First-Stage DEA Results

This chapter will introduce the results from first stage of the Data Envelopment Analysis. This will be done in a standard DEA model proposed Bogetoft & Otto (2011). Firstly, the efficiency scores of the DSOs will be calculated, before the peer units for each company is decided.

In the first stage analysis, a standard DEA model has been computed. It comprises of the input variable *(x),* which is total costs, while the output variables (*y1, y2* and *y3)* represents number of customers, length of HV network and number of substations, respectively. The number of firms (*n)* is 100. With one input and three outputs assigned to each firm, the total number of observations in this part of the analysis is 400. The data sample described in chapter 6 is utilized.

7.1.1 Efficiency Scores

During the first stage DEA, the relative efficiency of every single DSO is calculated to determine which firms are the most efficient in the Norwegian electricity distribution industry. This has been done according to the six models presented in chapter 3, where the efficiency score is estimated by the lowest relative input compared to the outputs. As mentioned in chapter 4, the basic DEA models mainly differ in the assumptions that they make about the technology. This will impact the efficiency scores of the individual DSOs.

In the table below, there are descriptive statistics of all six technologies used in the first stage analysis. The FDH model only includes one out four possible assumptions of the DEA technology and it has therefore the highest efficiency mean of 0,9351. In this model, 63 out of 100 DSOs were fully efficient. More surprisingly is that FDR is second with an average mean of 0,8000. Due to the technology size, theory from Bogetoft & Otto (2011) suggest that FDR should be close to VRS, DRS and IRS technology in terms of measures. However, FDH and FDR do not include convexity as an assumption for the technology, which can partially explain why it differs from the other models. CRS has the lowest industry mean with 0,7018 which indicates that potential efficiency gains among DSOs are 29,83%.

Model	Average	Median	Min	Max	Std. Dev.
VRS	0,7350	0,7075	0,3613	1	0,1679
CRS	0,7018	0,6937	0,3556	1	0,1610
FDH	0,9351	1	0,4958	1	0,1216
FDR	0,8000	0,7914	0,3737	1	0,1635
DRS	0,7261	0,7016	0,3613	1	0,1706
IRS	0,7107	0,6997	0,3556	1	0,1595

Table 4: Descriptive statistics of DEA. Source: Own contribution

Except for FDH, all models have a lower median than mean. This indicates that the firm size is positively skewed as the medians of the cost and outputs are slightly smaller than the means (Bogetoft & Wang, 2005). The standard deviation varies from 0,1216 in the FDH model to 0,1706 in the DRS model. Considering that the FDH model has the lowest range between minimum and maximum value, and 63 firms at 100% efficiency, this is not seen as controversial.

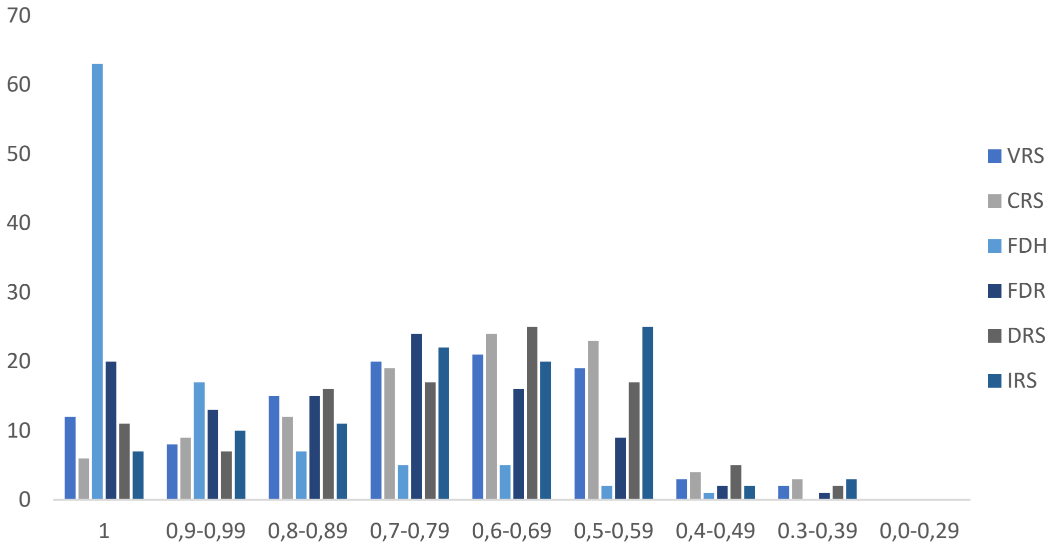

Figure 20: Efficiency Scores from VRS,CRS, FDH, FDR, DRS and IRS. Source: Own contribution

According to the estimates, six companies are situated at the efficiency frontier, meaning that they are fully efficient under all six technologies. These are Bindal Kraftlag SA, Krødsherad Everk EF, Nord-Østerdal Kraftlag SA, Norgesnett AS, Røros Elektrisitetsverk AS and Trøgstad Elverk AS. When the three outputs are decomposed separately and is measured relative to the input, all of these firms are ranked top ten within at least one measurement. As mentioned in 6.2.1, output 2, *Length of HV network,* appears to be the single strongest cost driver as eight of the ten most efficient firms has the shortest length of network in relation to total costs.

On the other hand, three companies experience average efficiency scores below 50%. Namely Lofotkraft AS, Odda Energi AS and Fitjar Kraftlag SA. Moreover, twelve firms are below 60% in terms of average efficiency using all six models. Except for Norgesnett AS, none of the firms characterized as large is at the highest or lowest end of the scale.

7.1.1.1. Exclusion of models

This study wishes to research the different DSOs sizes and the effect this has on the firm-specific efficiency. Due to how the decreasing return to scale (DRS) and increasing return to scale (IRS) will have the tendency to discriminate firm sizes, the models are therefore excluded from the further analysis (Bogetoft, 2012). Further, as the data sample is restricted to one input and three outputs, there is not enough data to avoid the convexity assumption. As a result, FDH and FDR are also excluded from the analysis. In addition, NVE use CRS in the regulation of Norwegian DSOs. The firms themselves, favor the VRS assumption, due to its improved efficiency measures (Bogetoft & Otto, 2011). For this paper to be relevant for the regulating authorities and the DSOs, including the potential for generalization, it is important that its results are applicable. Therefore, in efforts to be two-sided, VRS and CRS are chosen as the models for the further analysis.

Model	Small	Medium	Large
VRS	0,72	0,74	0,78
CRS	0,69	0,72	0,69

Table 5: Average values of DEA, sorted in size of companies. Source: Own contribution

When filtering the descriptive statistics by the sizes of the firms, it shows how the VRS assumption entails higher values for the larger on average, than the CRS assumption. The results following a DEA makes a cautious inner approximation of the production possibility set, and when observations are more sparse, the bias is larger. Hence, if there are only few large units comparable to the small one, the CRS model is most likely too pessimistic (Bogetoft & Otto, 2011). By applying VRS and CRS continuously throughout the analysis, the study will have one model that is subject to upward biases, and another model that is more pessimistic in terms of efficiency measures.

7.1.2 Scale efficiencies

Scale efficiencies (SE) estimate to which degree inefficiencies are due to the size of the firm, and is calculated by

$$SE = \frac{E(CRS)}{E(VRS)}.$$

(Bogetoft & Otto, 2011)

This measure is never higher than 1 and the firms are at optimal scale when the VRS and CRS technologies coincide at precisely 1. Thus, the same six firms that were fully efficient in first part of this analysis is at optimal scale. The remaining 94 DSOs possess a value that is less than

1. To further examine if these DSOs are below or above optimal size, the following statement is tested:

$$E(VRS) - E(DRS) < 0{,}0001$$

(Bogetoft & Otto, 2011)

Company Size	Above	At	Below
Small	15	4	25
Medium	32	1	8
Large	14	1	0
Sum	61	6	33

Table 6: Test of Optimal Size, Based on Scale Efficiency. Source: Own contribution

For 33 DSOs; this test was FALSE, indicating that they are below optimal scale. In other words, 33 out of 100 DSOs are too small in terms of cost efficiency. The remaining 61 firms are above optimal scale and is deemed too large. Out of the 20 most efficient companies under the VRS and CRS models in the data sample, only two DSOs are below optimal scale. Excluding the six that are at, the remaining twelve are above optimal scale which indicate that firms considered too large are more efficient than firms that are below optimal scale.

7.1.3 Peer Units

Previously, when calculating the efficiency scores, a handful of companies were on the efficient frontier. A strength of the DEA is that it identifies explicit real peer-units for every calculated unit. The firms that are on the efficient frontier and efficient in every return to scale assumption, are reference units for the other companies. The associated peers are the companies that will be compared with the reference unit. Furthermore, by designating weights to the peer companies, it will show in what manner the DSO should emulate the peer units to be on the efficient frontier themselves (Johnes & Yu, 2008). Peer units are units with positive weighted average towards the inefficient DSOs, i.e.

$$\text{Peer Units} = \{\kappa \in \{1, \dots, K\} \mid \lambda^k > 0\}$$

Where:

$K = firms$

$\lambda = reference\ weight$

(Bogetoft & Otto, 2011)

In the DEA models, the number of possible peer units for a given firm is equal to the number of input and outputs. This is not the case for CRS technologies, where there can generally be one less peer unit, as mentioned in chapter 4. The six firms that are regarded as fully efficient in the standard DEA model are thus targeted as peer units for the other DSOs. Fully efficient firms have themselves as the only peer unit with a weight of 1. In the table below, these are removed to extract the correct lambdas.

VRS			CRS		
Peer units	**#**	**Lambda**	**Peer units**	**#**	**Lambda**
BINDAL KRAFTLAG SA	17	0,53	BINDAL KRAFTLAG SA	10	2,11
EIDSIVA NETT AS	1	0,54	KRØDSHERAD EVERK KF	43	1,62
HAFSLUND NETT AS	5	0,76	NORD-ØSTERDAL KRAFTLAG SA	16	0,54
HALLINGDAL KRAFTNETT AS	2	0,36	NORGESNETT AS	55	0,74
KRØDSHERAD EVERK KF	31	0,57	RØROS ELEKTRISITETSVERK AS	62	1,13
MODALEN KRAFTLAG SA	17	0,45	TRØGSTAD ELVERK AS	55	1,01
NORD-ØSTERDAL KRAFTLAG SA	43	0,57			
NORGESNETT AS	64	0,54			
NTE NETT AS	16	0,56			
RØROS ELEKTRISITETSVERK AS	30	0,54			
TRØGSTAD ELVERK AS	45	0,57			
VALDRES ENERGIVERK AS	21	0,49			

Table 7: Peer units for the VRS and CRS model, with average Lambdas. Source: Own contribution

Under the VRS technology, each firm can at most have four peer units. The exact twelve DSOs that are fully efficient in the first stage analysis are peer units for the remainders. Norgesnett AS is the most associated peer unit, and is demonstrating how 64 other DSOs can improve by emulating their input and outputs towards this ratio. Trøgstad Elverk AS and Nord-Østerdal Kraftlag have the second and third most peer units, with 45 and 43, respectively. Among the 64 peer units of Norgesnett AS, the average lambda, λ, is 0,5362. Unlike the CRS model, no average weight of reference unit is above 1. Under CRS technology, Røros Elektrisitetsverk is the most popular reference unit, whereas Norgesnett AS and Trøgstad Elverk follows with 55 peer units each.

7.2 Bias-corrected analysis

The first stage DEA efficiency scores along with the designated peers has now been calculated. As mentioned in the analytical framework, the DEA model is prone to upward bias (Bogetoft & Otto, 2011). Therefore, the cost efficiencies of the DSOs are bias-corrected. The bias-corrected efficiencies are calculated by applying a smoothed bootstrapping sample on the already calculated efficiency scores, as explained in chapter 4. The bias-corrected efficiency scores are found in Appendix I.

B =	25	50	100	250	500	1 000	2 500	5 000	10 000
Run: 1	7 314	6 665	6 297	6 445	6 658	6 761	6 754	6 551	6 508
Run: 2	7 363	6 906	6 080	6 947	6 597	6 259	6 396	6 747	6 654
Run: 3	5 716	6 071	6 674	6 501	6 489	6 751	6 602	6 492	6 656
Run: 4	7 070	6 420	6 374	7 211	7 056	6 306	6 431	6 491	6 634
Run: 5	5 426	8 153	5 548	6 295	6 368	6 308	6 458	6 639	6 580
Run: 6	6 894	5 502	7 087	6 737	6 517	6 659	6 511	6 580	6 544
Run: 7	6 151	6 832	6 495	6 001	6 583	6 327	6 790	6 726	6 550
Run: 8	6 050	8 645	6 834	6 277	6 913	6 705	6 646	6 689	6 598
Run: 9	8 502	6 423	6 481	6 734	6 468	6 602	6 474	6 537	6 577
Run: 10	6 603	7 575	5 542	7 581	5 983	6 570	6 470	6 429	6 644
min	5 426	5 502	5 542	6 001	5 983	6 259	6 396	6 429	6 508
max	8 502	8 645	7 087	7 581	7 056	6 761	6 790	6 747	6 656
Diff	3 076	3 143	1 545	1 580	1 073	502	394	318	148

Table 8: Standard Error of the Median at Different Bootstrap Samples B

Firstly, it is relevant to identify the optimal number of replicates B to be used in the analysis. The optimal number of replicates, B, can be found by calculating the standard error of the median at different scenarios. Using nine different bootstrap samples ranging from 25 to 1.000, the standard error of the median is calculated and run ten times to ensure a sufficient basis for comparison. The results in table 8 indicate that at B = 25, the standard error of the median varies from a minimum of 5 426´ to a maximum of 8 502´. Bogetoft & Otto (2011) states that the required number of bootstrap samples in a DEA analysis is significantly higher than in other approaches, whereas a bootstrap sample between 50 and 200 often is sufficient. This is supported by the above table where the fluctuations decrease with the number of replicates. Thus, a minimum of 1 000 bootstraps is required to ensure a standard error of the median without large fluctuations. At B = 10 000, the standard error of the median varies by only 148 compared to B = 5 000 where the variation is 318. Hence, as the fluctuations are the lowest when B = 10 000, this number of replicates is used when calculating the bias-corrected efficiency scores.

7.2.1 Bias-corrected efficiency scores

Model	Mean	Median	Min	Max	Std. Dev.
VRS	0,74	0,71	0,36	1	0,17
VRS-BC	0,67	0,66	0,34	0,95	0,14
CRS	0,70	0,69	0,36	1	0,16
CRS-BC	0,66	0,65	0,35	0,96	0,15
SE	0,96	0,98	0,70	1,00	0,06
SE-BC	0,99	1,00	0,80	1,08	0,05

Table 9: Efficiency scores post bias-correction, Source: Own contribution

The bias-corrected efficiency scores of Norwegian DSOs in this table show a higher degree of inefficiencies than the results presented in the standard DEA model. After bias-correction, none of the DSOs are in fact fully efficient. The average efficiency score under VRS technology decrease from 0.7350 to 0.6701, a total reduction of 6,5%. Similarly, the efficiency score under CRS technology decrease from 0.7018 to 0.6646. By applying the bootstrap method to the DEA results, the upward bias of the analysis has been corrected.

When estimating the bias-corrected scale efficiencies, the pattern is the same as in the first stage DEA. One transformation, however, is that the six fully efficient firms pre bias-correction is no longer at optimal scale. These six are now below optimal scale, resulting in 39 DSOs below and 61 above what is considered optimal scale in terms of cost efficiency. By utilizing a finite number of bootstrap samples in the bias-correction, the efficiency scores has been recalculated. Since these DSOs are no longer situated on the efficient frontier, their size is no longer considered optimal.

7.3 Second-Stage Analysis

This chapter will undertake a second stage DEA analysis, following the methods described in theory chapter 4. The DSOs are obliged to operate in the area of where they have received its concessions. Despite having different surroundings, in the first stage DEA they are treated as equals. Thus, to account for the variations in demanding exogenous circumstances, the environmental variables will in turn adjust the input from the original model. A second stage analysis for accounting for environmental variables has been done in similar research (Zschille, 2012; Subal, Amundsveen, Kvile, & Lien, 2014). In this study it will be done by utilizing an ordinary least squares (OLS) regression as suggested in Hoff (2007), with bias-corrected efficiency scores as the dependent variable and environmental variables introduced in chapter 6 as the independent. Bootstrapped efficiency scores are used in the second stage analysis to avoid serial correlation (Simar & Wilson, 2007). In turn, the results from this method will lead to new efficiency values. These efficiency values will be the foundation for the upcoming merger analysis.

As mentioned in section 6.4, there are five environmental variables (z) that are tested and implemented in the final model. These are *Share of underground network (z1), coniferous forest (z2),* and three composite variables that are named *Geo1 (z3), Geo2 (z4) and Geo3 (z5).* The three Geo-variables are grouped together of three separate variables due to serial correlation.

Moving forward, Modalen Kraftlag SA does not incorporate the same environmental variables as the other DSOs in this analysis. It is now excluded from the further analysis due to lack of data. Nevertheless, Modalen Kraftlag SA is the smallest of the firms, only serving 420 subscribers. This may be a reason for the insufficient operating information. Henceforth, there are 99 firms and 396 new observations in the second stage analysis.

7.3.1. OLS-regression

The OLS regression is structured according to the theory described in chapter 4 using the environmental variables mentioned in the introduction. Thus, the regression performed in this chapter is the following:

$$E = a_1 z_1 + a_2 z_2 + a_3\, z_3 + a_4 z_4 + a_5 z_5 + \varepsilon$$

Where:

$E = Previously\ estimated\ bias\text{-}corrected\ efficiency\ scores$

$a = Coeffisient\ from\ regressions$

$z = Enviromental\ variable$

$\varepsilon =\ random\ error\ that\ explains\ how\ the\ model\ cannot\ completely\ explain\ efficiency\ levels$

(Bogetoft & Otto, 2011)

The regression is performed both under the VRS and CRS assumption. All five variables proved significant on a 5% level. A summary of the regression is listed in the tables below. For full results, check appendix J.

Variable	Coefficients	Standard Deviation
Intercept	0,7624	0,0367
Z1	-0,2381	0,0755
Z2	-0,0641	0,1505
Z3: Geo 1	-0,0489	0,0080
Z4: Geo 2	-0,0507	0,0083
Z5: Geo 3	-0,0273	0,0097

Table 10: Regression Coefficients and Standard Deviation for Assumption VRS. Source: Own contribution

Variable	Coefficients	Standard Deviation
Intercept	0,7624	0,0367
Z1	-0,2381	0,0755
Z2	-0,0641	0,1505
Z3: Geo 1	-0,0489	0,0080
Z4: Geo 2	-0,0507	0,0083
Z5: Geo 3	-0,0273	0,0097

Table 11: Regression Coefficients and Standard Deviation for Assumption CRS. Source: Own contribution

	VRS	CRS
Multiple R	0,6460	0,6613
R Square	0,4173	0,4373
Adjusted R Square	0,3860	0,4070
Standard Deviation	0,1129	0,1161
Observations	99	99

Table 12: Regression Statistics for Both Assumptions. Source: Own contribution

7.3.2. Adjustment of Input

At this stage of the analysis, the effects of the environmental variables are calculated. What remains now is to incorporate the effects into the total expenditures from the original model explained in chapter 6.2.1. The new model is now the same as in the original DEA, except the input is now environmentally adjusted. The outputs remain the same. The input's adjustment factor is the residuals from the previous regression.

	VRS Input	CRS Input	Original Input
Max	2.531.769	2.403.666	2.679.064
Min	7.915	8.248	10.558
Average	183.026	185.135	179.700
Median	56.557	55.351	55.397

Table 13: Average Inputs. Source: Own contribution

Due to the nature of the OLS – regression, the average of the residuals, i.e. the average change in total input by every single company will be 0%. However, when exploring the new inputs further, some companies' input has altered significantly. The average input of all DSOs under both models has increased. Exploring further, the change in companies like Luster Energiverk AS, Rauland Kraftforsyningslag AS and Nordvest Nett AS' inputs experienced a reduction of over 20% under both assumptions. This would mean that under the normal input model, their total costs suffered under tougher environmental circumstances than what their competitors did. On the other hand, there are companies like NEAS AS, SFE Nett As, and Haugaland Kraft Nett AS that have increased input, also with over 20% under both assumptions, in the new model. Compared to the previously mentioned firms that experienced a decrease, these DSOs will be determined to operate in an environment more challenging to work in, i.e. their adjusted input will increase. For full new model, check appendix H.

7.3.3. Second-Stage DEA Scores

Following the correction of the inputs, the new efficiency scores of the second-stage DEA can be calculated. This is done in the same manner as in the first-stage DEA. Due to the formerly mentioned removal of Modalen Kraftlag SA from the original model, the number of DSOs is now 99, with the total number of data observations adding up to 396.

Model	Average
VRS	0,7350
VRS-S2	0,6696
Change %	-8,90%
CRS	0,7018
CRS-S2	0,5954
Change %	-15,16%

Model	Average
VRS-BC	0,6690
VRS-S2	0,6696
Change %	0,09%
CRS-BC	0,6635
CRS-S2	0,5954
Change %	-10,27%

Table 14: Comparison Between First and Second Stage DEA, Comparison Between Bias-Corrected and Second Stage DEA. Source: Own contribution

For the updated results, there have been some changes to the efficient frontier. Røros Elektrisitetsverk AS is no longer fully efficient in any of the models, while Krødsherad EVERK KF is now one of the 14 efficient firms in the VRS model. Some DSOs has naturally also increased their performance measures due to this change. Valdres Energiverk AS and Luster Elverk AS is now considered fully efficient. Bindal Kraftlag SA, Krødsherad Everk EF, Nord-Østerdal Kraftlag SA, Norgesnett AS, Trøgstad Elverk AS remain at the efficiency frontier. On the other hand, while having a efficiency score of around 0.50, Andøy Energi AS and Notodden Energi AS drop with respectively 17% and 15% under the VRS model. For the CRS model, the changes are severe, with Eidsiva Nett AS and Stange Energi Nett AS, enduring a loss of efficiency of about 20% each.

This thesis has an aim of characterizing the potential mergers combination in Norway, sorted by which county it was a part of before the county consolidation in 2020. Therefore, it would be of great interest to examine how the different DSOs in each company performs, after the adjustment for environmental variables has been performed.

Old County	DSOs	Average VRS	Average CRS
Østfold	3	0,96	0,95
Trøndelag	7	0,92	0,81
Oslo, Akershus	2	0,91	0,82
Hedmark	3	0,83	0,66
Troms	4	0,80	0,62
Oppland	7	0,78	0,73
Buskerud	12	0,76	0,69
Møre & Romsdal	11	0,65	0,55
Telemark	9	0,64	0,59
Rogaland, Agder	6	0,58	0,49
Sogn & Fjordane	8	0,56	0,50
Finnmark	5	0,54	0,48
Nordland	11	0,54	0,48
Hordaland	11	0,49	0,45
Total	**99**	**0,67**	**0,60**

Table 15: Overview of Counties with Average VRS and CRS, Source: Own Contribution

There are interesting issues to discuss regarding table 10. The average in the VRS model is over 6% higher than in the CRS model. This might be a reason to why the different DSOs will favor this assumption, while the regulators favor the CRS assumption (Bogetoft & Otto, 2011).

Another notable tendency in the observations is how the general performance of DSOs in regions west (Hordaland, Sogn & Fjordane) and north (Nordland and Finnmark) generally performs less efficient than DSOs operating in the eastern regions (Østfold, Oslo and Akershus, Hedmark and Oppland). A notable exception is the northern county of Troms, which under the VRS assumption performs better than average.

Continuing in the same path of the first-stage DEA, scale efficiencies will be calculated according to Bogetoft & Otto's (2012) formula for precisely this measure.

Model	Scale efficiency
VRS - Model	0,9249
CRS - Model	0,9193

Table 16: Average scale efficiency after second stage DEA. Source: Own contribution

VRS - Model			
Company Size	Above	At	Below
Small	25	5	13
Medium	21	2	18
Large	7	1	7
Sum	53	8	38

CRS-Model			
Company Size	Above	At	Below
Small	19	5	19
Medium	37	2	2
Large	14	1	0
sum	70	8	21

Table 17: Number of companies and their optimal size for both models. Source: Own Contribution

At this point there are 0 large firms that are below the optimal size in the CRS-model, just one that is at the optimal scale. Under the VRS-model the firms are more evenly distributed.

7.4 Merger Analysis

Based on the observations from the previous sections, this paper now focuses on merger analysis between Norwegian DSOs. The revision of the regulating model in 2013 by NVE had an aim of incentivizing mergers to increase the overall efficiency (NVE, 2019b). Thus, this paper conducts an analysis of the entire industry with a purpose to locate the most beneficial merger combinations. The analysis is done following the framework of Bogetoft & Wang (2005). By utilizing both the environmental adjusted input data from the second stage, two potential merger models will be made. Total economic effects are presented before the overall merger potentials are decomposed into learning, harmony and size effects. This is done to understand what types of gains can be achieved from the mergers. Lastly, pure merger effects that is correcting for individual inefficiencies are introduced.

The potential mergers are examined pairwise and restricted to the former Norwegian county as closely located mergers among DSOs are the most likely form (NVE, 2019b). Saastamoinen, Bjørndal, & Bjørndal (2017), examines mergers among DSOs which service areas share geographical border, while Mydland et. al (2018b) studies mergers with no geographical restrictions, apart from the Norwegian borders. Nevertheless, this thesis desires to still research the mergers that contain geographically close DSOs, but not be limited to the sharing of borders. This is because they share much of the same environmental challenges, but relaxing the assumption of shared geographical borders, to investigate a greater number of combinations. Prior to the consolidation of counties in January 2020, there were 19 counties in total. If two or less DSOs was located in one county, these are added to the neighboring county. For instance, this was the case for large industry players such as Hafslund Nett AS and Agder Energi AS. As a result, these two were moved to Buskerud and Rogaland, respectively.

Potential mergers and its gains are analyzed under both CRS and VRS model as in the previous sections. When VRS is assumed in the DEA model, some mergers may be infeasible in terms of their size against the original technology (Bogetoft & Otto, 2011). A total of 21 such mergers were identified in this estimation. When two DSOs are merged, they will often become very large compared to the existing DSOs and consequently be above the optimal scale size for this mixture. However, harmony gains are computable even in these 21 mergers, as by construction the average firm that forms the basis for evaluating harmony gains is still within the technology (Saastamoinen, Bjørndal, & Bjørndal, 2017). Thus, harmony gains are reported also for these potential mergers. In total, there are 431 possible pairwise mergers, providing a satisfactory analyzing sample.

7.4.1 Total Economic Effects

The input and output data for a merged firm is the direct summation of the costs and the output of the merging firms. Summary statistics of the merged costs and output are presented in the table below. On average, the merged DSOs are rather big compared to the original firms since the mean costs and output are about twice as high. Here, the original input data is not adjusted for the operating environment.

N = 431, Descriptive statistics merged DSOs

Statistics	AdjTEX_VRS	Number of customers	Length of HV network	Number of substations
Mean	362 618	67 396	990	2 558
Median	125 691	18 235	636	1 145
Min	21 932	3 290	59	172
Max	3 018 798	794 232	6 512	21 292
Std	560 828	139 667	1 076	3 788

Statistics	AdjTEX_CRS	Number of customers	Length of HV network	Number of substations
Mean	361 460	67 396	990	2 558
Median	125 671	18 235	636	1 145
Min	21 892	3 290	59	172
Max	2 889 511	794 232	6 512	21 292
Std	548 498	139 667	1 076	3 788

N = 99, Descriptive statistics original data

Statistics	TOTEX	Number of customers	Length of HV network	Number of substations
Mean	179 700	30 511	589	1 298
Median	55 397	7 525	240	416
Min	10 558	1 063	13	62
Max	2 679 064	701 125	4 759	17 837
Std	363 008	80 777	895	2 469

Table 18: Descriptive Statistics of the merged DSO under CRS and VRS. Source: Own contribution

In the merger scenarios, the mean of the input, total costs, is approximately doubled. This is due to the fact that the input and output data is the direct summation of the data on the merging firms. More interestingly is that average *Number of Customers* of the merged firms are increasingly higher, indicating that the merged firms will have more subscribers. This is not the case for the other outputs, *Length of HV network* and *Number of Substations* where the new average is less than doubled despite the double in costs. The median value of the *Length of HV network* and *Number of substations* is nearly tripled, indicating that the smaller firms will increase their output severely following a merger.

7.4.2 Overall Potential Gain

The overall potential gains from mergers is the efficiency of the input-output combinations of the two units. To find the overall potential, E^H, of the direct combination of the firms involved in the merger (H), the efficiency of E is:

$$\left(\sum_{\kappa \in H} x^{\kappa}, \sum_{\kappa \in H} y^{\kappa}\right)$$

Thus, the potential savings, or merger gains, for the combined units are 1 – E.

(Bogetoft & Otto, 2011)

Average efficiency from the 410 merged units under a VRS technology are 0,6725, indicating potential merger gains of 0,3275. Even larger gains are possible assuming constant return-to-scale, where the average of 431 possible mergers equals 0,4106. As shown in table 14, maximum efficiency under VRS technology are 1,4552, suggesting that the two DSOs combined would be roughly 145% efficient. In total, 35 mergers experience efficiency scores above 1. The interpretation is then that it will be more costly for the DSOs to operate jointly than individually.

Statistics	E-VRS	E-CRS
Mean	0,6725	0,5894
Median	0,6432	0,5652
Min	0,2972	0,2526
Max	1,4552	1
Std.dev	0,2060	0,1758

Table 19: Descriptive Statistics of Overall Efficiency under VRS model and CRS model. Source: Own Contribution

In total, 88 potential mergers have gains above 50% assuming variable return-to-scale (VRS). All of the top four most promising involves Lofotkraft AS. This was expected as Lofotkraft AS clearly had the lowest efficiency of 0,2625 in the second stage analysis. Fellow DSOs from the county Nordland that has potential savings from merging with Lofotkraft AS are Bindal Kraftlag SA, Andøy Energi AS, Trollfjord Nett AS, Meløy Energi AS and ISE AS. Despite being fully efficient individually, according to this analysis Bindal Kraftlag AS has around 70% in potential savings from merging with Lofotkraft AS. In total, Nordland county is represented in seven out of the top 5% most promising merger combinations among DSOs. As shown in table 19, this is due to the low efficiency scores of the county in general. Moreover, Odda Energi AS is the second least efficient firm individually are included in five of the most promising 25 merger combinations. It is clear that the individually non-efficient firms are favored in terms of merging with neighboring DSOs.

Under CRS technology, again, Lofotkraft AS is continuously represented as a merging unit. More so than assuming VRS, being involved in nine of the 25 combinations with the most gains. The three least efficient DSOs are Lofotkraft AS, SFE Nett AS and Odda Energi AS on an individual basis. Thus, the 18 most promising combinations in terms of economic gains involves either one of them. Of the 431 combinations that were analyzed, two mergers has zero gains in combining units. As the DSOs were fully efficient before, Krødsherad Everk KF - Norgesnett AS, and Krødsherad Everk KF - Trøgstad Elverk AS, has no savings potential of merging according to combined efficiency scores.

However, even though the most promising combinations are affected by individual inefficiency, it is still unclear what the basis of the efficiencies are. To decompose the efficiency results of the combined units an analysis of learning effects, harmony effects and size effects are presented.

7.4.3. Learning Effects

The learning effects estimate economic effects that the DSOs will obtain by learning the best practice (Kristensen, Bogetoft, & Pedersen, 2010). The score is a measure of the underlying units technical efficiency. Thus, 1 – LE = learning potential, or, technical inefficiency. The comparison is the overall potential (E) to the pure merger potential (E*):

$$LE^H = {E^H}/{E^{*H}}$$

(Bogetoft & Wang, 2005)

As mentioned in the previous section, the average potential savings out of the 410 mergers under the VRS assumption are 0,3275. In fact, 0,3430 is accounted for by learning potentials. The large number is due to technical inefficiency among the DSOs. Hence, this partially explains why some combinations achieve overall potential gains beyond 1 in the VRS model. Moreover, as is discussed even further below, the learning potential is clearly the strongest effect on the mergers. This is also the case for the CRS model where roughly the entire 41,06% of average potential savings can be asserted to the learning effect of 40,24%.

Statistics	E-VRS	L-VRS	E-CRS	L-CRS
Mean	0,6725	0,6570	0,5894	0,5976
Median	0,6432	0,6402	0,5652	0,5753
Min	0,2972	0,2781	0,2526	0,2544
Max	1,4552	1	1	1
Std.dev	0,2060	0,1814	0,1758	0,1772

Table 20: Descriptive statistics of overall merger potential and learning effects under VRS and CRS technology. Source: Own contribution

If the overall merger potential, E, under VRS are restricted to the merger combinations below one (N = 375), it paints a more accurate picture of the learning effects. Here, the mean is 0,6346, while the learning effect is 0,6282. As with the CRS model, a large degree of the benefits of merger combinations can be allocated to technical inefficiencies among DSOs.

For the top 25 merger combinations under VRS technology that were estimated in section 7.4.2, the learning effects differs. Combinations involving Lofotkraft AS and SFE Nett AS, twelve in total, have higher learning potential than the economic gain itself from a merger with another DSO. This can be explained by the fact that a merger may also have a positive effect on learning by increasing the scale of process development, and by re-evaluate and change past procedures (Bogetoft & Otto, 2011). Of the overall potential gain from the remaining 13 combinations, learning effects can be attributed in the range of 91,36% to 99,2%.

Potential savings from the top 25 mergers in the CRS model is highly asserted to the learning effect. In five explicit combinations, the potential learning effect is equal to the merger gain. Except for one potential merger between Nord-Salten Kraft AS and Lofotkraft AS where 2,67% is due to other factors, learning effects explain over 99% of the overall potential to merge.

As the results between technical efficiency and the overall merger potentials only differentiates marginally, this resembles the conclusion of Farrell & Shapiro (1990), where large learning effects are necessary for a merger to result in economic gains. It deviates, however, with the results in Harris et al. (2000) as they conclude that economic gains from merger is mainly due to size effects. Following, harmony effects and size effects will be outlined.

7.4.4. Harmony Effects

Another source of potential savings, called the scope, or harmony effect, is associated with the mix of resources used and the mix of services provided (Bogetoft, 2012). The harmony effect (HA), evaluate the average efficient firm, i.e., find the efficiency of

$$\left(\frac{1}{H}\sum_{\kappa\in H} E^{\kappa}x^{\kappa}, \frac{1}{H}\sum_{\kappa\in H} y^{\kappa}\right).$$

It can be achieved by reallocating resources and services through merging, or otherwise (Bogetoft, 2012).

Statistics	E-VRS	L-VRS	H-VRS
Mean	0,6725	0,6570	0,9577
Median	0,6432	0,6402	0,9634
Min	0,2972	0,2781	0,8476
Max	1,4552	1	1
Std.dev	0,2060	0,1814	0,0354

Table 21: Overall merger potential, learning effects and harmony effects under VRS technology. Source: Own Contribution

On average, the harmony effect constitute 0,0423 and 0,0137 of the overall merger gains following VRS and CRS technology, respectively. Under VRS there are some very large size-related diseconomies present (values above 100%), which often offset the positive harmony effect. If these combinations are excluded, the harmony effect equals 0,9547. Only 24 out of 410 potential mergers can generate savings of more than 10% by reallocating resources and task in the VRS model. As mentioned in the theory section, this is theoretically possible without a merger. The reallocation of resources and tasks may be easier within a merged firm, however, where problems such as asymmetric information and competition over profit shares may be reduced (Bogetoft & Otto, 2011). This is why the harmony effect is especially important to Norwegian DSOs, as the regulator (NVE) use it to correct the cost norm calculated for merged firms. The net present value of the harmony effects over 10 years are calculated and paid as a windfall gain to the merged firm (NVE, 2019). In practice, this means that the extra savings potential measured by the harmony effect can be kept by the DSOs for the first ten years.

Statistics	E-CRS	L-CRS	H-CRS
Mean	0,5894	0,5976	0,9863
Median	0,5652	0,5753	0,9954
Min	0,2526	0,2544	0,8815
Max	1	1	1
Std.dev	0,1758	0,1772	0,0201

Table 22: Overall merger potential, learning effects and harmony effects under CRS technology. Source: Own Contribution

The harmony gains resemble what Saastamoinen et al. (2017) and Agrell et al. (2015) found in theirs environmental adjusted DEA-models. Even though this thesis has more observations, the average standard deviations of the harmony measures is significantly lower compared to these.

7.4.5 Size Effects

When decomposing the merger gains further, it is important to consider how a potential merger will have an impact on the scale of operation. Therefore, the size or scale effect is calculated. Where there are economies of scale, a larger firm can produce more, at a lower average cost. The size effects are captured by calculating how much could have been saved operating at full scale, rather than the average scale (Bogetoft, 2012). Under the CRS model, the size effect is bound to be 1 in all the merger combinations, as the CRS assumption will grant no gain purely from resizing (Bogetoft & Otto, 2011)

$$SI^H = {E^*}^H / {HA^H}.$$

(Bogetoft, 2012)

As for the VRS model, the mean and the median are about the same at 1,06. The values above 1 means a loss from merged units operating at a larger scale. There are large deviations however, ranging from 0,7319 to 1,4704, illustrating that the outlying combinations are either too small or too large to be efficient. Of the 25 DSOs with the largest gains from merging in section 7.4.1, 14 will find it costly to operate at a larger scale. Especially SFE Nett AS and Lofotkraft AS risk potential losses of 16% and 12%, accordingly. Odda Energi AS on the other hand, has a more neutral saving potential of 1%, indicating that merger combinations with either Fitjar Kraftlag SA, Fjelberg Kraftlag SA, Fusa Kraftlag SA or Voss Energi Nett AS, would result in small savings.

Statistics	E-VRS	L-VRS	H-VRS	S-VRS
Mean	0,6725	0,6570	0,9577	1,0660
Median	0,6432	0,6402	0,9634	1,0640
Min	0,2972	0,2781	0,8476	0,7319
Max	1,4552	1	1	1,4704
Std.dev	0,2060	0,1814	0,0354	0,0790

Table 23: Overall merger potential decomposed into learning, harmony and size effects under VRS technology. Source: Own Contribution

7.4.5 Pure Merger Effects

Up until now, this study has decomposed the potential merger gains into learning, harmony and size effects. The learning effects measures what already could have been gained by making the individual firm efficient. Therefore, it is not to be included in the pure merger (E*) effects. The pure merger gains include harmony effect and size effect, due to the need of collaboration and sharing of resources (Bogetoft, 2012). The combinations of these gains are therefore expressed as:

$$E^* = HA * SI$$

(Bogetoft, 2012)

The high mean and median value under both VRS and CRS assume low potential gains from merging. The mean value of 1,0197 in the VRS model suggest that in general, mergers would be more costly than beneficial. Anyhow, as shown below, there are large variations between minimum and maximum pure merger effect. There are still 154 merging combinations that at least has some pure gain from combining units with a fellow DSO under VRS technology.

Statistics	E-VRS	E*-VRS	E-CRS	E*-CRS
Mean	0,6725	1,0197	0,5894	0,9863
Median	0,6432	1,0172	0,5652	0,9954
Min	0,2972	0,7112	0,2526	0,8815
Max	1,4552	1,4613	1	1
Std.dev	0,2060	0,0767	0,1758	0,0201

Table 24: Overall merger potential vs. pure merger potential under VRS and CRS technology. Source: Own Contribution

In the CRS model, no pure merger value exceeds 1 as the size effects are not taken into account. Therefore, all the mergers are operating at the CRS part of the frontier and the pure gains will come from the harmony effects. There are 77 combinations in total that experience no pure merger gains after the removal of the learning effect. As we have seen in the previous sections, the decomposition of the pure merger effect into the harmony and size effects are rather trivial. However, the majority of combinations have at least something to gain in terms of reallocating tasks and services, in the form of a merger or otherwise. 33 mergers has a potential savings of more than 5%.

When individual learning efficiencies are excluded from the merger potential, the top 25 prospects changes drastically. Under VRS assumption, none of the DSOs that were the most promising due to individual learning potential are represented in terms of pure merger gains. The top 25 most promising mergers in terms of pure merger effects are shown below.

7.4.6 Summary

In light of the research questions, this study investigates what impact potential mergers will have on the industry. In addition, by also applying a firm-specific view, the results of the potential merger gains will provide the 25 most promising merger combinations from the VRS and CRS model. This summary is extracted from the merger analysis results to pinpoint the most important findings from the analysis.

The total economic effects in chapter 7.4.1 shows how the DSOs will roughly double their costs. The merged firms input and output data is the direct summation of the merging parties. Despite this, the post-merger data showed how the average entails a higher number of customers, shorter length of HV network and a smaller number of substations. Nonetheless, the median value is nearly tripled in the length of HV network and number of substations, indicating the smaller firms would potentially increase their outputs severely.

The overall merger potentials, E, is the ratio of the input-output combination for the merged DSOs. By comparing these measures with the efficiency scores from the second stage analysis, the average efficiency is 1% lower under both VRS and CRS technology. The median efficiency is higher, though, demonstrating that the smaller DSOs is more efficient post-merger. By looking at the 25 most promising potential mergers in terms of merger gains, combinations involving either Lofotkraft AS or Odda Energi AS are the most common under VRS technology. An explanation could be that these two were the least efficient firms pre-merger. This trend naturally follows the results from the overall merger potential measures, including the results from the CRS model, where Lofotkraft AS, Odda Energi AS and SFE Nett AS are represented in the 18 most promising merger combinations. Another explanation is the low average efficiency in the counties these firms are operating in, namely, Nordland and Hordaland.

When the overall merger potential is decomposed, firstly into learning effects, the potentials are mainly due to technical inefficiency. In fact, under VRS technology the average learning potential is even higher than the overall merger potential, illustrating what could be gained by applying best practice. The learning effects are also the strongest driver for overall merger potential in the CRS model, accounting for 40,24% of the average 41,06% in merger gains. The similar pattern follows the 25 most promising potential merger combinations. In the VRS model, twelve mergers experience higher learning effects than overall merger potential, and the remaining can assert over 90% of the merger gain to potential technical efficiency improvements. Under CRS technology, the learning effects describe over 99% of the merger gains of the most promising potential mergers, except for one case.

By further decomposing the overall merger potential, harmony and size effects can be delved into. As the learning effects mostly contribute to the overall merger potential, harmony and size effects are rather trivial for the merged DSOs. Under VRS technology the economies of scope equal 95,77% leaving 4,23% of harmony effects to gain from a merger. The harmony effect is lower in the CRS model where 1,37% is the only potential gain on average. The average size effect indicates a loss from the mergers operating at a larger scale. Of the 25 most promising potential combinations in terms of overall merger potential, the size and harmony effects were low in both models. There were on average 6,2% to gain in terms of the harmony effect, but this is partially offset by 5,1% additional cost arising from operating at a scale deemed too large in terms of efficiency.

When the technical efficiency, or learning potential, is extracted from the overall merger potential, it is possible to determine the pure merger effects. Given that the learning effects accounted for most of the potential merger effects, the pure merger gains are negative on average in the VRS model. Under CRS technology is it not much to gain when learning effects are removed, only 1,37% on average. However, the estimates suggest that some of the merged DSOs do in fact have large gains in terms of economy of scope and scale. These are not the same mergers which had the highest overall merger potential prior to the decomposition. The 25 most promising potential mergers with respect to pure merger gains are presented in the tables below, under VRS and CRS technology, respectively. These combinations are further elaborated upon in the discussion chapter.

Firm 1	Firm 2	E*	Merger gain	E	LE	HA	SI
NESSET KRAFT AS	SANDØY ENERGI AS	**0,71**	**28,9%**	0,49	0,70	0,97	0,73
AURLAND ENERGIVERK AS	ÅRDAL ENERGI KF	**0,77**	**22,8%**	0,41	0,53	0,89	0,87
SANDØY ENERGI AS	STRANDA ENERGI AS	**0,80**	**19,8%**	0,48	0,60	0,95	0,84
LÆRDAL ENERGI AS	AURLAND ENERGIVERK AS	**0,81**	**19,2%**	0,36	0,45	1,00	0,81
FJELBERG KRAFTLAG SA	FITJAR KRAFTLAG SA	**0,81**	**19,1%**	0,36	0,45	1,00	0,81
SANDØY ENERGI AS	SYKKYLVEN ENERGI AS	**0,82**	**18,2%**	0,69	0,84	0,91	0,90
ROLLAG ELEKTRISITETSVERK SA	UVDAL KRAFTFORSYNING SA	**0,82**	**17,6%**	0,66	0,80	0,99	0,83
SANDØY ENERGI AS	SUNNDAL ENERGI KF	**0,83**	**16,5%**	0,53	0,64	0,87	0,96
RAUMA ENERGI AS	SANDØY ENERGI AS	**0,85**	**15,1%**	0,53	0,62	0,85	1,00
LÆRDAL ENERGI AS	ÅRDAL ENERGI KF	**0,85**	**14,9%**	0,39	0,46	0,94	0,91
FUSA KRAFTLAG SA	FJELBERG KRAFTLAG SA	**0,86**	**14,4%**	0,42	0,49	0,90	0,95
NORE ENERGI AS	UVDAL KRAFTFORSYNING SA	**0,88**	**12,1%**	0,60	0,69	0,99	0,88
FJELBERG KRAFTLAG SA	AUSTEVOLL KRAFTLAG SA	**0,89**	**11,1%**	0,45	0,50	0,94	0,94
NORE ENERGI AS	ROLLAG ELEKTRISITETSVERK SA	**0,89**	**10,9%**	0,71	0,80	1,00	0,89
ODDA ENERGI AS	FJELBERG KRAFTLAG SA	**0,89**	**10,7%**	0,33	0,37	0,96	0,93
HURUM NETT AS	RAKKESTAD ENERGI AS	**0,89**	**10,6%**	0,70	0,78	0,90	1,00
STRYN ENERGI AS	ÅRDAL ENERGI KF	**0,90**	**10,2%**	0,53	0,59	0,90	1,00
SANDØY ENERGI AS	SVORKA ENERGI AS	**0,90**	**10,1%**	0,59	0,66	0,87	1,04
FLESBERG ELEKTRISITETSVERK AS	ROLLAG ELEKTRISITETSVERK SA	**0,90**	**9,8%**	0,68	0,75	0,91	0,99
HEMSEDAL ENERGI KF	UVDAL KRAFTFORSYNING SA	**0,91**	**8,6%**	0,58	0,64	0,94	0,98
HARDANGER ENERGI AS	FJELBERG KRAFTLAG SA	**0,91**	**8,5%**	0,51	0,56	0,90	1,02
KRØDSHERAD EVERK KF	ROLLAG ELEKTRISITETSVERK SA	**0,92**	**8,2%**	0,91	0,99	1,00	0,92
KRØDSHERAD EVERK KF	UVDAL KRAFTFORSYNING SA	**0,92**	**8,1%**	0,75	0,82	1,00	0,92
HURUM NETT AS	UVDAL KRAFTFORSYNING SA	**0,92**	**8,1%**	0,64	0,70	0,95	0,96
HURUM NETT AS	NORE ENERGI AS	**0,92**	**7,8%**	0,65	0,70	0,93	1,00

Table 25: 25 most promising potential merger combination in the VRS model. Source: Own contribution

Firm 1	Firm 2	E*	Merger gain	E	LE	HA	SI
AURLAND ENERGIVERK AS	ÅRDAL ENERGI KF	**0,88**	**11,8%**	0,38	0,43	0,88	1
NORD-SALTEN KRAFT AS	NORDKRAFT NETT AS	**0,90**	**10,5%**	0,52	0,58	0,90	1
HURUM NETT AS	RAKKESTAD ENERGI AS	**0,90**	**10,2%**	0,66	0,74	0,90	1
NORD-SALTEN KRAFT AS	ISE NETT AS	**0,90**	**9,5%**	0,53	0,59	0,90	1
DRANGEDAL EVERK KF	NOTODDEN ENERGI NETT AS	**0,91**	**8,8%**	0,41	0,45	0,91	1
STRYN ENERGI AS	ÅRDAL ENERGI KF	**0,92**	**8,2%**	0,51	0,55	0,92	1
NORD-SALTEN KRAFT AS	LOFOTKRAFT AS	**0,92**	**8,0%**	0,31	0,33	0,92	1
ØVRE EIKER NETT AS	RAKKESTAD ENERGI AS	**0,92**	**7,8%**	0,78	0,84	0,92	1
HURUM NETT AS	TRØGSTAD ELVERK AS	**0,92**	**7,8%**	0,71	0,77	0,92	1
HEMSEDAL ENERGI KF	HØLAND OG SETSKOG ELVERK SA	**0,93**	**7,4%**	0,64	0,69	0,93	1
RAUMA ENERGI AS	SYKKYLVEN ENERGI AS	**0,93**	**7,4%**	0,55	0,59	0,93	1
NTE NETT AS	TRØNDERENERGI NETT AS	**0,93**	**7,3%**	0,62	0,67	0,93	1
SVORKA ENERGI AS	SYKKYLVEN ENERGI AS	**0,93**	**6,9%**	0,58	0,62	0,93	1
FLESBERG ELEKTRISITETSVERK AS	HEMSEDAL ENERGI KF	**0,93**	**6,5%**	0,58	0,62	0,93	1
NORD-SALTEN KRAFT AS	NORDLANDSNETT AS	**0,94**	**6,4%**	0,45	0,48	0,94	1
HÅLOGALAND KRAFT NETT AS	YMBER AS	**0,94**	**6,3%**	0,64	0,68	0,94	1
ISE NETT AS	BINDAL KRAFTLAG SA	**0,94**	**6,2%**	0,54	0,58	0,94	1
HØLAND OG SETSKOG ELVERK SA	NORE ENERGI AS	**0,94**	**6,0%**	0,67	0,72	0,94	1
FUSA KRAFTLAG SA	AUSTEVOLL KRAFTLAG SA	**0,94**	**5,9%**	0,43	0,46	0,94	1
KVAM KRAFTVERK AS	FUSA KRAFTLAG SA	**0,94**	**5,8%**	0,48	0,51	0,94	1
DRANGEDAL EVERK KF	MIDT-TELEMARK ENERGI AS	**0,94**	**5,8%**	0,61	0,65	0,94	1
HEMSEDAL ENERGI KF	HURUM NETT AS	**0,94**	**5,7%**	0,59	0,63	0,94	1
ØVRE EIKER NETT AS	TRØGSTAD ELVERK AS	**0,94**	**5,7%**	0,84	0,89	0,94	1
KRAGERØ ENERGI AS	VEST-TELEMARK KRAFTLAG AS	**0,94**	**5,6%**	0,55	0,58	0,94	1
ORKDAL ENERGINETT AS	SODVIN SA	**0,95**	**5,5%**	0,76	0,80	0,95	1

Table 26: 25 most promising potential merger combinations in the CRS model. Source: Own contribution

8. Discussion

This chapter will utilize the results and tendencies from chapter 7 to discuss the research questions. It will contain implications and benefits of the methods and theories chosen to best answer the research questions. The findings will be compared with the previous literature within this topic as discussed under the literature review.

The three research questions this thesis aims to answer are:

1. *How are the firm sizes of the DSOs in the Norwegian electricity industry affecting their performances?*
2. *What are the potential efficiency gains from mergers in the Norwegian electricity industry?*
3. *What are the most promising potential combinations of mergers? And what do they imply?*

Up until now, this thesis has applied a data envelopment analysis to analyze the quantitative dataset of over 100 electricity distributors in Norway. The chapter is organized in a manner that allows a discussion on each research question separately, and at the same time draw lines between them.

8.1. Research Question 1

How are the firm sizes of the DSOs in the Norwegian electricity industry affecting their performances?

This research question aims to analyze in what manner the companies of the Norwegian electricity industry are performing at a sub-optimal level due to the size of the companies. Reiten et al. (2014) states how there were too many and too small companies in the mentioned industry. Today, the industry structure consists of 15 large, 41 medium and 44 small DSOs. By utilizing features of the DEA, this thesis will discuss how firms may be of non-optimal size for performing at the optimal level or exploiting potential economies of scale.

During the first stage DEA, the scale efficiencies were analyzed. The scale efficiencies measure to what degree the firm's inefficiencies are due to the size of the firm (Bogetoft & Otto, 2011). The first stage scale efficiency results showed tendencies towards how firms might be above the optimal size, and especially the larger and medium-sized firms. The smaller firms showed a tendency to be below their optimal size. This agrees with the findings of Kumbhakar et al. (2015) and Mydland, Haugom & Lien (2018a), that the biggest potential for economies of scale were from the smaller firms. When applying the bootstrap method to correct for biasing, the results in terms of scale efficiency does not experience any changes and continue to further back the results from the previous research.

Going forward, the environmental variables might have changed the scenario. Half of the small DSOs that were below optimal scale in the first stage analysis, are now either at or above optimal size. This observation makes sense, with respect to how the environmental variables could benefit the small firms, as the small DSOs generally operate in sparsely populated areas with sub-optimal building and manufacturing conditions (NVE, 2019b).

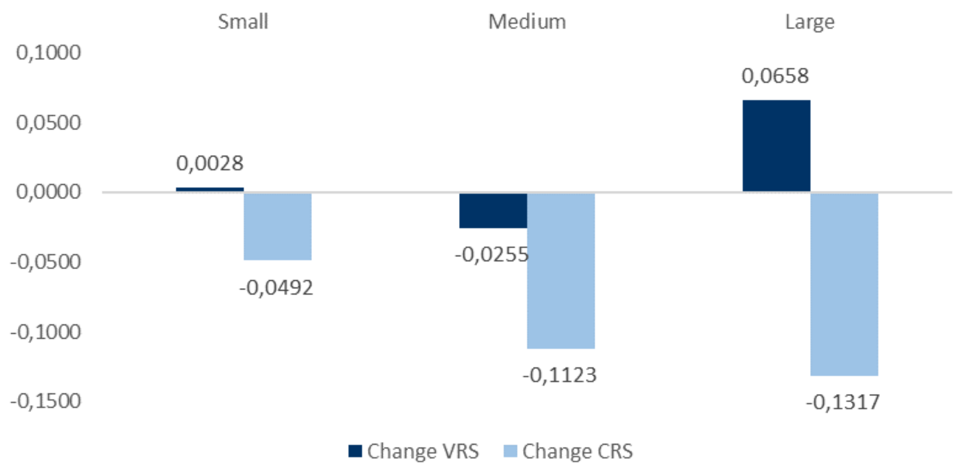

Figure 21 :VRS and CRS changes in efficiency scores after 2nd stage adjusted by size. Source: Own Contribution

From figure 15, this does not seem to be the general case. On average, the environmental variables in the VRS model improve the efficiency of the larger companies, more than the small companies. In the CRS model, however, the results are worse the larger the size of the firm is. When further exploring the data, the results vary. The general effects may be the same, but small companies in Østfold, Trøndelag, Buskerud and Sogn & Fjordane receive better efficiency evaluations after the employment of the environmental variables. Larger companies under the CRS model will experience worse results, as the CRS assumption is pessimistic regarding size (Bogetoft & Otto, 2011). Under the VRS model, however, some of the companies at the eastern part of Norway receive better efficiency scores. This emphasizes how the results of this study will be sensitive to the choice of return to scale assumption, as well as it further amplifies how the DSOs prefer the VRS assumption to the CRS assumption.

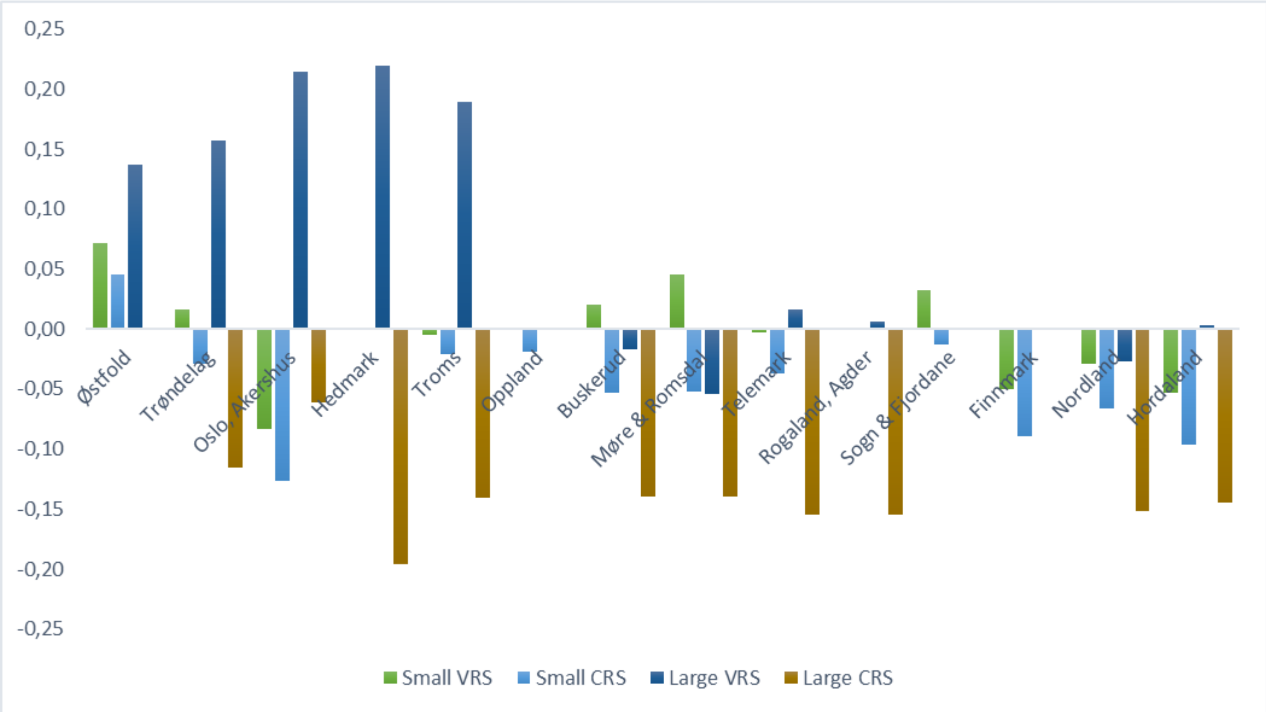

Figure 22: Firm's change in efficiency, sorted by size and belonging county. Source: Own contribution

To quantify how the environment affects the operations of a company fairly is not an easy task. Near-shore companies like Lofotkraft AS, Haugaland Kraft Nett AS and NEAS AS are all examples of how their adjusted costs were over 20% higher than their original costs. To our knowledge, these findings have not been reported in earlier research. The choice of these environmental variables will thus have consequences for the analysis, where the wrong companies might receive superior efficiency scores for wrong reasons. This thesis has chosen the same environmental variables as NVE, due to generalization potential and making own would simplify results. This choice is also backed by recent research in the area (Agrell, Bogetoft, & Grammeltvedt, 2015)(Mydland et al. 2018).

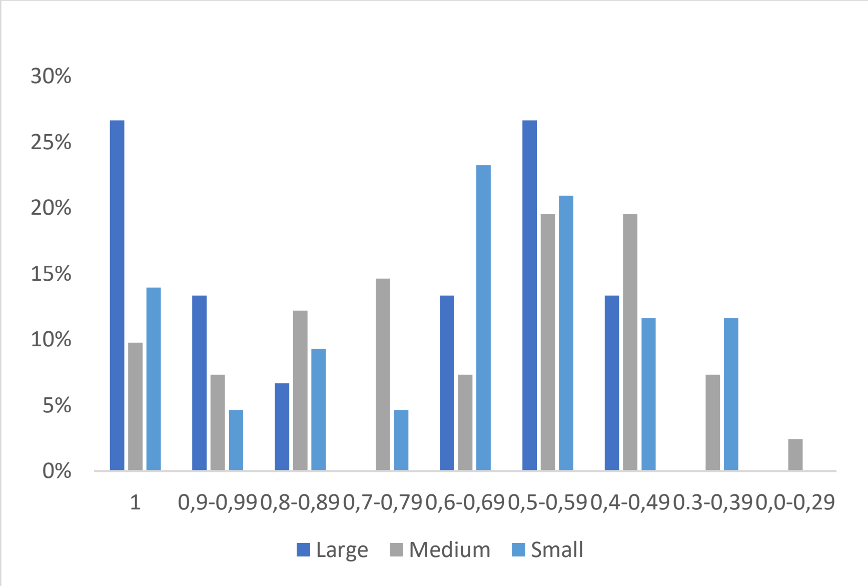

Figure 23: Percentage of firm size in efficiency interval. VRS Model. Source: Own contribution.

In the VRS model from the second stage analysis, four of the 14 fully efficient firms were large DSOs. As mentioned, there are only 15 large DSOs in total, suggesting that about 27% of these are fully efficient. The share of medium and small firms on the efficiency frontier and right below, is smaller. As seen in figure 14, the large DSOs are well represented in the highest intervals under VRS technology. This might indicate better efficiency for the larger DSOs. However, they are also represented in the lower. The small number of observations of the larger firms will lead to higher percentage shares, thus, the impact firm size has on efficiency cannot be concluded. There are also varying differences between the medium sized firms and small firms, but from *0,7-0,99*, the medium sized firms are outperforming the small.

Continuing, under the CRS technology only one of the large DSOs are deemed as fully efficient. The second stage results do not deviate with the first stage analysis, where the fully efficient large operators amount to the same. This strengthens the fact that firm-size efficiency is dependent on what models are chosen. Considering the overall efficiency scores from both parts of the analysis, it is not possible to conclude that large DSOs perform better than smaller firms. It highly depends on the model.

To answer the research question, scale efficiencies and the efficiency of the firms relative to firm size has been researched to understand how the size will affect the performances. There are reasons to believe that there is firm-specific potential for economies of scale in the industry and that some firms are too small. This was shown in the first stage scale efficiency scores where the small firms were mainly situated below optimal scale. This agrees with the findings of Kumbhakar et al. (2015) and Mydland et al. (2018a), that the outmost potential for economies of scale were from the smaller firms. Further, Reiten et al. (2014) shows concerns for how the smaller companies can acquire the needed competence, as well as lack of capital to perform the various upgrades that are required in the future. The results from the efficiency scores indicate that some the larger DSOs outcompete the small under VRS technology. The CRS model showed opposite results, further proving that the performance is dependent on the chosen model. However, the large variations from the efficiency scores and size efficiencies express how there the performance might not be explained by size differences, at least at an industry level.

8.2. Research Question 2

Research Question 2: What are the potential efficiency gains from mergers in the Norwegian electricity industry?

In the electricity distribution sector, the market structure is not generally shaped by the normal entry and exit but rather through merger activity between DSOs (Agrell, Bogetoft, & Grammeltvedt, 2015). NVE´s main intention with the regulation is to encourage efficient distributors of electricity to the consumers. Merging inefficient firms is an alternative to achieve this. Thus, potential gains from horizontal integration in the Norwegian electricity industry has been analyzed in this thesis.

By investigating the hypothetical consolidation of the Norwegian DSOs at the pre-existing county level, there are gains from horizontal integration in the majority of cases. In the VRS-model, the overall efficiency (E) showed that 375 out of the initial 431 merger combinations had some room for improvement by merging. As mentioned in the results, there was no score to obtain from 21 mergers as the result was too large compared to the existing DSOs under the VRS assumption. This was mainly mergers involving Hafslund Nett AS which is by far the largest operator. In the CRS model, there were potential savings from merging in 429 out of 431 combinations.

Model	Mean	Median	Min	Max	Std. Dev.
VRS	0,74	0,71	0,36	1	0,17
VRS-bs	0,67	0,66	0,34	0,95	0,14
VRS-S2	0,67	0,62	0,26	1	0,21
VRS-H	0,66	0,64	0,30	1,46	0,21
CRS	0,70	0,69	0,36	1	0,16
CRS-bc	0,66	0,65	0,35	0,96	0,15
CRS-S2	0,60	0,55	0,24	1	0,20
CRS-H	0,59	0,57	0,25	1	0,18

Table 27: Comparison of statistics from first stage, bias-corrected, second stage and post-merger analysis under VRS and CRS technology. Source: Own contribution

The overall efficiency was lower in the CRS model with 0,5894, than the VRS with 0,6725. Conversely, the potential merger gains were greater. The DSOs are the most efficient in the standard DEA-model, but the estimation should be more precise after accounting for the operating environment. The mean values are lower post-merger than before, indicating that the merged firms are less efficient. However, the median value is higher post-merger than in the second stage analysis. Saastamoinen et al. (2017) use the median value for comparison throughout their paper, as the mean is to some degree distorted upwards due to some large size-related losses. Thus, the median might be a better indicator. Moreover, as the adjusted costs and outputs in the merger analysis stems from the second stage analysis, these figures should be the main comparison. Under both technology assumptions, the overall efficiency is 0,02 higher if we use the median value as indicator.

To gain further knowledge on the effects of potential mergers, the efficiency scores from the merger analysis are decomposed into learning effects, size effects and harmony effects. The results from the decomposing measured how learning effects is the main driver for the efficiency gains in the Norwegian electricity industry. Other studies can show for similar results (Farrell & Shapiro, 1990); (Agrell, Bogetoft, & Grammeltvedt, 2015). These learning effects are possible to achieve by mergers, however, in this manner it is the ability to sharing and applying best practice. In other words it can be obtained by other operations rather than mergers

(Bogetoft & Otto, 2011). However, if technical inefficiencies are a result of mismanagement, a merger could lead to replaced management and thus improved performance (Asquith, 1983). A new organization after a merger could also lead to new facilities and competencies that the models utilized in this study are not able to capture.

The harmony effect, or scope effect, could be accomplished by reallocating resources and services. As with the learning effect, the harmony effect can be gained by other actions than mergers. In addition to reducing inefficiencies in the individual electricity utilities, potential harmony effects could arise from a simple cooperation between different DSOs (Zschille, 2012). NVE seek inefficient DSOs to merge, therefore they incentivizes mergers by paying a compensation of the ten-year NPV effects to the merged firm (NVE, 2019b). The average harmony effect under the VRS assumption did not describe much of the overall potential merger effect among the DSOs, only 0,0403. When non-efficient combinations are excluded, it is larger equaling 0,9562, or 0,044 in potential scope effect from reallocating resources and services.

The size, or scale effects, are captured by calculating how much could have been saved by operating at full scale rather than average scale (Bogetoft & Otto, 2011). As a contradiction to the learning and harmony effects which can be obtained by actions other than a merger, the size effects can only be obtained by a full-scale merger (Bogetoft, 2012). The results from the merger analysis suggests that scale effects have a negative average impact on potential merger effects. In other words, it will be more costly to merge in most cases. It corresponds with Saastamoinen et al.'s (2017) findings that the high learning effect is often offset by the additional cost arising from being too large. Moreover, scale effects are found to be the highest for the mergers consisting of DSOs characterized as "small" in the energy network. This finding aligns with Kumbhakar et al.'s (2015) that the high learning effect indicate that there is big potential for scale economies for the smaller firms.

The empirical evidence in the literature on the existence of returns to scale among distribution system across Northern Europe suggests that optimal size for electricity distribution operators is usually reached at higher output levels (Kuosmanen, Saastamoinen, & Sipiläinen, 2013). The lack of gains from larger scale, and in many cases even losses from the merged units operating at larger scales, has been a consisted finding throughout the analysis. Since scale effects are found to be low or negative in many cases, the necessity of mergers is questionable.

Despite the application of a bootstrap procedure for the calculation of bias-corrected efficiency scores, the low merger gains and correspondingly low harmony and scale effects might be explained by the low number of sufficiently large DSOs in the data sample (Zschille, 2012). Best practices of large firms are thus likely to underestimate the true best practices in the entire industry. Regarding the small-scale nature of the industry structure of Norwegian electricity distribution, the given data sample further might not cover the full range of possible firm sizes when estimating the DEA technology set. This was seen as merger combinations involving Hafslund Nett AS were deemed to large assuming variable return-to-scale (VRS). In fact, Hafslund´s average total costs of the period 2014-2018 is around 800x times larger than the smallest DSO in the data sample, Modalen Kraftlag AS.

At last, the merger analysis proved that there are potential savings in most cases from merging. When these savings were decomposed, it became evident that learning effects, or technical efficiency, is the main driver for these savings. This effect is strong in many cases, and when excluded, the merger gains are significantly lower in both of the VRS and CRS model. As learning effects can be achieved in other circumstances than merger, it alone does not suggest mergers to increase the overall efficiency in the industry. Nevertheless, the efficiency results from the merged units do not give a clear answer to if the overall efficiency among Norwegian distribution system operators increase by merging. The average efficiency was 1% lower than pre-merger, while the median was 2% higher. However, the merger analysis showed that some of the DSOs would clearly benefit from merging with a neighboring DSO. If these are consolidated it would benefit the merged unit and the industry efficiency in general. Our results suggest that merging activity by itself would not increase overall efficiency, but the potential gain in adjusting to optimal scale are highly beneficial. The results implies that there are high technical inefficiencies among Norwegian DSOs, and that merging is a way of enhancing competence in some DSOs. Moreover, as the harmony effect is paid as a 10-year windfall in the case of mergers, it would be highly recommended if there are potential of economies of scope from merging.

8.3 Research question 3

What are the most promising potential combinations of mergers and what do the results imply?

During the discussion of research question two, this thesis examined potential mergers in the Norwegian electricity industry. Overall potential efficiency gains were found in the majority of combinations, but of varying degree. Moving forward, the last research question will further examine the opportunities for mergers, but now exploring the most promising potential combinations. To answer the research question, the criteria for sorting the most promising mergers are discussed. The mergers from the merger analysis are sorted thereafter. The results are then discussed along with further implications.

In Norway, 100 firms have distribution of electricity as their core operations by the year-end of 2019. The DSOs serve different geographical regions, and in the past, mergers with respect to their service area has been the most likely form (NVE, 2019). Nevertheless, this thesis desires to still research the mergers that contain geographically close DSOs, but not be limited to the sharing of borders. This is because they share much of the same environmental challenges, but relaxing the assumption of shared geographical borders, to investigate a greater number of combinations. Thus, for the purpose of considering the most promising merger combinations, the mergers in this analysis was pairwise and restricted to former county. Former, as there was a consolidation of the 19 counties in January 2020. This leads to a total of 431 possible mergers involving two DSOs.

The merger gains from the possible 431 combinations were tested using both CRS and VRS models. Of the 431 mergers, the top 25 most promising is presented. There are different views on what defines a merger as "promising". Saastamoinen, Bjørndal & Bjørndal (2017) consider learning effect to be no true merger gain, thus they do not include this in their research on potential merger combinations. To define promising merger in terms of overall merger potential, have however been done through various previous literature (Bagdadiouglu, Price, & Weyman-Jones, 2006; Bogetoft & Gammeltvedt, 2006). The overall merger potential includes the learning effect, but this thesis follows the views of Saastamoinen, Bjørndal & Bjørndal (2017), due to how learning effect can be obtained through applying best practice. Therefore, the pure merger gains, consisting only of harmony and size effects, will be a better fit for sorting the most promising mergers.

When exploring these possibilities, overall merger potential, E, of the combined units were firstly calculated. The average values were about 32,75% and 41,06% in potential savings under VRS and CRS technology, respectively. Then, the overall merger potential was decomposed, firstly, into learning effects, or, technical efficiency. As the overall efficiency among the DSO was low, it was expected that the learning effects would be a decisive effect. In fact, technical inefficiency accounted for the entire merger gains expect for 4% under both technology assumptions. In certain prospects under E, the score is so reliant on the learning potentials that it neglects negative effects, especially from size effects (Saastamoinen, Bjørndal, & Bjørndal, 2017). This further backs the reasoning for decomposing the overall efficiency before proposing the top 25 combinations. Furthermore, as mentioned in the previous discussion, lack of managerial competence might be removed if the acquirer already has quality competence in management positions. Otherwise, if the two merging DSOs are both prone to managerial inefficiencies, the combined unit would still possess such characteristics.

When learning effects are removed, it is possible to estimate the pure merger gains, E*. In the VRS model, E* comprises of harmony and size effects, while under CRS, the pure merger effects are entirely harmony effects as constant return to scale are the convexity assumption. If there are potential harmony effect improvements, they are possible to achieve by reallocating resources, either within the firm or through an inter-unit market for inputs and outputs. If the size effect is low, however, a genuine merger may be called for to enable the optimal specialization (Bogetoft, 2012). The 25 most promising combinations presented below all have potential savings in either scope or scale effect from merging.

Firm 1	Firm 2	E*	Merger gain	E	LE	HA	SI
NESSET KRAFT AS	SANDØY ENERGI AS	**0,71**	**28,9%**	0,49	0,70	0,97	0,73
AURLAND ENERGIVERK AS	ÅRDAL ENERGI KF	**0,77**	**22,8%**	0,41	0,53	0,89	0,87
SANDØY ENERGI AS	STRANDA ENERGI AS	**0,80**	**19,8%**	0,48	0,60	0,95	0,84
LÆRDAL ENERGI AS	AURLAND ENERGIVERK AS	**0,81**	**19,2%**	0,36	0,45	1,00	0,81
FJELBERG KRAFTLAG SA	FITJAR KRAFTLAG SA	**0,81**	**19,1%**	0,36	0,45	1,00	0,81
SANDØY ENERGI AS	SYKKYLVEN ENERGI AS	**0,82**	**18,2%**	0,69	0,84	0,91	0,90
ROLLAG ELEKTRISITETSVERK SA	UVDAL KRAFTFORSYNING SA	**0,82**	**17,6%**	0,66	0,80	0,99	0,83
SANDØY ENERGI AS	SUNNDAL ENERGI KF	**0,83**	**16,5%**	0,53	0,64	0,87	0,96
RAUMA ENERGI AS	SANDØY ENERGI AS	**0,85**	**15,1%**	0,53	0,62	0,85	1,00
LÆRDAL ENERGI AS	ÅRDAL ENERGI KF	**0,85**	**14,9%**	0,39	0,46	0,94	0,91
FUSA KRAFTLAG SA	FJELBERG KRAFTLAG SA	**0,86**	**14,4%**	0,42	0,49	0,90	0,95
NORE ENERGI AS	UVDAL KRAFTFORSYNING SA	**0,88**	**12,1%**	0,60	0,69	0,99	0,88
FJELBERG KRAFTLAG SA	AUSTEVOLL KRAFTLAG SA	**0,89**	**11,1%**	0,45	0,50	0,94	0,94
NORE ENERGI AS	ROLLAG ELEKTRISITETSVERK SA	**0,89**	**10,9%**	0,71	0,80	1,00	0,89
ODDA ENERGI AS	FJELBERG KRAFTLAG SA	**0,89**	**10,7%**	0,33	0,37	0,96	0,93
HURUM NETT AS	RAKKESTAD ENERGI AS	**0,89**	**10,6%**	0,70	0,78	0,90	1,00
STRYN ENERGI AS	ÅRDAL ENERGI KF	**0,90**	**10,2%**	0,53	0,59	0,90	1,00
SANDØY ENERGI AS	SVORKA ENERGI AS	**0,90**	**10,1%**	0,59	0,66	0,87	1,04
FLESBERG ELEKTRISITETSVERK AS	ROLLAG ELEKTRISITETSVERK SA	**0,90**	**9,8%**	0,68	0,75	0,91	0,99
HEMSEDAL ENERGI KF	UVDAL KRAFTFORSYNING SA	**0,91**	**8,6%**	0,58	0,64	0,94	0,98
HARDANGER ENERGI AS	FJELBERG KRAFTLAG SA	**0,91**	**8,5%**	0,51	0,56	0,90	1,02
KRØDSHERAD EVERK KF	ROLLAG ELEKTRISITETSVERK SA	**0,92**	**8,2%**	0,91	0,99	1,00	0,92
KRØDSHERAD EVERK KF	UVDAL KRAFTFORSYNING SA	**0,92**	**8,1%**	0,75	0,82	1,00	0,92
HURUM NETT AS	UVDAL KRAFTFORSYNING SA	**0,92**	**8,1%**	0,64	0,70	0,95	0,96
HURUM NETT AS	NORE ENERGI AS	**0,92**	**7,8%**	0,65	0,70	0,93	1,00

Table 28: Top 25 most promising merger combinations under VRS technology. Source: Own contribution

The 25 merger combinations with the most potential pure merger gains in the VRS model are shown in table 28. The outmost promising combination is between Nesset Kraft AS and Sandøy Energi AS with a merger gain of nearly 30%. This is mainly due to the large size effect, indicating that both of them would benefit from operating at larger scale. Sandøy Energi AS is represented in six mergers in total. Except for the merger with Svorka Energi AS, all mergers have gains in terms of harmony and scale. Second most promising are Aurland Energiverk AS and Årdal Energi KF with roughly 23% potential savings from a merger. Along with large size effects, the combination has the largest potential in terms of reallocating the mixture of inputs and outputs to gain efficiency. A common factor for the abovementioned DSOs is that they are labelled as small and could utilize from large scale distribution. Furthermore, none of the firms are situated in densely populated territories, indicating that there are more to gain from merging in areas in more troubled terrain.

Firm 1	Firm 2	E*	Merger gain	E	LE	HA	SI
AURLAND ENERGIVERK AS	ÅRDAL ENERGI KF	**0,88**	**11,8%**	0,38	0,43	0,88	1
NORD-SALTEN KRAFT AS	NORDKRAFT NETT AS	**0,90**	**10,5%**	0,52	0,58	0,90	1
HURUM NETT AS	RAKKESTAD ENERGI AS	**0,90**	**10,2%**	0,66	0,74	0,90	1
NORD-SALTEN KRAFT AS	ISE NETT AS	**0,90**	**9,5%**	0,53	0,59	0,90	1
DRANGEDAL EVERK KF	NOTODDEN ENERGI NETT AS	**0,91**	**8,8%**	0,41	0,45	0,91	1
STRYN ENERGI AS	ÅRDAL ENERGI KF	**0,92**	**8,2%**	0,51	0,55	0,92	1
NORD-SALTEN KRAFT AS	LOFOTKRAFT AS	**0,92**	**8,0%**	0,31	0,33	0,92	1
ØVRE EIKER NETT AS	RAKKESTAD ENERGI AS	**0,92**	**7,8%**	0,78	0,84	0,92	1
HURUM NETT AS	TRØGSTAD ELVERK AS	**0,92**	**7,8%**	0,71	0,77	0,92	1
HEMSEDAL ENERGI KF	HØLAND OG SETSKOG ELVERK SA	**0,93**	**7,4%**	0,64	0,69	0,93	1
RAUMA ENERGI AS	SYKKYLVEN ENERGI AS	**0,93**	**7,4%**	0,55	0,59	0,93	1
NTE NETT AS	TRØNDERENERGI NETT AS	**0,93**	**7,3%**	0,62	0,67	0,93	1
SVORKA ENERGI AS	SYKKYLVEN ENERGI AS	**0,93**	**6,9%**	0,58	0,62	0,93	1
FLESBERG ELEKTRISITETSVERK AS	HEMSEDAL ENERGI KF	**0,93**	**6,5%**	0,58	0,62	0,93	1
NORD-SALTEN KRAFT AS	NORDLANDSNETT AS	**0,94**	**6,4%**	0,45	0,48	0,94	1
HÅLOGALAND KRAFT NETT AS	YMBER AS	**0,94**	**6,3%**	0,64	0,68	0,94	1
ISE NETT AS	BINDAL KRAFTLAG SA	**0,94**	**6,2%**	0,54	0,58	0,94	1
HØLAND OG SETSKOG ELVERK SA	NORE ENERGI AS	**0,94**	**6,0%**	0,67	0,72	0,94	1
FUSA KRAFTLAG SA	AUSTEVOLL KRAFTLAG SA	**0,94**	**5,9%**	0,43	0,46	0,94	1
KVAM KRAFTVERK AS	FUSA KRAFTLAG SA	**0,94**	**5,8%**	0,48	0,51	0,94	1
DRANGEDAL EVERK KF	MIDT-TELEMARK ENERGI AS	**0,94**	**5,8%**	0,61	0,65	0,94	1
HEMSEDAL ENERGI KF	HURUM NETT AS	**0,94**	**5,7%**	0,59	0,63	0,94	1
ØVRE EIKER NETT AS	TRØGSTAD ELVERK AS	**0,94**	**5,7%**	0,84	0,89	0,94	1
KRAGERØ ENERGI AS	VEST-TELEMARK KRAFTLAG AS	**0,94**	**5,6%**	0,55	0,58	0,94	1
ORKDAL ENERGINETT AS	SODVIN SA	**0,95**	**5,5%**	0,76	0,80	0,95	1

Table 29: 25 most promising merger combinations under CRS technology. Source: Own Contribution

The VRS assumption shows a higher degree of potential pure merger gains than the CRS assumption. This contradicts with the views of Bogetoft & Wang (2005), that predicted higher gains from the CRS assumption. As mentioned, there are no size effects in the CRS model, as there is no gain in rescaling under this assumption. Thus, since individual inefficiency has been removed, E* = Harmony effect (HA). The results are given above, with the highest merger gain of around 12% for Aurland Energiverk and Årdal Energi KF. This combination was second most promising under the VRS technology as well, providing a more thorough ground for recommending a merger. Other DSOs such as Hurum Nett AS, Sykkylven Energi AS and Svorka Energi AS are also represented under both technology assumption. Moreover, DSOs that were most promising under the overall efficiency measures, E, are also proposed under pure merger gains, E*. Indicating that Lofotkraft AS, Nord-Salten Kraft AS and NTE Nett AS have more than just potential learning effects as the only reason to merge. The results show higher potential for pure merger gains under both models for smaller and medium sized mergers, compared to mergers including the larger DSOs. A reason for this finding might be corresponding with how Kwoka (2005) found potential diseconomies of scale for the large firms in the industry.

It is important to stress the fact that the suggestions of these 25 possible combinations for mergers does not necessarily entail that they should be enforced. A merger is a too complicated operation for this to be the instance. Problems that could arise during a merger include differences in culture, mismanagement etc. (Galpin & Herndon, 2007). This would not be captured in this model and would be of interest for further research among the most promising combinations. However, parts of this model are built upon the same model as the NVE regulates the industry with, i.e. the income is based upon this model. Thus, improved efficiency post-merger, will lead to improved profit. Additionally, the harmony effects compensation scheme that NVE has proposed will further increase the applicability of the model used.

To summarize, the 25 merger combinations with the outmost potential among Norwegian DSOs, was restricted to country borders. The results from the merger analysis showed how the overall merger potential in the industry is mainly due to learning effects. As learning effects can be obtained elsewhere, for instance by strengthening managerial competence, the term "promising" in the research question were identified as mergers involving harmony and size effects. Thus, pure merger gains, E*, consists of both and were chosen as the best indicator in terms of merger gains for this specific industry. The 25 most promising potential mergers are shown in table 28 and 29, under VRS and CRS technology, respectively. Under both assumptions, a finding was that the promising combinations entails only smaller or medium sized firms. Hence, confirming this thesis´ suspicion of higher gains from merging for smaller DSOs than large. The results are similar to that of Mydland et al. (2018b) and Saastamoinen et al. (2017), who describe the findings by potential economies of scale in the industry. Another finding was that the DSOs with the largest pure merger gains, were situated in sparsely populated areas. The large Norwegian DSOs are mainly situated in or around the cities, while the smaller are more spread throughout the nation (NVE, 2019b). Ultimately, the findings indicate that small DSOs in rural areas has the largest potential gains from merging.

9. Conclusion

In this research, an evaluation of the efficiency in the Norwegian electricity distribution industry has been executed. The DEA framework (Bogetoft & Otto, 2011; Bogetoft & Wang, 2005) has been utilized to examine the performance of the DSOs as well as further explore the merger possibilities. Three research questions were constructed to analyze this further. This chapter will conclude the findings for these research questions before limitations regarding the research will be discussed. Finally, perspectives for further research and clarification of the mentioned findings will be presented.

Research Question 1: How are the firm sizes of the DSOs in the Norwegian electricity industry affecting their performances?

To answer research question 1 the firm sizes were investigated with respect to the performance of the DSOs. This was done by checking for scale efficiencies to see how the companies were of sub-optimal size as well as comparing the efficiencies to the different firm sizes. The findings from the discussion presented how the smaller firms showed a tendency to be below their optimal size for potential economies of scale. This agrees with the findings of Kumbhakar et al. (2015) and Mydland, Haugom & Lien (2018a).

Further, the efficiency scores tell us that many large companies perform better than the rest of the industry under the VRS assumption. This is not the case under the CRS assumption, and shows how the results of the analysis are sensitive to the choice of models. Following this sensitivity argument, this study finds that companies at the coast of Norway will receive worse efficiency scores after environmental variables are adjusted for. To the authors' knowledge, no previous literature has expressed these findings.

There are dubious reasons to believe how the firm size on average will affect the industry performance. The large variations from the efficiency scores and size efficiencies express how the performance might not be explained by size differences, at least at an industry level. However, the variations indicate that there are several firm-specific potentials for economies of scale in the industry, i.e. that some firms are too small.

Research Question 2: What are the potential efficiency gains from mergers in the Norwegian electricity industry?

In research question two, the potential efficiency gains from mergers in the Norwegian electricity industry are assessed. This was done by comparing the efficiency scores pre- and post-merger. Moreover, the overall potential for mergers were decomposed to identify alternative means of improving industry performance.

By investigating the hypothetical consolidation of the Norwegian DSOs at the pre-existing county level, there are gains from horizontal integration in the majority of cases. The overall efficiency experienced a slight decrease post-merger, but the median overall efficiency rose, indicating that smaller firms benefits the most from a merger.

When the overall merger potential was decomposed, it became evident that learning effects are the major cause for efficiency gains following mergers in the Norwegian electricity industry. The lack of gains from harmony and size effects, and in many cases even losses from the merged units operating at larger scales, has been a consistent finding throughout the analysis. Since scale effects are found to be low or negative in many cases, the necessity of mergers is doubtful.

On the other hand, the merger analysis showed that some of the DSOs would clearly benefit from merging with a neighboring DSO. If these are consolidated it would benefit the merged unit and the industry efficiency in general. Our results suggest that merging activity by itself would not increase overall efficiency, but the potential gain in adjusting to optimal scale is highly beneficial. Further, the results imply that there are high technical inefficiencies among Norwegian DSOs, and that merging is a way of reducing these by enhancing competence in some DSOs.

Research Question 3: What are the most promising potential combinations of mergers, and what do the results imply?

Research question 3 aimed at defining the most promising potential combination of mergers and then analyze these results further. The possible mergers were limited to the belonging counties. As found when discussing question 2, the overall merger potential consisted mostly of learning effects. However, as the learning effect can be obtained by applying the best practice, the most promising potential mergers were set to be sorted by pure merger effect, rather than overall merger potential.

The most promising potential combinations are presented in table 28 and 29. The merger results confirms the views of Mydland, Haugom, & Lien (2018a) and Saastamoinen, Bjørndal, & Bjørndal (2017), on how there are higher gains from merging for the smaller companies. Adding to these findings, the small DSOs are situated in sparsely populated areas.

An important consideration to make is how the suggestion of these combinations for mergers does not necessarily entail that they should be enforced. However, their income is decided by parts of the same model utilized in this thesis. Improved efficiency post-merger here will all else equal, lead to improved profit. Additionally, the harmony effects compensation scheme that NVE has proposed will further increase the applicability of the model used.

The data utilized to undergo these analyses are collected from NVE, a governmental organization. Data from governmental organizations are generally considered as reliable information. However, there is bound to be information asymmetry between regulators, and there could be measurement biases originating from the DSOs. Similar data is nonetheless used by different researchers and has been through triangulation to further ensure validity. In addition, the authors' role in this thesis have been value free, and the authors have an independent and objective stance on the research, as should have in a positivist research strategy. Therefore, the results are dependable.

9.1. Limitations

This thesis has several limitations. Firstly, the study of the Norwegian DSOs is solely based on the quantitative data attained from NVE. Even though the data are from an acknowledged governmental organization, it is important to bear in mind that the results displayed in this thesis does not offer a perfect picture of real activities of the operators. If this thesis had included qualitative data, more detailed information on complex issues could have been provided.

Secondly, the current regulation encourages the DSOs to constantly try to maximize their revenue cap and make new investments in the grid. Maximizing the revenue cap would lead the operators to have higher capital costs and controllable operating costs that can bias the models in this study. New investments in the grid will in turn penalize the operators in the DEA model since it will lead to lower efficiency scores.

Thirdly, other benchmarking models would have certainly given significant divergences in the results. This includes the environmental variables, where the inclusion of the ones chosen are debatable. This thesis applied same variables as NVE.

9.2. Future Research

This section will further elaborate some of the questions arisen after the completion of this study.

When decomposing the overall potential gains from mergers, learning effects were concluded to be strongest driver. Learning effects can be gained by learning best practice from the companies better performing peers. It remains however unclear what the best practice is, and how the different companies could learn from best practice. Thus, further examination of the learning effects would be interesting for future research.

Continuing, this study found differing impact from the adjustment of the environmental effects on geographical locations, especially the near-shore areas in the west and north of Norway. This could of course be intended, as the variables are supposed to account for different in operating environment. However, to the authors' knowledge, no former studies have been made on the subject.

Another subject for future study is the potential merger combinations. As mentioned in the discussion, a merger is a complex operation. More detailed examination of the parts would be necessary before completing such an operation.

In addition, some of the DSOs in the industry have other operations such as production and/or retail of electricity integrated in their current value chains. To further explore the efficiency effects of being vertically integrated would be of interest. A prolonging of this could be to capture effects from mergers involving such firms.

10. References

Agrell, P. J., Bogetoft, P., & Grammeltvedt, T. E. (2015). The efficiency of the regulation for horizontal mergers among electricity distribution operators in Norway. *12th International Conference on the European Energy Market (EEM)*, 1-5.

Agrell, P. J., Bogetoft, P., & Tind, J. (2005). DEA and dynamic yardstick competition in Scandinavian electricity distribution. *Journal of Productivity Analysis, 23(2)*, 173-201.

Aigner, D. J., & Chu, S. F. (1968). On estimating the industry production function. *The American Economic Review, 58(4)*, 826-839.

Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of econometrics, 6(1)*, 21-37.

Amundsveen, R., & Kvile, H. M. (2016). Balancing incentives: The development and application of a regulatory benchmarking model. *Productivity and Efficiency Analysis*, 233-247.

Amundsveen, R., Eirum, T., Kordahl, O.-P., Kvile, H. M., Langset, T., & Vøllestad, K. (2013). *Forslag til endring av modeller for å fastsette kostnadsnormer (Authors' own translation).* Oslo: NVE.

Amundsveen, R., Kordahl, O., Kvile, H. M., & Langset, T. (2014). Second stage adjustment for firm heterogeneity in DEA: A novel approach used in regulation of Norwegian electricity DSOs. *Recent Developments in Data Envelopment Analysis and its Applications, 334*.

Asquith, P. (1983). Merger Bids, Uncertainty and Stockholder Returns. *Journal of Financial Economics*, 51-83.

Bagdadioglu, N., Price, C. W., & Weyman-Jones, T. (2007). Measuring potential gains from mergers among electricity distribution companies in Turkey using a non-parametric model. *The energy journal, 28(2)*.

Bagdadiouglu, N., Price, C. W., & Weyman-Jones, T. (2006). Measuring Potential Gains from Mergers among Electricity Distribution Companies in Turkey using a Non-Parametric Model. *Economic & Social Research Council*.

Banker, R. D. (1989). An introduction to data envelopment analysis with some of its models and their uses. *Research in governmental and nonprofit accounting, 5(1)*, 125-163.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science, 30(9)*, 1078-1092.

Banker, R. D., Charnes, A., Cooper, W. W., Swarts, J., & Thomas, D. (1989). An introduction to data envelopment analysis with some of its model and their uses. *Research in governmental and nonprofit accounting*, 125-163.

Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficency and panel data: with application to paddy farmers in India. *Journal of productivity analysis, 3(1-2)*, 153-169.

Biddle, C. (2014). What Is Objectivism? *The Objective Standard*.

Bjørndal, E., Bjørndal, M., & Fange, K. A. (2010). Benchmarking in regulation of electricity networks in Norway: An overview. *Energy, natural resources and environmental economics*, 317-342.

Blumer, H. (1956). Sociological Analysis and the "Variable". *American Sociological Review, 21*, 683-690.

Bogetoft. (2012). Perfomance Analysis: DEA. I P. Bogetoft, *Performance Benchmarking* (s. 71-102). Boston, MA: Springer.

Bogetoft, P., & Gammeltvedt, T. E. (August 2006). *Mergers In Norwegian Electricity Distribution: A Cost Saving Exercise?* Hentet fra https://www.researchgate.net/publication/296839740_MERGERS_IN_NORWEGIAN_ELECTRICITY_DISTRIBUTION_A_COST_SAVING_EXERCISE/stats

Bogetoft, P., & Otto, L. (2011). *Benchmarking with dea, sfa, and r (Vol. 157).* Springer Science & Business Media.

Bogetoft, P., & Otto, L. (2011). *Benchmarking with DEA, SFA, and R (Vol. 157).* Springer Science & Business Media.

Bogetoft, P., & Wang, D. (2005). Estimating the potential gains from mergers. *Journal of Productivity Analysis, 23(2)*, 145-171.

Boye, K., & Meyer, C. B. (2008). *Fusjoner og oppkjøp (Author's own translation).* Oslo: Cappelen Akademisk Forlag.

Bryman, A. (1989). *Research Methods and Organization Studies.* Routlegde.

Bryman, A. (2012). *Social Research Methods.* New York: Oxford University Press.

Çelen, A. (2013). The effect of merger and consolidation activities on the efficiency of electricity distribution regions in Turkey. *Energy policy, 59*, 674-682.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of operational research, 2(6)*, 429-444.

Cicourel, A. (1964). Method and Measurement in Sociology. *New York: Free Press*.

Clark, J. A. (1988). Economies of Scale and Scope At Depository Financial Institutions: A Review of the Literature. *Economic Review*, 16-33.

Clemente, M. N., & Greenspan, D. S. (1998). *Winning at Mergers and Acquisitions: The Guide to Market-Focused Planning and Integration.* Wiley.

Coelli, T. (1998). A multi-stage methodology for the solution of oriented DEA models. *Operations Research Letters, 23(3-5)*, 143-149.

Coelli, T. J., Gautier, A., Perelman, S., & Saplacan-Pop, R. (2013). Estimating the cost of improving quality in electricity distribution: A parametric distance function approach. *Energy Policy, 53*, 287-297.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2004). Data envelopment analysis. *Handbook on data envelopment analysis* , 1-39.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The Case Study Approach. *BMC Medical Research Methodology*.

D. e. (1984). The Performance of Public Enterprises Concepts and Measurements. *Elsevier*.

Dale, A., Arber, S., & Procter, M. (1988). *Doing Secondary Research.* London: Unwin Hyman.

Davidson, R., & MacKinnon, J. G. (2006). The power of bootstrap and asymptotic tests. *Journal of Economtetrics, 133(2)*, 421-441.

Debreu, G. (1951). The coefficient of resource utilization. *Econometrica: Journal of the Econometric Society*, 273-292.

Efron, B., & Tibshirani, R. (1986). Bootstrap methods for standard erros, confidence intervals, and other measures of statistical accuracy. *Statistical science*, 54-75.

Farrell, J., & Shapiro, C. (1990). Horizontal Mergers: An Equilibrium Analysis. *The American Economic Review*, 107-126.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A (General), 120(3)*, 253-281.

Fethi, M. D., Jackson, P. M., & Weyman-Jones, T. G. (2001). European airlines: a stochastic dea study of efficiency with market liberalisation.

Filippini, M. (1996). Economies of Scale and Utiliziation in the Swiss Electric Power Distribution Industry. *Resour Energy Econ*, 543-550.

Folland, S., Goodman, A. C., & Stano, M. (2012). *The Economics of Health and Health Care.* Prentice Hall.

Førsund, F. R., & Edvardsen, D. F. (2003). International benchmarking of electricity distribution utilities. *Resource and energy Economics, 25(4)*, 353-371.

Førsund, F., & Hjalmarsson, L. (2004). Are All Scales Optimal in DEA? Theory and Empirical Evidence. *Journal of Productivity Analysis*.

Førsund, F., & Kittelsen, S. (1998). Productivity Development of Norwegian Electricity Distribution Utilities. *Resour Energy Econ*, 207-224.

Foss, N. J., Klein, P. G., Kor, Yasemin, Y. K., Mahoney, & T, J. (2006). Entrepreneurship, Subjectivism, and the Resource-based. *Center for Strategic Management and Globalization; Copenhagen Business School*.

Fried, H. O., Schmidt, S. S., & Lovell, C. K. (1993). *The measurement of productive efficiency: Techniques and applications.* Oxford university press.

Galpin, T. J., & Herndon, M. (2007). *The Complete Guide to Merchers and Acquisitions: Process Tools to Support M&A Integration at Every Level.* Jossey-Bass Business & Management Ser. Web.

Gaughan, P. A. (2011). *Mergers, Acquisitions and Corporate Restructurings.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Gill, J., & Johnson, P. (2002). *Research Methods for Managers.* Sheffield: SAGE Publications.

Grant, M. (1. 04 2020). *Investopedia*. Hentet fra Horizontal Merger: https://www.investopedia.com/terms/h/horizontalmerger.asp

Greene, W. H. (1990). A gamma-distributed stochastic frontier model. *Journal of econometrics, 46(1-2)*, 141-163.

Greene, W. H. (2008). The measurement of productive efficiency and productivity growth. *The econometric approach to efficiency analysis*, 92-250.

Greer, M. (2012). The Theory of Natural Monopoly and Literature Review. *Electricity Marginal Cost Pricing*, 15-38.

Growitsch, C., Jamasb, T., & Pollit, G. (2009). Quality of Service, Efficiency and Scale in Network Analysis: An Analysis of European Electricity Distribution. *Resource Energy Economics*, 2555-2570.

Growitsch, C., Jamasb, T., & Wetzel, H. (2012). Efficiency effects of observed and unobserved heterogeneity: Evidence from Norwegian electricity distribution networks. *Energy Economics, 34(2)*, 542-548.

Hakim, C. (2000). *Research Design : Successful Designs for Social and Economic Research.* Routledge.

Haney, B. A., & Pollitt, G. M. (2011). Exploring the determinants of "best practice" benchmarking in electricity network regulation. *Energy Policy*, 7739-7746.

Harris, J., Ozgen, H., & Ozcan, Y. (2000). Do mergers enhance the performance of hospital efficiency. *Journal of the Operational Research Society, 51(7)*, 801-811.

Heien, M. H., Melvær, P., Nibstad, S. P., Sergieva, R. Y., & Sliwinski, T. H. (2018). *Utvikling i nøkkeltal for nettselskap.* Oslo: Norges vassdrags- og energidirektorat.

Heltne, L. (19. February 2019). *NVE: Strømkunder kan spare milliarder hvis antall nettselskaper halveres (Author's own translation)*. Hentet fra Dagens Næringsliv: https://www.dn.no/energi/nve/energi/strom/nve-stromkunder-kan-spare-milliarder-hvis-antall-nettselskaper-halveres/2-1-543749

Hoff, A. (2007). Second stage DEA: Comparison of approaches. *European Jorunal of Operational Research*, 425-435.

Holden, M. T., & Lynch, P. (2004). Choosing the Appropriate Methodology: Understanding Research Philosophy. *The Marketing Review*.

Jacob, H. (1994). *Using Published Data: Errors and Remedies.* (M. S. Lewis-Beck, Red.) London: Sage and Toppan Publishing.

Jamasb, T., & Pollitt, M. (2003). International benchmarking and regulation: an application to European electricity distribution utilities. *Energy policy, 31(5)*, 1609-1622.

Johannessen, F. E. (25. November 2015). *Elektrifiseringen av hjemmet (Author's own translation).* Hentet fra Norgeshistorie: https://www.norgeshistorie.no/forste-verdenskrig-og-mellomkrigstiden/1621-elektrifiseringen-av-hjemmet.html

Johannesson, P., & Perjons, E. (2014). Research Paradigms. I P. Johannesson, & E. Perjons, *An Introduction to Design Science* (s. 167-159). Stockholm: Springer, Cham.

Johansson, R. (2003). Case Study Methodology. *Methodologies in Housing.* Stockholm: Royal Institute of Technology.

Johnes, J., & Yu, L. (2008). Measuring the Research Performance of Chinese Higher Education Institutions Using Data Envelopment Analysis. *China Economic Review*, 679-696.

Johnson, A. L., & Kuosmanen, T. (2012). One-stage and two-stage DEA estimation of the effects of contextual variables. *European Journal of Operational Research, 220(2)*, 559-570.

Johnson, G., Whittington, R., & Scholes, K. (2012). *Fundamentals of Strategy.* Harlow: Pearson.

Joskow, P. L. (2007). *Regulation of Natural Monopolies.* Massachusetts Institute of Technology, Cambridge, MA, USA.

Joskow, P. L. (2008). Incentive regulation and its application to electricity networks. *Review of Network Economics, 7(4)*.

Kervin, J. B. (1999). *Methods for Business Research (2nd edition).* New York: HarperCollins.

Kopsakangas-Savolainen, M., & Svento, R. (2010). Comparing welfare effects of different regulation schemes: an application to the electricity distribution industry. *Energy Policy*, 7370-7377.

Kristensen, T., Bogetoft, P., & Pedersen, M. K. (2010). Potential gains from hospital mergers in Denmark. *Health Care Management Science*, 334-346.

Kuhn, P., Huber, M., Dorfner, J., & Hamacher, T. (2016). Challenges and opportunities of power systems from smart homes to super-grids. *Ambio*, 50-62.

Kumbhakar, S. C., Amundsveen, R., Kvile, H. M., & Lien, G. (2015). Scale economies, technical change and efficiency in Norwegian electricity distribution, 1998-2010. *Journal of Productivity Analysis, 43(3)*, 295-305.

Kumbhakar, S., & Hjalmarsson, L. (1998). Relative Perfomance of Public and Private Ownership under Yardstick Competition: Electric Retail Distribution. *Eur Econ Rev*, 97-122.

Kuosmanen, T., Saastamoinen, A., & Sipiläinen, T. (2013). What is the best practice for benchmark regulation of electricity distribution? Comparison of DEA, SFA and StoNED methods. *Energy Policy, 61*, 740-750.

Kwoka, J. (2005). Electric Power Distribution: Economies of Scale, Mergers and Restructuring. *Applied Economics*, 2373-2386.

Kwoka, J., & Pollitt, M. (2010). Do mergers improve efficiency? Evidence from restructuring the US electric power sector. *International Journal of Industrial Organization, 28(6)*, 645-656.

Laffont, J. J., & Tirole, J. (1993). *A theory of incentives in procurement and regulation.* MIT press.

Langset, T., & Syvertsen, S. C. (2015). VII. The WACC model in the regulation of the Norwegian electricity network operators. *The ICER Chronicle Edition 4*.

Lichtenberg, F., & Siegel, D. S. (1987). Productivity and Changes in Ownership of Manufactoring Plants. *Brookings Papers on Economic Activity*, 643-684.

McDonald, J. (2009). Using Least Squares and Tobit in Second Stage DEA Efficiency Analyses. *European Journal of Operational Research*, 792-798.

Miguéis, V., Camanho, A., Bjørndal, E., & M, B. (2011). Productivity Change and Innovation in Norwegian Electricity Distribution Companies. *Journal of the Operational Research Society*, 982-990.

Ministry of Petroleum and Energy. (29. June 1990). *Act relating to the generation, conversion, transmission, trading, distribution and use of energy etc. [Energy Act] (Author's own translation)*. Hentet fra Lovdata: https://lovdata.no/dokument/NL/lov/1990-06-29-50

Moffet, M. H., Stonehill, A. I., & Eiteman, D. K. (2015). *Fundamentals of Multinational Finance.* Boston: Pearson Education Limited.

Mortimer, D., & Peacock, S. (2002). Hospital Efficiency Measurement: Simple Ratios vs Frontier Methods. *Centre for Health Program Evaluation*.

Mydland, Ø., Haugom, E., & Lien, G. (2018a). Economies of Scale in Norwegian Electricity Distribution: A Quantile Regression Approach. *Applied Economics*.

Mydland, Ø., Kumbhakar, S., Lien, G., Amundsveen, R., & Kvile, H. M. (2018b). Lost economies of scope and potential merger gains in the Norwegian electricity. *Faculty of Economics and Organization Science, Inland Norway University of Applied Sciences, Lillehammer, Norway*.

Nagin, D. S., & Land, K. C. (1993). Age, criminal careers, and population heterogeneity: Specification and estimation of a nonparametric, mixed Poisson model. *Criminology, 31(3)*, 327-362.

Nord Pool. (20. December 2019). *Bidding Areas*. Hentet fra Nord Pool: https://www.nordpoolgroup.com/the-power-market/Bidding-areas/

Norwegian Ministry of Petroleum and Energy. (5. December 2019). *Organiseringen av kraftmarkedet, authors own translation*. Hentet fra EnergiFakta Norge: https://energifaktanorge.no/norsk-energiforsyning/kraftmarkedet/

Norwegian Ministry of Petroleum and Energy. (4. February 2020). *Energy Facts Norway*. Hentet fra https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

NTB. (9. February 2019). *NVE og energiministeren: Færre nettselskaper kan gi billigere strøm. (Author's own translation)*. Hentet fra Teknisk Ukeblad: https://www.tu.no/artikler/nve-og-energiministeren-faerre-nettselskaper-kan-gi-billigere-strom/457660

NVE. (26. November 2015). *Harmoniinntekt ved fusjoner. (Author's own translation)*. Hentet fra NVE: https://www.nve.no/reguleringsmyndigheten/okonomisk-regulering-av-nettselskap/harmoniinntekt-ved-fusjoner/

NVE. (December 2019). *Inntektsrammer for 2020 - varsel. (Authors own translation).* Hentet fra The Norwegian Water Resources and Energy Directorate: https://www.nve.no/reguleringsmyndigheten/okonomisk-regulering-av-nettselskap/inntektsrammer/inntektsrammer-for-2020-varsel/

NVE. (31. October 2019). *Om reguleringen av strømnettselskapenes inntekter.* Hentet fra The Norwegian Water Resources and Energy Directorate: https://www.nve.no/media/8368/om-reguleringen-av-str%C3%B8mnettselskapenes-inntekter.pdf

NVE. (2019a). *Veiledning til beregningsgrunnlag for inntektsrammer 2020.* Hentet fra NVE.no: http://webfileservice.nve.no/API/PublishedFiles/Download/201911456/2985855

NVE. (2019b). *Om reguleringen av strømnettselskapenes inntekter. (Author's own translation).* Hentet fra NVE: https://www.nve.no/media/8368/om-reguleringen-av-str%C3%B8mnettselskapenes-inntekter.pdf

NVE. (2019c). Grunnlagsdata. "(Authors' own translation). Retrieved from NVE: https://www.nve.no/reguleringsmyndigheten/okonomisk-regulering-av-nettselskap/inntektsrammer/inntektsrammer-for-2020-varsel/

NVE. (2019d). *Historiske parameterverdier for referanserenten (Authors' own translation)*. Hentet fra https://www.nve.no/reguleringsmyndigheten/okonomisk-regulering-av-nettselskap/om-den-okonomiske-reguleringen/referanserenten/historiske-parameterverdier-for-referanserenten/

NVE. (2019e). *Inntektsrammer for 2020 - varsel (Authors' own translation).* Hentet fra The Norwegian Energy Regulatory Authority: https://www.nve.no/reguleringsmyndigheten/okonomisk-regulering-av-nettselskap/inntektsrammer/inntektsrammer-for-2020-varsel/

NVE. (2020). *Infoskriv RME-Ø 4/2019: Om utrekning av inntektsramme og kostnadsnorm for 2020 (Authors' own translation).* Oslo: NVE.

NVE. (10. April 2020). *NVE Kraftsystem Nettanlegg (Author's own translation)*. Hentet fra NVE: https://temakart.nve.no/link/?link=nettanlegg

O'Driscoll, G. P., Rizzo, M. J., & Garrison, R. W. (1996). The Economics of Time and Ignorance. *Psychology Press*.

Olesen, O. B., & Petersen, N. C. (1995). Chance constrained efficiency evaluation. *Management science, 41(3)*, 442-457.

Perry, M. K., & Porter, R. H. (1985). Oligopoly and the Incentive for Horizontal Merger. *American Economic Review*.

Posner, R. A. (1968). Natural Monopoly and Its Regulation. *Stanford Law Review*, 548-643.

Proff. (15. March 2020). *Proff – The Business Finder (Author's own translation)*. Hentet fra Proff.no: http://innsikt.proff.no/om-proff/

Rasmussen, S. (2012). *Production Economics.* Copenhagen: Springer.

Reiten, E., & Al, E. (2014). *Et bedre organisert strømnett.* Norwegian Ministry of Petroleum and Energy.

Resti, A. (1998). Regulation can foster mergers, can mergers foster efficiency? The Italian case. *Journal of economics and business, 50(2)*, 157-169.

Robson, C. (2002). *Real World Research: A Resource for Social Scientists and Practitioner Researchers.* Oxford: Blackwell Publisher.

Röller, L.-H., Stennek, J., & Verboven, F. (2000). Efficiency Gains from Mergers. *Discussion Paper FS IV 00-09,*.

Saastamoinen, A., Bjørndal, E., & Bjørndal, M. (2017). Specification of merger gains in the Norwegian electricity distribution industry. *Energy Policy, 102*, 96-107.

Salvanes, K., & S, T. (1994). Productivity Differences in Multiple Output Industries: An Empirical Application to Electricity Distribution. *Journal of Productivity Analysis*, 23-43.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students.* Harlow, England: Pearson Education Limited.

Schutz, A. (1962). Collected Papers 1: The Problem of Social Reality. *The Gague: Martinus Nijhof*.

Shahrur, H. (2005). Industry Structure and Horizontal Takeovers: Analysis of Wealth Effects on Rivals, Suppliers and Corporate Customers. *Journal of Financial Economics*, 423-460.

Shuttleworth, & Graham. (2005). Benchmarking of electricity networks: Practical problems with its use for regulation. *Utilities Policy*, 310-317.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology*.

Simar, L., & Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*, 31-64.

Skjeret, F., & Sørgard, L. (2002). Fusjoner og oppkjøp - Er det lønnsomt? (Author's own translation). *Konkurransestrategier i det norske kraftmarkedet*.

SSB. (20. December 2019). *Konsumprisindeksen*. Hentet fra Statistics Norway: https://www.ssb.no/kpi

Subal, C. K., Amundsveen, R., Kvile, H. M., & Lien, G. (2014). Scale economies, technical change and efficiency in Norwegian electricity distribution, 1998-2010. *Springer Science+Business Media New York*, 295-305.

Taylor, T., & Greenlaw, S. A. (2016). REGULATING NATURAL MONOPOLIES. I T. Taylor, & S. A. Greenlaw, *Principles of Economics.* BC Campus.

von der Fehr, N.-H. M., Hagen, K. P., & Hope, E. (2002). *Nettregulering.* Bergen: Samfunns- og Næringslivsforskning AS.

Wang, H. J., & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis, 18(2)*, 129-144.

Welch, C. (2000). The Archeology of Business Research: The Use of Archival Records in Case Study Research. *Journal of Strategic Marketing*, 197-208. Hentet fra https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:2n987&datastreamId=FULL-TEXT.PDF

Zhou, P., Ang, B. W., & Poh, K. L. (2008). A survey of data envelopment analysis in energy and environmental studies. *European journal of operational research, 189(1)*, 1-18.

Zschille, M. (2012). Consolidating the Water Industry: An Analysis of the Potential Gains from Horizontal. *Deutsches Institut für Wirtschaftsforschung*.

11. Appendices

Appendix A: First stage DEA-model

Company name	Size of company	County	Nord Pool Area	Input	Output 1	Output 2	Output 3
AGDER ENERGI NETT AS	Big	Aust-Agder	NO 2	1134182,9	195479	4111,2	8077,8
ALTA KRAFTLAG SA	Medium	Finnmark	NO 4	92368,215	12519	627,2	906,4
ANDØY ENERGI AS	Small	Nordland	NO 4	37843,105	3640,2	189	221,2
ARDAL ENERGI KF	Small	Sogn og Fjordane	NO 5	24653,419	3577	53,4	134,8
AS EIDEFOSS	Medium	Oppland	NO 1	91703,943	14186,4	798,8	1058,6
AURLAND ENERGIVERK AS	Small	Sogn og Fjordane	NO 5	19533,97	1388,6	69	147,2
AUSTEVOLL KRAFTLAG SA	Small	Hordaland	NO 5	30348,412	4228,2	99,6	172,6
BINDAL KRAFTLAG SA	Small	Nordland	NO 4	10557,903	1196,8	131	110,2
BKK NETT AS	Big	Hordaland	NO 5	1292873,2	205620,2	2286,6	5812,8
DALANE NETT AS	Medium	Rogaland	NO 2	112178,75	14505	355	791,6
DRANGEDAL EVERK KF	Small	Telemark	NO 1	24474,107	3608,4	198	279,8
EIDSIVA NETT AS	Big	Hedmark	NO 1	1063073,2	160298,8	4758,8	10551
FINNAS KRAFTLAG SA	Medium	Hordaland	NO 5	48597,024	8128,2	135,6	311
FITJAR KRAFTLAG SA	Small	Hordaland	NO 5	24903,573	2444,6	68,8	148,2
FJELBERG KRAFTLAG SA	Small	Hordaland	NO 5	15949,282	2024,8	37,2	102,6
FLESBERG ELEKTRISITETSV	Small	Buskerud	NO 1	24185,223	3999,6	142,4	207
FOSEN NETT AS	Medium		NO 3	61072,158	11484,2	424,8	776,8
FUSA KRAFTLAG SA	Small	Hordaland	NO 5	28926,84	3122,8	137,6	233,8
GLITRE ENERGI NETT AS	Big	Buskerud	NO 1	468835,32	89817,4	715,2	3455
GUDBRANDSDAL ENERGI I	Medium	Oppland	NO 1	104680,7	19253,8	523,6	1109,6
HAFSLUND NETT AS	Big	Oslo	NO 1	2679063,5	701124,6	3384,4	17837,4
HALLINGDAL KRAFTNETT A	Medium	Buskerud	NO 1	128896,4	23914,8	561,6	1687,2
HALOGALAND KRAFT NETT	Medium	Troms	NO 4	161785,19	25782,8	941	1271,8
HAMMERFEST ENERGI NET	Medium	Finnmark	NO 4	75149,577	7787	391,6	453,4
HARDANGER ENERGI AS	Small	Hordaland	NO 5	53671,291	6679,8	288,8	452
HAUGALAND KRAFT NETT A	Big	Rogaland	NO 2	572329,06	79174,4	1169,8	3099,6
HELGELAND KRAFT AS	Big	Nordland	NO 4	488478,13	45141,6	2284,8	3037,4
HEMSEDAL ENERGI KF	Small	Buskerud	NO 1	29612,881	3953,4	123,2	335,8
HJARTDAL ELVERK AS	Small	Telemark	NO 1	17645,212	2488,2	94,4	149,8
HØLAND OG SETSKOG ELV	Small	Akershus	NO 1	30536,718	6210,6	195,2	320,2
HURUM NETT AS	Medium	Buskerud	NO 1	34783,205	7141,4	65,8	297,4
ISE NETT AS	Medium	Nordland	NO 4	55397,264	7924	218,6	350,2
ISTAD NETT AS	Medium	Møre og Romsdal	NO 3	155368,56	27063	687,2	1404,6
JÆREN EVERK KF	Medium	Rogaland	NO 2	48400,205	8695,6	32	396,6
KLEPP ENERGI AS	Medium	Rogaland	NO 2	40051,679	8440,8	27	307,4
KRAGERØ ENERGI AS	Medium	Telemark	NO 1	60166,45	9636,2	197,6	381,6
KRØDSHERAD EVERK KF	Small	Buskerud	NO 1	13690,787	3008,2	87,4	186,4
KVAM KRAFTVERK AS	Medium	Hordaland	NO 5	45397,845	7217,8	129,2	371,6
KVINNHERAD ENERGI AS	Medium	Hordaland	NO 5	50139,359	7245,6	238,2	407,8
LÆRDAL ENERGI AS	Small	Sogn og Fjordane	NO 5	22237,332	1900,6	79,2	133,4
LOFOTKRAFT AS	Medium	Nordland	NO 4	220392,94	16623,6	554	839,4
LUOSTEJOK KRAFTLAG SA	Small	Finnmark	NO 4	53603,874	3893,2	441	354,2
LUSTER ENERGIVERK AS	Small	Sogn og Fjordane	NO 5	24473,717	3767,2	193,6	254
LYSE ELNETT AS	Big	Rogaland	NO 2	820807,85	142884,4	651,2	3889,6
MELØY ENERGI AS	Small	Nordland	NO 4	40283,727	4859,4	195,4	250,4
MIDTKRAFT AS	Medium	Buskerud	NO 1	78371,586	13633	326,6	786,4
MIDT-TELEMARK ENERGI A	Medium	Telemark	NO 1	60184,956	10710,2	240,2	617,4
MODALEN KRAFTLAG SA	Small	Sogn og Fjordane	NO 5	3347,6122	424,8	28	9,2
MØRENETT AS	Big	Møre og Romsdal	NO 3	456334,08	64306,6	875,2	2583,4
NEAS AS	Medium	Møre og Romsdal	NO 3	224302,36	26039	781,2	1332
NESSET KRAFT AS	Small	Møre og Romsdal	NO 3	20785,185	2339,6	129	110
NORDKRAFT NETT AS	Medium	Nordland	NO 4	104714,43	15293,2	456,6	692,6
NORDKYN KRAFTLAG SA	Small	Troms	NO 4	27978,39	1868,8	206	134,2
NORDLANDSNETT AS	Big	Nordland	NO 4	304690,96	39194	1016	1673,4
NORD-ØSTERDAL KRAFTLA	Medium	Hedmark	NO 1	78815,853	10860,4	870,2	956
NORD-SALTEN KRAFT AS	Small	Nordland	NO 4	76696,407	6671,2	700,8	532,4
NORDVEST NETT AS	Medium	Møre og Romsdal	NO 3	68630,591	14221,8	397,8	865
NORE ENERGI AS	Small	Buskerud	NO 1	16625,468	2094,4	87,4	187,6
NORGESNETT AS	Big	Østfold	NO 1	322255,66	93107,4	646,8	3051,2
NOTODDEN ENERGI NETT A	Medium	Telemark	NO 1	62004,829	7524,6	132,4	416
NTE NETT AS	Big	Nord-Trøndelag	NO 3	587590,75	85752	4134,8	6893,8
ODDA ENERGI AS	Small	Hordaland	NO 5	61590,641	6190	88,8	232,8
OPPDAL EVERK AS	Medium	Sør-Trøndelag	NO 3	33729,029	7084,2	187	435,6
ORKDAL ENERGINETT AS	Medium	Sør-Trøndelag	NO 3	33912,164	7144,8	143,8	340,6
ØVRE EIKER NETT AS	Medium	Buskerud	NO 1	45589,879	9751,2	92,6	522,2
RAKKESTAD ENERGI AS	Small	Østfold	NO 1	26742,395	4403,2	216,4	379
RAULAND KRAFTFORSYNIN	Small	Telemark	NO 1	25686,526	4236,4	247,6	224,4
RAUMA ENERGI AS	Small	Møre og Romsdal	NO 3	42531,265	5146,4	222,8	371,8
REPVAG KRAFTLAG SA	Small	Finnmark	NO 4	64401,074	4429,2	361,8	288,6

Table 30: Full 1st stage DEA-model 1/2. Data source: Input: Own Calculations. Company Muncipality and County: The respective companies' websites. Nord Pool Zone (Nord Pool, 2019). Outputs: (NVE,2019)

Company nan	Size of compa	Muncipality	County	Nord Pool Ar	Input	Output 1	Output 2	Output 3
RINGERIKS-KF	Mellomstort	Ringerike	Buskerud	NO 1	118735,08	21450,4	394	1333,6
ROLLAG ELEK	Lite	Rollag	Buskerud	NO 1	12183,592	2136,4	56,6	152,4
RØROS ELEKTI	Lite	Rørps	Nord-Trøndel	NO 3	34047,893	6247,6	307	347,6
SANDØY ENER	Lite	Alesund	Møre og Rom	NO 3	10612,892	1063,4	13,2	62,4
SFE NETT AS	Mellomstort	Florø	Sogn og Fjord	NO 5	322546,64	24348,4	1089,6	1566,4
SKAGERAK NE	Stort	Porsgrunn	Telemark	NO 1	1100799,6	191445	1259,8	6796
SKJAK ENERGI	Lite	Skjåk	Oppland	NO 1	18908,358	2059,4	132,8	202,6
SODVIN SA	Lite	Heim	Sør-Trøndela	NO 3	31022,34	4531	251,2	326,6
SOGNEKRAFT	Mellomstort	Vik I Sogn	Sogn og Fjord	NO 5	79506,783	9039,6	318,4	570
SØR AURDAL I	Lite	Sør-Aurdal	Oppland	NO 1	26987,417	2926,4	128,2	290,4
STANGE ENER	Mellomstort	Stange	Hedmark	NO 1	73244,239	11092,2	289,8	725,8
STRANDA ENE	Lite	Stranda	Møre og Rom	NO 3	28390,366	3434,4	103,4	223,2
STRYN ENERG	Lite	Stryn	Sogn og Fjord	NO 5	35179,802	4678,6	200,2	354,8
SUNNDAL ENE	Lite	Sunndal	Møre og Rom	NO 3	33654,054	4838,6	132,2	280,4
SUNNFJORD E	Mellomstort	Sunnfjord	Sogn og Fjord	NO 5	152384,08	15792,2	829,2	1099,4
SVORKA ENER	Lite	Surnadal	Møre og Rom	NO 3	60705,164	6684,6	426,4	542,6
SYKKYLVEN EN	Lite	Sykkylven	Møre og Rom	NO 3	25031,264	4598,6	70,8	223,4
TINN ENERGI /	Mellomstort	Tinn	Telemark	NO 1	53723,6	7476,4	206,6	416,2
TRØGSTAD EL	Lite	Indre Østfold	Østfold	NO 1	17747,469	3261,2	145,2	304,2
TROLLFJORD I	Lite	Hadsel	Nordland	NO 4	55327,073	5432,8	227,8	321,8
TROMS KRAFT	Stort	Tromsø	Troms	NO 4	508837,12	73399,8	3020,8	4233,2
TRØNDERENE	Stort	Trondheim	Sør-Trøndela	NO 3	774067,67	155536,2	2377	5078,8
UVDAL KRAFT	Lite	Nore og Uvda	Buskerud	NO 1	14068,237	2081	73,6	131,4
VALDRES ENE	Mellomstort	Nord-Aurdal	Oppland	NO 1	68520,939	14338	397,2	987
VANG ENERGI	Lite	Vang	Oppland	NO 1	19063,075	2322,6	111,2	214,8
VARANGER KF	Mellomstort	Vadsø	Finnmark	NO 4	189006,45	16752,6	1062,6	1175,6
VESTERALSKR	Mellomstort	Sortland	Nordland	NO 4	102921,85	11716	502	715
VEST-TELEMAI	Mellomstort	Tokke	Telemark	NO 1	110739,4	13920	800,2	929
VOKKS NETT A	Mellomstort	Nordre Land	Oppland	NO 1	85321,877	13282,6	650,2	912,2
VOSS ENERGI	Mellomstort	Voss	Hordaland	NO 5	84911,136	10795,8	238,8	578,8
YMBER AS	Mellomstort	Nordreisa	Troms	NO 4	84654,061	8854,2	802,8	681,2

Table 31: Full 1st stage DEA-model 2/2. Data source: Input: Own Calculations. Company Muncipality and County: The respective companies' websites. Nord Pool Zone (Nord Pool, 2019). Outputs: (NVE,2019c)

Appendix B: Total Input Factors for First Stage DEA-Model , 2014-2018

Company name	O&M	Cost of power losses	Cost of energy not supplied	Depreciation	Book value * Wacc
AGDER ENERGI NETT AS	2186711,038	486111,6885	444202,868	1166037	1387851,901
ALTA KRAFTLAG SA	232397,001	40061,31859	13882,938	86871	88628,81512
ANDØY ENERGI AS	91270,766	9868,40485	6450,62	41625	40000,73306
ÅRDAL ENERGI KF	74931,098	6917,483804	2184,49	19183	20051,02157
AS EIDEFOSS	214153,484	54521,01974	22803,46	83444	83597,75202
AURLAND ENERGIVERK AS	55907,812	4299,226083	6611,639	16555	14296,17438
AUSTEVOLL KRAFTLAG SA	94757,462	12280,89813	3611,159	20335	20757,54222
BINDAL KRAFTLAG SA	30293,423	2194,626176	1859,517	8396	10045,94733
BKK NETT AS	2711463,803	520829,7576	318706,782	1420203	1493162,887
DALANE NETT AS	275747,508	30660,33738	26372,589	113306	114807,3308
DRANGEDAL EVERK KF	68045,468	6987,258381	4336,075	21725	21276,73161
EIDSIVA NETT AS	2124846,503	515336,6381	368436,853	1023899	1282847,09
FINNÅS KRAFTLAG SA	118252,447	12524,50641	5512,669	45752	60943,49605
FITJAR KRAFTLAG SA	84116,236	6359,193024	2760,281	14995	16287,15567
FJELBERG KRAFTLAG SA	51242,705	3172,027177	2220,091	11861	11250,58786
FLESBERG ELEKTRISITETSVERK AS	65410,285	5432,233583	2294,77	23572	24216,82696
FOSEN NETT AS	133073,522	20136,82194	13784,307	72010	66356,13807
FUSA KRAFTLAG SA	87425,513	9402,943502	2322,86	20900	24582,88409
GLITRE ENERGI NETT AS	947610,485	323247,8998	105032,408	467047	501238,8271
GUDBRANDSDAL ENERGI NETT AS	280458,235	45799,40411	40484,278	66936	89725,58634
HAFSLUND NETT AS	5971853,789	1679039,436	475402,848	2448342	2820679,592
HALLINGDAL KRAFTNETT AS	354468,857	55981,37211	24349,21	111443	98239,56456
HÅLOGALAND KRAFT NETT AS	393783,038	54747,74809	30911,784	177121	152362,3567
HAMMERFEST ENERGI NETT AS	204567,332	31266,49272	14344,012	57159	68411,04821
HARDANGER ENERGI AS	156026,509	19771,17593	9469,508	40858	42231,26443
HAUGALAND KRAFT NETT AS	1205650,625	185719,1469	122792,001	548397	609127,1001
HELGELAND KRAFT AS	1227201,821	197218,3549	136200,071	392506	489264,3829
HEMSEDAL ENERGI KF	65115,55	6992,411302	2872,437	40212	32872,0053
HJARTDAL ELVERK AS	51243,898	3815,871369	4066,001	14193	14907,28821
HØLAND OG SETSKOG ELVERK SA	77280,843	15407,67124	3719,588	28693	27582,48693
HURUM NETT AS	84474,623	13611,89361	6298,915	37090	32440,59521
ISE NETT AS	158804,88	17206,26882	6257,52	50315	44402,65232
ISTAD NETT AS	359488,099	59903,15131	24292,819	154053	179105,7402
JÆREN EVERK KF	116726,498	13465,28282	8051,669	51057	52700,57538
KLEPP ENERGI AS	82256,743	18455,83285	1808,463	50421	47316,35759
KRAGERØ ENERGI AS	181754,167	15186,43549	10600,473	47693	45598,1766
KRØDSHERAD EVERK KF	41379,078	4153,355599	2703,906	10948	9269,593352
KVAM KRAFTVERK AS	129425,355	11785,87468	4482,185	37162	44133,81194
KVINNHERAD ENERGI AS	140683,964	13732,19675	6796,392	43033	46451,24391
LÆRDAL ENERGI AS	67861,697	13172,23263	7605,183	11698	10849,54655
LOFOTKRAFT AS	430359,665	51812,56443	66115,541	229659	324017,941
LUOSTEJOK KRAFTLAG SA	154637,262	11410,67373	19511,749	37393	45066,68318
LUSTER ENERGIVERK AS	72187,059	9168,792528	10001,285	16534	14477,44807
LYSE ELNETT AS	1701374,051	351862,6123	102117,244	930662	954267,1531
MELØY ENERGI AS	125283,661	11694,10076	11285,105	28098	25057,76781
MIDTKRAFT AS	176349,657	29819,79093	10661,589	87697	87329,8922
MIDT-TELEMARK ENERGI AS	139501,554	23592,56316	10402,431	60720	66708,23255
MODALEN KRAFTLAG SA	6956,124	1545,11954	813,271	3490	3933,546707
MØRENETT AS	974857,962	220217,9281	91588,87	457454	537551,6477
NEAS AS	550033,583	82878,57653	19714,568	220498	248387,0754
NESSET KRAFT AS	72805,226	4121,418326	2092,455	14991	9915,825692
NORDKRAFT NETT AS	280747,434	43349,28675	19403,357	84784	95288,07398
NORDKYN KRAFTLAG SA	77352,31	25383,89297	5259,997	17518	14377,75127
NORDLANDSNETT AS	677325,99	171052,7848	54940,493	280754	339381,524
NORD-ØSTERDAL KRAFTLAG SA	223792,366	21924,90504	18593,912	70460	59308,08183
NORD-SALTEN KRAFT AS	205403,559	33331,81548	14308,093	67025	63413,56952
NORDVEST NETT AS	147801,632	35693,2141	13278,864	74845	71534,24717
NORE ENERGI AS	52192,911	3337,017608	991,854	12896	13709,5586
NORGESNETT AS	678644,27	181045,4516	53843,642	344842	352902,943
NOTODDEN ENERGI NETT AS	177452,336	18210,63492	3299,915	47825	63236,25716
NTE NETT AS	1382784,802	227584,5204	105411,67	569076	653096,768
ODDA ENERGI AS	144556,19	28386,21639	7953,089	49436	77621,70847
OPPDAL EVERK AS	89776,751	7846,49501	2661,71	35009	33351,18859
ORKDAL ENERGINETT AS	73783,815	14867,6423	4762,556	38440	37706,8044
ØVRE EIKER NETT AS	101290,945	22554,2897	3941,235	54184	45978,92286
RAKKESTAD ENERGI AS	66604,63	10607,54442	4059,73	28242	24198,06975
RAULAND KRAFTFORSYNINGSLAG SA	78080,766	11629,69388	3370,429	19067	16284,74005
RAUMA ENERGI AS	122547,101	17054,50666	7074,134	29245	36735,58355
REPVÅG KRAFTLAG SA	169754,86	20104,96422	21719,901	56342	54083,64493

Table 32:Total input factors, 2014-2018 1/2. Data source: NVE, 2019. Own calculations

RINGERIKS-KRAFT NETT AS	277769,644	46991,88363	26902,255	116469	125542,5944
ROLLAG ELEKTRISITETSVERK SA	39167,702	4087,937074	1751,804	8264	7646,519211
RØROS ELEKTRISITETSVERK AS	101616,805	12814,94257	6784,288	27495	21528,43118
SANDØY ENERGI AS	35593,099	1766,905926	256,816	7539	7908,641077
SFE NETT AS	764775,031	82619,48368	55563,877	307021	402753,8305
SKAGERAK NETT AS	2226054,318	572774,0487	262039,313	1329237	1113893,267
SKJÅK ENERGI KF	65076,647	2979,68941	2174,45	14798	9513,002443
SODVIN SA	95648,867	6925,533026	4554,846	27273	20709,45259
SOGNEKRAFT AS	202712,183	27146,88934	12910,72	56982	97782,12515
SØR AURDAL ENERGI AS	67809,979	6355,288781	3028,923	25489	32253,89419
STANGE ENERGI NETT AS	159210,885	15238,63864	8469,407	79651	103651,2647
STRANDA ENERGI AS	75877,867	16934,57402	5306,642	19278	24554,74812
STRYN ENERGI AS	94955,514	12269,75709	5519,898	31281	31872,84078
SUNNDAL ENERGI KF	96228,662	8293,308065	3566,484	34256	25925,81453
SUNNFJORD ENERGI AS	384888,536	44421,2507	27721,064	152121	152768,5416
SVORKA ENERGI AS	151086,911	21718,4166	8311,409	56961	65448,08272
SYKKYLVEN ENERGI AS	59419,825	9875,704097	4075,54	31650	20135,25062
TINN ENERGI AS	129970,737	22452,93699	9412,963	53865	52916,36531
TRØGSTAD ELVERK AS	49508,547	8306,097217	2011,779	15524	13386,9235
TROLLFJORD NETT AS	138387,237	13246,40825	14889,19	55651	54461,52805
TROMS KRAFT NETT AS	1041317,192	225921,5157	160329,437	481551	635066,4572
TRØNDERENERGI NETT AS	1845537,474	431629,3215	136380,237	705750	751041,3102
UVDAL KRAFTFORSYNING SA	43268,463	2952,13541	549,024	11638	11933,56046
VALDRES ENERGIVERK AS	172173,446	23665,13536	10840,257	64891	71034,85631
VANG ENERGIVERK KF	58071,844	4291,677072	3262,242	15466	14223,61224
VARANGER KRAFTNETT AS	394591,222	71452,58953	32317,131	185066	261605,3191
VESTERÅLSKRAFT NETT AS	289351,783	31889,78512	22398,742	90421	80547,92814
VEST-TELEMARK KRAFTLAG AS	274998,997	45280,09138	36598,626	79773	117046,2837
VOKKS NETT AS	218791,178	22265,50355	36846,654	75929	72777,05066
VOSS ENERGI NETT AS	199591,524	30777,84842	12894,639	87332	93959,66683
YMBER AS	210944,029	26658,24223	18187,403	96067	71413,62934

Table 33: Total input factors, 2014-2018 2/2. Data source: NVE, 2019. Own calculations

Appendix C: Calculations Used in Total Input Factors for First Stage DEA-Model

Year	NO 1	NO 2	NO 3	NO 4	NO 5
2014	246,06	245,10	274,58	274,05	243,97
2015	200,80	200,24	211,82	204,76	199,82
2016	260,69	248,45	276,58	244,63	247,51
2017	286,92	284,78	290,33	257,06	284,75
2018	424,60	420,45	428,15	423,89	418,69
2019	412,92	412,51	403,31	400,70	412,67

Table 34:Yearly average prices Nord Pool Zones weighted by consumption + 11 NOK as required by the NVE. Source: (Nord Pool, 2019)

Year	CPI	Wacc
2014	0,971	6,61%
2015	1	6,32%
2016	1,028	6,32%
2017	1,058	6,12%
2018	1,088	6,10%

Table 35: Consumer Price and WACCs. Source: CPI: (SSB, 2019). WACC: (NVE, 2019d)

Appendix D: Environmental Variables

Company name	Z1	Z2	Z3: Geo 1	Z4: Geo 2	Z5: Geo 3
AGDER ENERGI NETT AS	0,29271	0,18939	-0,1750	-0,45043	-0,5102
ALTA KRAFTLAG SA	0,22236	0,00004	-0,4636	-0,05653	2,7438
ANDØY ENERGI AS	0,35374	0,00034	-1,6188	0,18417	2,4070
ARDAL ENERGI KF	0,61379	0,11367	1,7661	-0,32137	1,0959
AS EIDEFOSS	0,22776	0,01611	-0,5711	-0,70189	0,5676
AURLAND ENERGIVERK AS	0,48966	0,01063	3,8974	0,06064	-0,6246
AUSTEVOLL KRAFTLAG SA	0,29375	0,19100	-0,7812	3,85163	-2,4373
BINDAL KRAFTLAG SA	0,07746	0,06935	-0,6369	-0,21351	-0,4451
BKK NETT AS	0,53801	0,14827	0,8120	-0,27562	-1,5621
DALANE NETT AS	0,50000	0,04315	0,8090	-0,45636	-1,1285
DRANGEDAL EVERK KF	0,28044	0,19166	-0,5650	-0,69236	-1,0436
EIDSIVA NETT AS	0,33810	0,22392	-1,5278	-0,69333	-0,1500
FINNAS KRAFTLAG SA	0,47547	0,22090	-1,0280	1,88947	-2,3980
FITJAR KRAFTLAG SA	0,48889	0,07119	-0,4463	4,86841	-2,5482
FJELBERG KRAFTLAG SA	0,40299	0,35628	-0,4109	1,73938	-2,1386
FLESBERG ELEKTRISITETSVERK AS	0,37719	0,26730	-1,2668	-0,63987	0,0226
FOSEN NETT AS	0,33434	0,03387	-1,0488	-0,10406	-0,6432
FUSA KRAFTLAG SA	0,24324	0,23504	2,5113	-0,31890	-1,9008
GLITRE ENERGI NETT AS	0,64521	0,21704	-1,1392	-0,65920	-0,0221
GUDBRANDSDAL ENERGI NETT AS	0,44480	0,13012	-0,3462	-0,65895	-0,2383
HAFSLUND NETT AS	0,72280	0,19601	-1,6136	-0,65471	-1,1737
HALLINGDAL KRAFTNETT AS	0,53372	0,09468	-0,5420	-0,64500	1,1208
HALOGALAND KRAFT NETT AS	0,20793	0,00421	-0,1576	0,02313	1,5862
HAMMERFEST ENERGI NETT AS	0,23507	0,00000	-0,5094	0,06389	5,0134
HARDANGER ENERGI AS	0,35957	0,14760	1,8072	-0,31581	-0,9207
HAUGALAND KRAFT NETT AS	0,46527	0,15371	-0,1658	-0,05842	-2,0659
HELGELAND KRAFT AS	0,23790	0,05323	-0,9709	0,22847	0,5198
HEMSEDAL ENERGI KF	0,48319	0,00091	-0,8422	-0,70259	2,4226
HJARTDAL ELVERK AS	0,36970	0,14986	0,3511	-0,36646	-0,1505
HØLAND OG SETSKOG ELVERK SA	0,23438	0,20454	-1,7612	-0,69932	-1,2309
HURUM NETT AS	0,62941	0,33222	-0,8964	-0,69178	-0,8367
ISE NETT AS	0,45802	0,03392	0,9250	-0,61919	0,7938
ISTAD NETT AS	0,37073	0,16613	-0,2196	0,12584	-1,1015
JÆREN EVERK KF	0,90365	0,04397	-1,5144	-0,52590	-1,9892
KLEPP ENERGI AS	0,87892	0,01243	-1,9707	-0,55711	-2,4920
KRAGERØ ENERGI AS	0,31672	0,16550	-0,7695	2,03661	-1,2369
KRØDSHERAD EVERK KF	0,46358	0,39163	-1,0815	-0,70160	-0,8386
KVAM KRAFTVERK AS	0,45600	0,19367	2,1414	-0,35740	-1,1188
KVINNHERAD ENERGI AS	0,28190	0,13400	2,6142	-0,28489	-2,1397
LÆRDAL ENERGI AS	0,48052	0,01198	2,4391	-0,70121	-0,2271
LOFOTKRAFT AS	0,27182	0,00127	-0,4811	3,18723	1,2599
LUOSTEJOK KRAFTLAG SA	0,12967	0,00000	-1,2927	-0,69172	1,6370
LUSTER ENERGIVERK AS	0,24806	0,07743	4,0149	-0,54052	-0,4046
LYSE ELNETT AS	0,75317	0,08764	0,2678	0,08269	-2,0479
MELØY ENERGI AS	0,31833	0,04906	0,0848	0,81265	-0,1687
MIDTKRAFT AS	0,45840	0,23694	-0,9558	-0,67763	-0,6735
MIDT-TELEMARK ENERGI AS	0,49237	0,24737	-1,0330	-0,58971	-1,3125
MØRENETT AS	0,49081	0,08416	1,1780	0,03620	-0,9654
NEAS AS	0,34053	0,20536	-0,8145	-0,09921	-1,3025
NESSET KRAFT AS	0,20122	0,22686	2,6460	-0,43488	-0,4426
NORDKRAFT NETT AS	0,28331	0,00600	0,6493	-0,30563	1,2383
NORDKYN KRAFTLAG SA	0,10044	0,00000	-0,5285	0,26981	6,1588
NORDLANDSNETT AS	0,30089	0,03330	0,0804	2,07524	0,3139
NORD-ØSTERDAL KRAFTLAG SA	0,14243	0,02347	-1,1882	-0,70241	0,1858
NORD-SALTEN KRAFT AS	0,16304	0,01875	-0,1609	0,19792	0,8465
NORDVEST NETT AS	0,29195	0,15850	0,7852	0,16726	-1,2464
NORE ENERGI AS	0,51648	0,13093	0,2942	-0,70189	0,0107
NORGESNETT AS	0,61252	0,17359	-1,3940	-0,46814	-1,5248
NOTODDEN ENERGI NETT AS	0,63429	0,22200	-0,6699	-0,66084	-0,9890
NTE NETT AS	0,22400	0,12663	-0,9339	-0,48000	-0,0361
ODDA ENERGI AS	0,63200	0,03472	3,7443	-0,47296	2,2158
OPPDAL EVERK AS	0,42492	0,00119	-1,0607	-0,69819	1,1737
ORKDAL ENERGINETT AS	0,46388	0,12340	-0,4331	-0,68950	0,3166
ØVRE EIKER NETT AS	0,72205	0,21323	-1,2492	-0,69893	-1,0749
RAKKESTAD ENERGI AS	0,23843	0,11909	-1,8007	-0,68860	-1,4412
RAULAND KRAFTFORSYNINGSLAG SA	0,22756	0,00309	-0,9965	-0,54370	3,7981
RAUMA ENERGI AS	0,38571	0,14523	1,9886	-0,56991	-0,8086
REPVAG KRAFTLAG SA	0,22062	0,00000	-0,8454	0,70999	5,0308

Table 36: Environmental variables for 2nd stage DEA. Source: (NVE, 2019e)

Appendix E: Results from First Stage DEA-Model

Company name	Size of companies	DEA_vrs	DEA_crs	DEA_fdh	DEA_fdr	DEA_drs	DEA_irs	SE	vrs - drs < 1e-4	Optimal size
AGDER ENERGI NETT AS	Big	0,8770	0,7114	1,0000	0,7177	0,8770	0,7114	0,8112	TRUE	Above
ALTA KRAFTLAG SA	Medium	0,7816	0,7594	0,9237	0,7897	0,7816	0,7594	0,9715	TRUE	Above
ANDØY ENERGI AS	Small	0,5438	0,5411	0,6467	0,6408	0,5411	0,5438	0,9950	FALSE	Below
ÅRDAL ENERGI KF	Small	0,5902	0,5563	0,9810	0,8270	0,5563	0,5902	0,9426	FALSE	Below
AS EIDEFOSS	Medium	0,9473	0,9190	1,0000	0,9715	0,9473	0,9190	0,9701	TRUE	Above
AURLAND ENERGIVERK AS	Small	0,5162	0,4393	0,7009	0,7009	0,4393	0,5162	0,8510	FALSE	Below
AUSTEVOLL KRAFTLAG SA	Small	0,5971	0,5919	0,8464	0,7821	0,5919	0,5971	0,9913	FALSE	Below
BINDAL KRAFTLAG SA	Small	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
BKK NETT AS	Big	0,6598	0,5817	1,0000	0,5848	0,6598	0,5817	0,8818	TRUE	Above
DALANE NETT AS	Medium	0,5729	0,5594	0,9332	0,6102	0,5729	0,5594	0,9764	TRUE	Above
DRANGEDAL EVERK KF	Small	0,8677	0,8675	1,0000	0,9908	0,8675	0,8677	0,9997	FALSE	Below
EIDSIVA NETT AS	Big	1,0000	0,6970	1,0000	0,7055	1,0000	0,6970	0,6970	TRUE	Above
FINNÅS KRAFTLAG SA	Medium	0,6589	0,6561	1,0000	0,8142	0,6561	0,6589	0,9957	FALSE	Below
FITJAR KRAFTLAG SA	Small	0,4599	0,4433	0,5498	0,5498	0,4433	0,4599	0,9639	FALSE	Below
FJELBERG KRAFTLAG SA	Small	0,5962	0,5152	0,7639	0,7639	0,5152	0,5962	0,8641	FALSE	Below
FLESBERG ELEKTRISITETSVERK AS	Small	0,8001	0,7968	1,0000	0,9814	0,7968	0,8001	0,9959	FALSE	Below
FOSEN NETT AS	Medium	0,9642	0,9320	1,0000	1,0000	0,9642	0,9320	0,9666	TRUE	Above
FUSA KRAFTLAG SA	Small	0,5779	0,5752	0,6135	0,6135	0,5752	0,5779	0,9954	FALSE	Below
GLITRE ENERGI NETT AS	Big	0,7394	0,6988	1,0000	0,7477	0,7394	0,6988	0,9451	TRUE	Above
GUDBRANDSDAL ENERGI NETT AS	Medium	0,8503	0,8204	1,0000	0,8755	0,8503	0,8204	0,9649	TRUE	Above
HAFSLUND NETT AS	Big	1,0000	0,9058	1,0000	0,9271	1,0000	0,9058	0,9058	TRUE	Above
HALLINGDAL KRAFTNETT AS	Medium	1,0000	0,8718	1,0000	0,9127	1,0000	0,8718	0,8718	TRUE	Above
HÅLOGALAND KRAFT NETT AS	Medium	0,8172	0,7738	1,0000	0,7969	0,8172	0,7738	0,9468	TRUE	Above
HAMMERFEST ENERGI NETT AS	Medium	0,5778	0,5727	0,8127	0,6225	0,5778	0,5727	0,9912	TRUE	Above
HARDANGER ENERGI AS	Small	0,6609	0,6528	1,0000	0,7069	0,6609	0,6528	0,9878	TRUE	Above
HAUGALAND KRAFT NETT AS	Big	0,5612	0,5308	1,0000	0,6331	0,5612	0,5308	0,9458	TRUE	Above
HELGELAND KRAFT AS	Big	0,6246	0,5174	1,0000	0,5232	0,6246	0,5174	0,8283	TRUE	Above
HEMSEDAL ENERGI KF	Small	0,6926	0,6905	0,9030	0,8738	0,6926	0,6905	0,9970	TRUE	Above
HJARTDAL ELVERK AS	Small	0,7095	0,6982	1,0000	0,9657	0,6982	0,7095	0,9840	FALSE	Below
HØLAND OG SETSKOG ELVERK SA	Small	0,9425	0,9419	1,0000	1,0000	0,9425	0,9419	0,9994	TRUE	Above
HURUM NETT AS	Medium	0,7913	0,7699	0,9750	0,9750	0,7699	0,7913	0,9730	FALSE	Below
ISE NETT AS	Medium	0,6359	0,6346	1,0000	0,7142	0,6346	0,6359	0,9980	FALSE	Below
ISTAD NETT AS	Medium	0,7889	0,7593	1,0000	0,7931	0,7889	0,7593	0,9624	TRUE	Above
JÆREN EVERK KF	Medium	0,7034	0,6977	0,9419	0,8486	0,6977	0,7034	0,9919	FALSE	Below
KLEPP ENERGI AS	Medium	0,7860	0,7543	1,0000	1,0000	0,7543	0,7860	0,9597	FALSE	Below
KRAGERØ ENERGI AS	Medium	0,6586	0,6570	1,0000	0,7882	0,6570	0,6586	0,9975	FALSE	Below
KRØDSHERAD EVERK KF	Small	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
KVAM KRAFTVERK AS	Medium	0,6525	0,6481	1,0000	0,8167	0,6481	0,6525	0,9933	FALSE	Below
KVINNHERAD ENERGI AS	Medium	0,6843	0,6810	1,0000	0,8063	0,6843	0,6810	0,9951	TRUE	Above
LÆRDAL ENERGI AS	Small	0,4582	0,4428	0,6157	0,6157	0,4428	0,4582	0,9663	FALSE	Below
LOFOTKRAFT AS	Medium	0,3613	0,3556	0,5848	0,3737	0,3613	0,3556	0,9843	TRUE	Above
LUOSTEJOK KRAFTLAG SA	Small	0,7311	0,6631	1,0000	0,7783	0,7311	0,6631	0,9069	TRUE	Above
LUSTER ENERGIVERK AS	Small	0,8707	0,8689	1,0000	0,9908	0,8689	0,8707	0,9979	FALSE	Below
LYSE ELNETT AS	Big	0,6277	0,6025	0,9431	0,6727	0,6277	0,6025	0,9599	TRUE	Above
MELØY ENERGI AS	Small	0,6082	0,6064	0,7580	0,7430	0,6064	0,6082	0,9970	FALSE	Below
MIDTKRAFT AS	Medium	0,7738	0,7536	0,8743	0,8542	0,7738	0,7536	0,9740	TRUE	Above
MIDT-TELEMARK ENERGI AS	Medium	0,7732	0,7610	1,0000	0,8849	0,7732	0,7610	0,9842	TRUE	Above
MODALEN KRAFTLAG SA	Small	1,0000	0,8106	1,0000	1,0000	0,8106	1,0000	0,8106	FALSE	Below
MØRENETT AS	Big	0,5540	0,5337	1,0000	0,6473	0,5540	0,5337	0,9633	TRUE	Above
NEAS AS	Medium	0,5419	0,5301	1,0000	0,5493	0,5419	0,5301	0,9782	TRUE	Above
NESSET KRAFT AS	Small	0,6643	0,6512	0,8538	0,8538	0,6512	0,6643	0,9803	FALSE	Below
NORDKRAFT NETT AS	Medium	0,6709	0,6634	0,9997	0,6857	0,6709	0,6634	0,9887	TRUE	Above
NORDKYN KRAFTLAG SA	Small	0,6250	0,5934	0,9181	0,7364	0,6250	0,5934	0,9495	TRUE	Above
NORDLANDSNETT AS	Big	0,5945	0,5603	1,0000	0,5945	0,5945	0,5603	0,9425	TRUE	Above
NORD-ØSTERDAL KRAFTLAG SA	Medium	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
NORD-SALTEN KRAFT AS	Small	0,8241	0,7460	1,0000	0,7756	0,8241	0,7460	0,9052	TRUE	Above
NORDVEST NETT AS	Medium	0,9679	0,9341	1,0000	0,9974	0,9679	0,9341	0,9650	TRUE	Above
NORE ENERGI AS	Small	0,7269	0,6713	1,0000	1,0000	0,6713	0,7269	0,9234	FALSE	Below
NORGESNETT AS	Big	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
NOTODDEN ENERGI NETT AS	Medium	0,5107	0,5096	0,9706	0,6381	0,5096	0,5107	0,9978	FALSE	Below
NTE NETT AS	Big	1,0000	0,8109	1,0000	0,8168	1,0000	0,8109	0,8109	TRUE	Above
ODDA ENERGI AS	Small	0,3892	0,3833	0,4958	0,4958	0,3833	0,3892	0,9848	FALSE	Below
OPPDAL EVERK AS	Medium	0,9430	0,9367	1,0000	1,0000	0,9430	0,9367	0,9933	TRUE	Above
ORKDAL ENERGINETT AS	Medium	0,8668	0,8656	1,0000	1,0000	0,8668	0,8656	0,9986	TRUE	Above
ØVRE EIKER NETT AS	Medium	0,8882	0,8858	1,0000	1,0000	0,8882	0,8858	0,9973	TRUE	Above
RAKKESTAD ENERGI AS	Small	0,9336	0,9279	1,0000	1,0000	0,9336	0,9279	0,9939	TRUE	Above
RAULAND KRAFTFORSYNINGSLAG S	Small	0,9863	0,9854	1,0000	1,0000	0,9863	0,9854	0,9991	TRUE	Above
RAUMA ENERGI AS	Small	0,6424	0,6381	1,0000	0,7392	0,6424	0,6381	0,9934	TRUE	Above
REPVÅG KRAFTLAG SA	Small	0,5039	0,5001	0,9426	0,5628	0,5039	0,5001	0,9925	TRUE	Above

Table 37: Results from First stage DEA-Model 1/2. Source: Own contribution

RINGERIKS-KRAFT NETT AS	Medium	0,8590	0,7994	1,0000	0,8606	0,8590	0,7994	0,9307	TRUE	Above
ROLLAG ELEKTRISITETSVERK SA	Small	0,9010	0,8273	1,0000	1,0000	0,8273	0,9010	0,9182	FALSE	Below
RØROS ELEKTRISITETSVERK AS	Small	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
SANDØY ENERGI AS	Small	0,5826	0,4306	0,9948	0,9948	0,4306	0,5826	0,7390	FALSE	Below
SFE NETT AS	Medium	0,4340	0,3998	1,0000	0,4062	0,4340	0,3998	0,9212	TRUE	Above
SKAGERAK NETT AS	Big	0,7289	0,6175	1,0000	0,6273	0,7289	0,6175	0,8472	TRUE	Above
SKJÅK ENERGI KF	Small	0,7316	0,7275	0,9386	0,9386	0,7275	0,7316	0,9944	FALSE	Below
SODVIN SA	Small	0,8585	0,8584	1,0000	1,0000	0,8584	0,8585	0,9999	FALSE	Below
SOGNEKRAFT AS	Medium	0,5617	0,5511	0,7681	0,5676	0,5617	0,5511	0,9812	TRUE	Above
SØR AURDAL ENERGI AS	Small	0,6323	0,6273	0,6576	0,6576	0,6273	0,6323	0,9921	FALSE	Below
STANGE ENERGI NETT AS	Medium	0,7007	0,6863	0,8338	0,7477	0,7007	0,6863	0,9795	TRUE	Above
STRANDA ENERGI AS	Small	0,5597	0,5592	0,8621	0,7430	0,5597	0,5592	0,9992	TRUE	Above
STRYN ENERGI AS	Small	0,7044	0,7005	1,0000	0,8508	0,7044	0,7005	0,9945	TRUE	Above
SUNNDAL ENERGI KF	Small	0,6442	0,6419	0,9074	0,7689	0,6442	0,6419	0,9965	TRUE	Above
SUNNFJORD ENERGI AS	Medium	0,6100	0,5918	1,0000	0,6033	0,6100	0,5918	0,9701	TRUE	Above
SVORKA ENERGI AS	Small	0,7024	0,7010	1,0000	0,7884	0,7024	0,7010	0,9980	TRUE	Above
SYKKYLVEN ENERGI AS	Small	0,7561	0,7306	1,0000	1,0000	0,7306	0,7561	0,9663	FALSE	Below
TINN ENERGI AS	Medium	0,6262	0,6228	1,0000	0,6901	0,6262	0,6228	0,9947	TRUE	Above
TRØGSTAD ELVERK AS	Small	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	TRUE	At
TROLLFJORD NETT AS	Small	0,5054	0,5046	0,6154	0,5682	0,5054	0,5046	0,9983	TRUE	Above
TROMS KRAFT NETT AS	Big	0,8962	0,7348	1,0000	0,7432	0,8962	0,7348	0,8198	TRUE	Above
TRØNDERENERGI NETT AS	Big	0,8851	0,7744	1,0000	0,7877	0,8851	0,7744	0,8749	TRUE	Above
UVDAL KRAFTFORSYNING SA	Small	0,7394	0,7195	0,9732	0,9732	0,7195	0,7394	0,9730	FALSE	Below
VALDRES ENERGIVERK AS	Medium	1,0000	0,9716	1,0000	1,0000	1,0000	0,9716	0,9716	TRUE	Above
VANG ENERGIVERK KF	Small	0,7056	0,6836	0,9310	0,9310	0,6836	0,7056	0,9689	FALSE	Below
VARANGER KRAFTNETT AS	Medium	0,6008	0,5569	1,0000	0,5699	0,6008	0,5569	0,9268	TRUE	Above
VESTERÅLSKRAFT NETT AS	Medium	0,6030	0,5907	0,8290	0,6294	0,6030	0,5907	0,9797	TRUE	Above
VEST-TELEMARK KRAFTLAG AS	Medium	0,7634	0,7480	1,0000	0,7808	0,7634	0,7480	0,9798	TRUE	Above
VOKKS NETT AS	Medium	0,8828	0,8594	1,0000	0,8913	0,8828	0,8594	0,9734	TRUE	Above
VOSS ENERGI NETT AS	Medium	0,5436	0,5370	0,7192	0,6272	0,5436	0,5370	0,9878	TRUE	Above
YMBER AS	Medium	0,8579	0,8129	0,9310	0,8728	0,8579	0,8129	0,9475	TRUE	Above

Table 38: Results from First stage DEA-Model 2/2. Source: Own contribution

Appendix F: Peers for VRS and CRS Models in Stage 1

Firm Name	Firm #	peer 1	peer 2	peer 3	peer 4		Firm #2	peer2	peer3	peer4
AGDER ENERG	[1,]	12	21	61			[1,]	37	59	72
ALTA KRAFTLA	[2,]	55	59	88	93		[2,]	55	72	88
ANDØY ENERG	[3,]	8	37	72			[3,]	55	72	88
ARDAL ENERGI	[4,]	37	48	59			[4,]	37	59	72
AS EIDEFOSS	[5,]	55	59	61	93		[5,]	55	72	88
AURLAND ENE	[6,]	48	88				[6,]	88	NA	NA
AUSTEVOLL KR	[7,]	37	59	72			[7,]	59	72	NA
BINDAL KRAFT	[8,]	8					[8,]	8	NA	NA
BKK NETT AS	[9,]	21	59	61			[9,]	59	72	NA
DALANE NETT	[10,]	55	59	88	93		[10,]	37	59	72
DRANGEDAL E	[11,]	8	55	72	88		[11,]	55	72	88
EIDSIVA NETT	[12,]	12					[12,]	37	59	88
FINNAS KRAFT	[13,]	37	59	72			[13,]	37	59	72
FITJAR KRAFTL	[14,]	37	48	88			[14,]	37	59	72
FJELBERG KRAI	[15,]	37	48	59			[15,]	37	59	88
FLESBERG ELEK	[16,]	37	59	72			[16,]	37	59	72
FOSEN NETT A	[17,]	55	59	88	93		[17,]	37	72	88
FUSA KRAFTLA	[18,]	8	37	72	88		[18,]	37	72	88
GLITRE ENERGI	[19,]	22	59	61			[19,]	59	88	NA
GUDBRANDSD	[20,]	55	59	88	93		[20,]	37	59	72
HAFSLUND NE	[21,]	21					[21,]	59	NA	NA
HALLINGDAL K	[22,]	22					[22,]	59	88	NA
HALOGALAND	[23,]	55	59	61			[23,]	37	59	72
HAMMERFEST	[24,]	55	59	72			[24,]	55	72	88
HARDANGER E	[25,]	55	59	72	88		[25,]	37	72	88
HAUGALAND K	[26,]	55	59	61			[26,]	37	59	72
HELGELAND KF	[27,]	55	59	61			[27,]	55	72	88
HEMSEDAL EN	[28,]	59	88	93			[28,]	59	88	NA
HJARTDAL ELV	[29,]	8	37	48			[29,]	37	72	88
HØLAND OG SI	[30,]	37	59	72	88		[30,]	37	59	72
HURUM NETT A	[31,]	37	48	59			[31,]	59	88	NA
ISE NETT AS	[32,]	37	59	72			[32,]	37	59	72
ISTAD NETT AS	[33,]	55	59	61	93		[33,]	37	59	72
JÆREN EVERK	[34,]	37	59	88			[34,]	59	88	NA
KLEPP ENERGI	[35,]	37	48	59			[35,]	59	88	NA
KRAGERØ ENE	[36,]	37	59	72			[36,]	59	72	NA
KRØDSHERAD	[37,]	37					[37,]	37	NA	NA
KVAM KRAFTV	[38,]	37	59	88			[38,]	59	88	NA
KVINNHERAD	[39,]	55	59	72	88		[39,]	37	59	72
LÆRDAL ENER	[40,]	8	37	48	88		[40,]	37	72	88
LOFOTKRAFT A	[41,]	55	59	72			[41,]	37	59	72
LUOSTEJOK KR	[42,]	8	55				[42,]	8	NA	NA
LUSTER ENERG	[43,]	8	37	72	88		[43,]	55	72	88
LYSE ELNETT A	[44,]	21	59				[44,]	59	NA	NA
MELØY ENERG	[45,]	37	59	72			[45,]	37	59	72
MIDTKRAFT AS	[46,]	55	59	88	93		[46,]	37	59	88
MIDT-TELEMAI	[47,]	55	59	88	93		[47,]	37	59	88
MODALEN KRA	[48,]	48					[48,]	8	72	NA
MØRENETT AS	[49,]	55	59	61	93		[49,]	37	59	72
NEAS AS	[50,]	55	59	88	93		[50,]	37	59	72
NESSET KRAFT	[51,]	8	37	72			[51,]	8	72	NA
NORDKRAFT N	[52,]	55	59	72			[52,]	37	59	72
NORDKYN KRA	[53,]	8	55				[53,]	8	NA	NA
NORDLANDSN	[54,]	55	59	61			[54,]	59	72	NA
NORD-ØSTERD	[55,]	55					[55,]	55	NA	NA
NORD-SALTEN	[56,]	8	55				[56,]	8	72	NA
NORDVEST NE	[57,]	55	59	88	93		[57,]	37	59	88
NORE ENERGI	[58,]	48	88				[58,]	59	88	NA
NORGESNETT	[59,]	59					[59,]	59	NA	NA
NOTODDEN EN	[60,]	37	59	88			[60,]	59	88	NA
NTE NETT AS	[61,]	61					[61,]	55	72	88
ODDA ENERGI	[62,]	37	48	59			[62,]	37	59	72
OPPDAL EVERK	[63,]	55	59	88	93		[63,]	37	59	88
ORKDAL ENER	[64,]	37	59	72	88		[64,]	37	59	72
ØVRE EIKER NE	[65,]	59	88	93			[65,]	59	88	NA
RAKKESTAD EN	[66,]	55	59	88	93		[66,]	55	72	88
RAULAND KRA	[67,]	8	55	72			[67,]	8	72	NA
RAUMA ENER	[68,]	55	59	72	88		[68,]	37	72	88
REPVAG KRAF	[69,]	8	55	72			[69,]	8	72	NA
RINGERIKS-KR	[70,]	22	59	93			[70,]	59	88	NA
ROLLAG ELEKT	[71,]	37	48	88			[71,]	59	88	NA
RØROS ELEKTR	[72,]	72					[72,]	72	NA	NA
SANDØY ENER	[73,]	37	48	88			[73,]	59	88	NA
SFE NETT AS	[74,]	55	59	61			[74,]	37	72	88
SKAGERAK NE	[75,]	21	59	61			[75,]	59	88	NA
SKJAK ENERGI	[76,]	8	48	88			[76,]	8	88	NA
SODVIN SA	[77,]	8	55	72	88		[77,]	55	72	88
SOGNEKRAFT A	[78,]	55	59	88	93		[78,]	37	72	88
SØR AURDAL E	[79,]	48	88				[79,]	88	NA	NA
STANGE ENER	[80,]	55	59	88	93		[80,]	59	88	NA
STRANDA ENE	[81,]	37	59	72	88		[81,]	37	59	88
STRYN ENERGI	[82,]	55	59	72	88		[82,]	37	72	88
SUNNDAL ENE	[83,]	37	59	72	88		[83,]	37	59	72
SUNNFJORD EI	[84,]	55	59	61	93		[84,]	55	72	88
SVORKA ENER	[85,]	55	59	72	88		[85,]	55	72	88
SYKKYLVEN EN	[86,]	37	48	59			[86,]	59	88	NA
TINN ENERGI A	[87,]	37	59	72	88		[87,]	37	59	72
TRØGSTAD ELV	[88,]	88					[88,]	88	NA	NA
TROLLFJORD N	[89,]	37	59	72	88		[89,]	37	72	88
TROMS KRAFT	[90,]	55	59	61			[90,]	37	59	72
TRØNDERENEF	[91,]	21	59	61			[91,]	59	72	NA
UVDAL KRAFTF	[92,]	8	37	48	88		[92,]	37	72	88
VALDRES ENEF	[93,]	93					[93,]	59	88	NA
VANG ENERGI	[94,]	8	48	88			[94,]	55	72	88
VARANGER KR	[95,]	55	59	61			[95,]	8	55	72
VESTERALSKRA	[96,]	55	59	72	88		[96,]	37	72	88
VEST-TELEMAF	[97,]	55	59	72			[97,]	55	72	88
VOKKS NETT A	[98,]	55	59	88	93		[98,]	55	72	88
VOSS ENERGI	[99,]	55	59	88	93		[99,]	37	59	88
YMBER AS	[100,]	8	55				[100,]	8	72	NA

Table 39: Peers for VRS and CRS Model. Source: Own contribution

Appendix G: Lambdas for Peers in Stage 1

Company #	8	12	21	22	37	48	55	59	61	72	88	93
[1,]		0,5373	0,5969						0,6866			
[2,]							0,5638	0,2588			0,7244	0,2393
[3,]	0,3539				0,2533					0,3929		
[4,]					0,2445	0,7283		0,2795				
[5,]							0,7795	0,2593	0,7278			0,8774
[6,]						0,5322					0,4678	
[7,]					0,9633			0,2566		0,2748		
[8,]												
[9,]			0,8894					0,4894	0,3293			
[10,]							0,4984	0,8336			0,5359	0,2362
[11,]	0,2649						0,2634			0,2323	0,4766	
[12,]												
[13,]					0,8639			0,5374		0,8595		
[14,]					0,7758	0,2853					0,5757	
[15,]					0,4498	0,5454		0,4726				
[16,]					0,7534			0,2224		0,2443		
[17,]							0,2478	0,2846			0,3822	0,3453
[18,]	0,6624				0,3568					0,9889	0,3788	
[19,]				0,3557				0,8474	0,7567			
[20,]							0,2542	0,8966			0,5373	0,6869
[21,]												
[22,]												
[23,]							0,8568	0,5276	0,3239			
[24,]							0,4492	0,2327		0,8455		
[25,]							0,3723	0,8865		0,2439	0,6623	
[26,]							0,5689	0,7395	0,4000			
[27,]							0,5443	0,2890	0,4349			
[28,]								0,3898			0,9647	0,3489
[29,]	0,2237				0,7326	0,4628						
[30,]					0,4970			0,2843		0,4224	0,6598	
[31,]					0,7327	0,2528		0,5244				
[32,]					0,4565			0,3640		0,5758		
[33,]							0,4776	0,6664	0,4879			0,4300
[34,]					0,6637			0,6237			0,2743	
[35,]					0,3784	0,5456		0,7594				
[36,]					0,5897			0,6388		0,3493		
[37,]												
[38,]					0,4857			0,4540			0,4749	
[39,]							0,8970	0,2875		0,4487	0,5445	
[40,]	0,8985				0,3424	0,3836					0,8434	
[41,]							0,3787	0,9935		0,5293		
[42,]	0,5854						0,4949					
[43,]	0,2760				0,3940					0,3667	0,2477	
[44,]			0,8868					0,9832				
[45,]					0,5486			0,3823		0,4829		
[46,]							0,7323	0,6256			0,4760	0,3896
[47,]							0,4000	0,5334			0,7274	0,2352
[48,]												
[49,]							0,6244	0,5793	0,6863			0,8996
[50,]							0,7224	0,8225			0,2838	0,8256
[51,]	0,5240				0,3953					0,8627		
[52,]							0,2285	0,9297		0,6967		
[53,]	0,8986						0,4885					
[54,]							0,6498	0,2860	0,6426			
[55,]												
[56,]	0,2287						0,7733					
[57,]							0,4873	0,5900			0,3257	0,4747
[58,]						0,3932					0,6678	
[59,]												
[60,]					0,6660			0,4793			0,7855	
[61,]												
[62,]					0,5389	0,4395		0,4785				
[63,]							0,2728	0,3893			0,9234	0,6544
[64,]					0,6927			0,4466		0,3592	0,5239	
[65,]								0,6523			0,8779	0,5684
[66,]							0,9424	0,4549			0,8997	0,5495
[67,]	0,4235						0,2770			0,5488		
[68,]							0,5378	0,9542		0,2277	0,7285	
[69,]	0,6289						0,2943			0,7697		
[70,]				0,3577				0,4679				0,5955

Company #	L8	L37	L55	L59	L72	L88
[1,]		3,4238		0,3457	9,5847	
[2,]			0,9958		0,8953	0,4995
[3,]			0,3267		0,4968	0,5547
[4,]		0,4834		0,3549	0,9466	
[5,]			0,3563		0,3799	0,7484
[6,]						0,4836
[7,]				0,2743	0,2679	
[8,]						
[9,]				0,9900	3,2558	
[10,]		3,4666		0,3749	0,9525	
[11,]			0,8394		0,2300	0,4525
[12,]		3,6766		0,2744		3,4959
[13,]		0,2788		0,6663	0,2947	
[14,]		0,7697		0,4353	0,4466	
[15,]		0,5934		0,4978		0,7887
[16,]		0,2690		0,9723	0,3658	
[17,]		2,8840			0,4492	0,8749
[18,]		0,3633			0,8879	0,4727
[19,]				0,8737		2,5966
[20,]		5,8358		0,2725	0,8524	
[21,]				7,5335		
[22,]				0,9637		4,5828
[23,]		0,2535		0,7939	2,8267	
[24,]			0,3993		0,5663	0,6863
[25,]		0,5433			0,5267	0,5778
[26,]		3,2753		0,6487	0,5326	
[27,]			0,3472		4,9244	3,2753
[28,]				0,5776		0,4730
[29,]		0,4586			0,6487	0,2473
[30,]		0,6596		0,7850	0,4798	
[31,]				0,6554		0,3956
[32,]		0,2452		0,4300	0,6592	
[33,]		4,7955		0,8947	0,6938	
[34,]				0,7349		0,5683
[35,]				0,8526		0,5499
[36,]				0,7324	0,4975	
[37,]						
[38,]				0,5346		0,6880
[39,]		0,3325		0,9444	0,3788	
[40,]		0,8857			0,2659	0,9364
[41,]		0,8592		0,5536	0,3923	
[42,]	3,3664					
[43,]			0,3797		0,4533	0,2523
[44,]				0,5346		
[45,]		0,6264		0,9380	0,5965	
[46,]		0,8354		0,5537		0,9739
[47,]		0,4235		0,6788		0,3368
[48,]	0,9860				0,4933	
[49,]		4,7874		0,5864	0,4499	
[50,]		2,9626		0,8420	0,5337	
[51,]	0,9426				0,3373	
[52,]		0,2483		0,7459	0,3246	
[53,]	0,5726					
[54,]				0,2363	2,8228	
[55,]						
[56,]	5,7299				0,7770	
[57,]		4,3578		0,8785		0,9456
[58,]				0,2873		0,6557
[59,]						
[60,]				0,5723		0,8594
[61,]			0,4874		4,5748	5,9945
[62,]		0,8929		0,5352	0,5474	
[63,]		0,9549		0,2393		0,6233
[64,]		0,7930		0,3639	0,8740	
[65,]				0,6876		0,2746
[66,]			0,4290		0,2387	0,9744
[67,]	0,5523				0,5728	
[68,]		0,3286			0,3273	0,6484
[69,]	2,2950				0,3257	
[70,]				0,8257		3,2326

Table 40: Lambda for the peers in stage 1. VRS and CRS 1/2. Source: Own contribution

[71,]					0,3858	0,3627					0,2558	
[72,]												
[73,]					0,4577	0,7623					0,9299	
[74,]							0,8294	0,9663	0,7399			
[75,]			0,6587					0,4976	0,3366			
[76,]	0,4458					0,4922					0,5587	
[77,]	0,7973						0,6239			0,3964	0,3672	
[78,]							0,2274	0,4567			0,7393	0,2286
[79,]						0,4746					0,9525	
[80,]							0,9862	0,2854			0,4483	0,5292
[81,]					0,7792			0,3869		0,7760	0,2943	
[82,]							0,3579	0,7574		0,5586	0,8782	
[83,]					0,6659			0,6385		0,8997	0,2772	
[84,]							0,8430	0,5354	0,5780			0,2837
[85,]							0,3428	0,2683		0,9535	0,4599	
[86,]					0,8350	0,4327		0,2766				
[87,]					0,3379			0,3777		0,2778	0,6568	
[88,]												
[89,]					0,9689			0,5968		0,5644	0,2330	
[90,]							0,7977	0,5365	0,6693			
[91,]			0,7655					0,4883	0,4560			
[92,]	0,6300				0,5628	0,3277					0,5498	
[93,]												
[94,]	0,2627					0,2883					0,6924	
[95,]							0,9230	0,6787	0,6258			
[96,]							0,3947	0,5489		0,2778	0,2764	
[97,]							0,8496	0,4327		0,7259		
[98,]							0,6266	0,4472			0,2656	0,2629
[99,]							0,6473	0,7868			0,8783	0,5588
[100,]	0,9664						0,9934					

[71,]				0,8373		0,4598
[72,]						
[73,]				0,6595		0,3784
[74,]		0,3747			2,4496	0,5846
[75,]				0,9633		2,6583
[76,]	0,4663					0,5895
[77,]			0,9975		0,3834	0,3256
[78,]		2,5483			0,3564	0,2394
[79,]						0,9539
[80,]				0,5472		0,8389
[81,]		0,8937		0,2265		0,6460
[82,]		0,3366			0,2238	0,7245
[83,]		0,3953		0,6523	0,4233	
[84,]			0,2424		0,5484	0,8644
[85,]			0,3248		0,2669	0,4988
[86,]				0,3656		0,3667
[87,]		0,6842		0,4756	0,6589	
[88,]						
[89,]		0,6246			0,5354	0,6426
[90,]		8,9900		0,9922	7,2786	
[91,]				0,3453	4,9756	
[92,]		0,4580			0,8759	0,5533
[93,]				0,6256		2,6234
[94,]			0,9770		0,8846	0,6430
[95,]	0,2324		0,6639		0,4843	
[96,]		0,2648			0,5598	0,3435
[97,]			0,3557		0,4869	0,2356
[98,]			0,4936		0,3798	0,2653
[99,]		2,4465		0,4648		0,2357
[100,]	5,9738				0,4453	

Table 41: Lambda for the peers in stage 1. VRS and CRS 2/2. Source: Own contribution

Appendix I: Bootstrapped Efficiency Scores

Company name	VRS BC	CRS BC
AGDER ENERGI NETT AS	0,7360	0,6862
ALTA KRAFTLAG SA	0,7247	0,7292
ANDØY ENERGI AS	0,5174	0,5207
ÅRDAL ENERGI KF	0,5439	0,5273
AS EIDEFOSS	0,8610	0,8778
AURLAND ENERGIVERK AS	0,4718	0,3942
AUSTEVOLL KRAFTLAG SA	0,5648	0,5731
BINDAL KRAFTLAG SA	0,8378	0,8872
BKK NETT AS	0,5763	0,5417
DALANE NETT AS	0,5426	0,5389
DRANGEDAL EVERK KF	0,8150	0,8243
EIDSIVA NETT AS	0,7809	0,6631
FINNÅS KRAFTLAG SA	0,6174	0,6262
FITJAR KRAFTLAG SA	0,4249	0,4263
FJELBERG KRAFTLAG SA	0,5477	0,4882
FLESBERG ELEKTRISITETSVERK AS	0,7665	0,7751
FOSEN NETT AS	0,9019	0,8970
FUSA KRAFTLAG SA	0,5431	0,5481
GLITRE ENERGI NETT AS	0,6561	0,6483
GUDBRANDSDAL ENERGI NETT AS	0,7863	0,7921
HAFSLUND NETT AS	0,7852	0,8247
HALLINGDAL KRAFTNETT AS	0,8784	0,8235
HÅLOGALAND KRAFT NETT AS	0,7620	0,7515
HAMMERFEST ENERGI NETT AS	0,5471	0,5510
HARDANGER ENERGI AS	0,6330	0,6309
HAUGALAND KRAFT NETT AS	0,5060	0,5025
HELGELAND KRAFT AS	0,5421	0,4991
HEMSEDAL ENERGI KF	0,6252	0,6331
HJARTDAL ELVERK AS	0,6657	0,6781
HØLAND OG SETSKOG ELVERK SA	0,9068	0,9170
HURUM NETT AS	0,7372	0,7212
ISE NETT AS	0,6098	0,6166
ISTAD NETT AS	0,7313	0,7357
JÆREN EVERK KF	0,6573	0,6605
KLEPP ENERGI AS	0,7247	0,6951
KRAGERØ ENERGI AS	0,6237	0,6330
KRØDSHERAD EVERK KF	0,9217	0,9597
KVAM KRAFTVERK AS	0,6129	0,6154
KVINNHERAD ENERGI AS	0,6591	0,6623
LÆRDAL ENERGI AS	0,4189	0,4261
LOFOTKRAFT AS	0,3422	0,3461
LUOSTEJOK KRAFTLAG SA	0,6641	0,5916
LUSTER ENERGIVERK AS	0,8286	0,8378
LYSE ELNETT AS	0,5466	0,5482
MELØY ENERGI AS	0,5841	0,5878
MIDTKRAFT AS	0,7253	0,7208
MIDT-TELEMARK ENERGI AS	0,7235	0,7233
MØRENETT AS	0,7866	0,7704
NEAS AS	0,4995	0,5011
NESSET KRAFT AS	0,5025	0,5160
NORDKRAFT NETT AS	0,6226	0,6253
NORDKYN KRAFTLAG SA	0,6367	0,6448
NORDLANDSNETT AS	0,5553	0,5335
NORD-ØSTERDAL KRAFTLAG SA	0,5538	0,5437
NORD-SALTEN KRAFT AS	0,8486	0,9146
NORDVEST NETT AS	0,7376	0,6724
NORE ENERGI AS	0,9060	0,8970
NORGESNETT AS	0,6639	0,6043
NOTODDEN ENERGI NETT AS	0,8629	0,9018
NTE NETT AS	0,4799	0,4866
ODDA ENERGI AS	0,7967	0,7636
OPPDAL EVERK AS	0,3608	0,3625
ORKDAL ENERGINETT AS	0,8882	0,8943
ØVRE EIKER NETT AS	0,8193	0,8304
RAKKESTAD ENERGI AS	0,8329	0,8476
RAULAND KRAFTFORSYNINGSLAG S.	0,8494	0,8595
RAUMA ENERGI AS	0,9301	0,9430
REPVÅG KRAFTLAG SA	0,6104	0,6117
RINGERIKS-KRAFT NETT AS	0,4565	0,4659

Table 42: Bootstrapped efficiency scores. 1/2. Source: Own contribution

ROLLAG ELEKTRISITETSVERK SA	0,7719	0,7637
RØROS ELEKTRISITETSVERK AS	0,8354	0,7791
SANDØY ENERGI AS	0,9450	0,9606
SFE NETT AS	0,5140	0,4123
SKAGERAK NETT AS	0,3935	0,3871
SKJÅK ENERGI KF	0,6301	0,5656
SODVIN SA	0,6562	0,6644
SOGNEKRAFT AS	0,8117	0,8230
SØR AURDAL ENERGI AS	0,5383	0,5337
STANGE ENERGI NETT AS	0,5628	0,5646
STRANDA ENERGI AS	0,6401	0,6502
STRYN ENERGI AS	0,5204	0,5338
SUNNDAL ENERGI KF	0,6618	0,6645
SUNNFJORD ENERGI AS	0,6127	0,6196
SVORKA ENERGI AS	0,5591	0,5697
SYKKYLVEN ENERGI AS	0,6415	0,6581
TINN ENERGI AS	0,7096	0,6917
TRØGSTAD ELVERK AS	0,6003	0,6037
TROLLFJORD NETT AS	0,8761	0,8902
TROMS KRAFT NETT AS	0,4851	0,4895
TRØNDERENERGI NETT AS	0,7748	0,7129
UVDAL KRAFTFORSYNING SA	0,7935	0,7366
VALDRES ENERGIVERK AS	0,6795	0,6971
VANG ENERGIVERK KF	0,8810	0,9161
VARANGER KRAFTNETT AS	0,6364	0,6165
VESTERÅLSKRAFT NETT AS	0,5332	0,5294
VEST-TELEMARK KRAFTLAG AS	0,5744	0,5729
VOKKS NETT AS	0,7008	0,7168
VOSS ENERGI NETT AS	0,8265	0,8286
YMBER AS	0,5139	0,5141

Table 43: Bootstrapped efficiency scores. 2/2. Source: Own contribution

Appendx J: OLS Regression Results

Coefficient	andard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95,0%	pper 95,0%
0,754068	0,035723	21,10895	3,07E-37	0,683129	0,825006	0,683129	0,825006
-0,20978	0,073428	-2,85702	0,005276	-0,3556	-0,06397	-0,3556	-0,06397
-0,04127	0,14644	-0,28181	0,778717	-0,33207	0,249533	-0,33207	0,249533
-0,04834	0,007804	-6,19438	1,58E-08	-0,06384	-0,03284	-0,06384	-0,03284
-0,04478	0,008064	-5,55311	2,65E-07	-0,0608	-0,02877	-0,0608	-0,02877
-0,02435	0,009416	-2,58619	0,011256	-0,04305	-0,00565	-0,04305	-0,00565

Table 44: Regression results for VRS

	Coefficients	andard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95,0%	pper 95,0%
Intercept	0,762402	0,036706	20,77024	1,07E-36	0,68951	0,835294	0,68951	0,835294
Z1	-0,2381	0,07545	-3,15574	0,002158	-0,38793	-0,08827	-0,38793	-0,08827
Z2	-0,06408	0,150473	-0,42584	0,671208	-0,36289	0,234732	-0,36289	0,234732
Z3: Geo 1	-0,0489	0,008019	-6,09803	2,43E-08	-0,06483	-0,03298	-0,06483	-0,03298
Z4: Geo 2	-0,05074	0,008287	-6,12371	2,16E-08	-0,0672	-0,03429	-0,0672	-0,03429
Z5: Geo 3	-0,02726	0,009675	-2,81706	0,005919	-0,04647	-0,00804	-0,04647	-0,00804

Table 45: Regression result for CRS

)bservatio	PredictedVRS	Residuals	'edicted CR	Residuals
1	0,72590	0,01010	0,72589	-0,03972
2	0,66554	0,05913	0,66021	0,06902
3	0,69124	-0,17384	0,68237	-0,16163
4	0,52294	0,02099	0,50904	0,01829
5	0,75084	0,11017	0,75521	0,12261
6	0,47499	-0,00318	0,46849	-0,07428
7	0,60920	-0,04439	0,58941	-0,01631
8	0,78615	0,05164	0,79363	0,09354
9	0,64621	-0,06993	0,64165	-0,09991
10	0,65620	-0,11365	0,65494	-0,11601
11	0,77106	0,04396	0,77455	0,04979
12	0,78245	-0,00152	0,78153	-0,11839
13	0,66868	-0,05124	0,65479	-0,02862
14	0,51418	-0,08930	0,48567	-0,05941
15	0,64887	-0,10121	0,63374	-0,14557
16	0,75325	0,01329	0,74927	0,02579
17	0,75356	0,14834	0,75473	0,14228
18	0,63251	-0,08944	0,63461	-0,08649
19	0,69489	-0,03881	0,68463	-0,03628
20	0,70744	0,07884	0,70502	0,08710
21	0,73025	0,05498	0,72186	0,10280
22	0,66599	0,21241	0,65794	0,16553
23	0,67823	0,08379	0,67592	0,07556
24	0,60444	-0,05739	0,59146	-0,04051
25	0,62174	0,01123	0,62008	0,01087
26	0,71106	-0,20503	0,70915	-0,20663
27	0,72601	-0,18386	0,72406	-0,22495
28	0,66584	-0,04063	0,65810	-0,02497
29	0,67343	-0,00770	0,67030	0,00784
30	0,84289	0,06388	0,84865	0,06832
31	0,70301	0,03424	0,69300	0,02817
32	0,62026	-0,01047	0,61573	0,00083
33	0,70124	0,03003	0,69786	0,03785
34	0,70788	-0,05053	0,69938	-0,03890
35	0,75007	-0,02539	0,74490	-0,04975
36	0,65691	-0,03320	0,64439	-0,01135
37	0,74478	0,17688	0,73827	0,22143
38	0,59014	0,02274	0,58533	0,03008
39	0,62789	0,03116	0,63164	0,03069
40	0,57179	-0,15286	0,56972	-0,14367
41	0,54683	-0,20463	0,52505	-0,17896
42	0,78047	-0,11636	0,78523	-0,19359
43	0,53880	0,28985	0,54050	0,29726
44	0,62567	-0,07912	0,61598	-0,06776
45	0,64888	-0,06482	0,64268	-0,05486
46	0,74107	-0,01582	0,73755	-0,01671
47	0,74887	-0,02536	0,74553	-0,02227
48	0,61257	-0,11309	0,60702	-0,10589
49	0,74969	-0,24722	0,74853	-0,23256
50	0,60484	0,01775	0,60470	0,02062

Table 46: Residuals from OLS regression 1/2. Source: Own contribution

51	0,64653	-0,00984	0,64457	0,00027
52	0,59649	-0,04117	0,58278	-0,04924
53	0,58511	-0,03134	0,57083	-0,02714
54	0,80759	0,04103	0,81567	0,09896
55	0,69739	0,04022	0,69713	-0,02468
56	0,67118	0,23484	0,66982	0,22716
57	0,65726	0,00663	0,65198	-0,04765
58	0,74389	0,11898	0,73892	0,16292
59	0,69791	-0,21803	0,69040	-0,20377
60	0,76937	0,02732	0,77196	-0,00833
61	0,40626	-0,04549	0,39020	-0,02767
62	0,71884	0,16936	0,71646	0,17783
63	0,69577	0,12358	0,69158	0,13883
64	0,71166	0,12123	0,70267	0,14493
65	0,85211	-0,00271	0,86028	-0,00075
66	0,68623	0,24388	0,68082	0,26219
67	0,61623	-0,00579	0,61497	-0,00326
68	0,59435	-0,13784	0,57807	-0,11217
69	0,73558	0,03632	0,72748	0,03619
70	0,71059	0,12477	0,70101	0,07805
71	0,78724	0,15778	0,79052	0,17010
72	0,25983	0,25421	0,18949	0,22283
73	0,61583	-0,22235	0,61280	-0,22575
74	0,68981	-0,05975	0,67806	-0,11249
75	0,74153	-0,08531	0,74238	-0,07794
76	0,71632	0,09536	0,71614	0,10689
77	0,51243	0,02589	0,50987	0,02384
78	0,68021	-0,11745	0,67301	-0,10837
79	0,80525	-0,16516	0,80585	-0,15569
80	0,49137	0,02902	0,48409	0,04971
81	0,63822	0,02356	0,64008	0,02443
82	0,57257	0,04011	0,56704	0,05253
83	0,59452	-0,03538	0,59294	-0,02321
84	0,69412	-0,05258	0,69504	-0,03692
85	0,53695	0,17264	0,52687	0,16486
86	0,65338	-0,05304	0,64535	-0,04167
87	0,83557	0,04052	0,83988	0,05028
88	0,58871	-0,10361	0,57211	-0,08258
89	0,66968	0,10516	0,66584	0,04704
90	0,71373	0,07974	0,71038	0,02624
91	0,72261	-0,04311	0,72198	-0,02485
92	0,70640	0,17460	0,70342	0,21266
93	0,65203	-0,01566	0,64500	-0,02851
94	0,72093	-0,18777	0,71792	-0,18857
95	0,64036	-0,06597	0,62900	-0,05609
96	0,70381	-0,00305	0,70157	0,01520
97	0,77179	0,05471	0,77338	0,05526
98	0,55516	-0,04122	0,54733	-0,03326
99	0,70872	0,04671	0,70509	0,04102

Table 47: Residuals from OLS-regression. Source: Own contribution

Appendix H: Adjusted Input After Environmental Variables

Company Name	Input VRS	Input CRS
AGDER ENERGI NETT AS	160150,888	168211,499
ALTA KRAFTLAG SA	26323,9236	26047,2561
ANDØY ENERGI AS	597290,884	591078,848
ARDAL ENERGI KF	82877,414	83105,8609
AS EIDEFOSS	21777,7443	21473,2188
AURLAND ENERGIVERK AS	17701,3602	18955,8487
AUSTEVOLL KRAFTLAG SA	62837,1142	61147,7097
BINDAL KRAFTLAG SA	57076,8585	54555,5546
BKK NETT AS	66340,6073	68199,8851
DALANE NETT AS	28605,8825	28666,4355
DRANGEDAL EVERK KF	1052408,89	1045991,63
EIDSIVA NETT AS	53805,3066	60083,9483
FINNAS KRAFTLAG SA	116413,368	113908,956
FITJAR KRAFTLAG SA	36741,1875	35732,7823
FJELBERG KRAFTLAG SA	37344,5395	38848,6285
FLESBERG ELEKTRISITETSVERK AS	30610,2069	30222,3064
FOSEN NETT AS	659242,616	663930,464
FUSA KRAFTLAG SA	26858,431	26785,6078
GLITRE ENERGI NETT AS	20291,9976	20242,684
GUDBRANDSDAL ENERGI NETT AS	20484,1136	20300,3765
HAFSLUND NETT AS	23128,1583	21957,9099
HALLINGDAL KRAFTNETT AS	254033,44	269155,111
HALOGALAND KRAFT NETT AS	72844,6147	73499,6092
HAMMERFEST ENERGI NETT AS	37198,6386	36604,8464
HARDANGER ENERGI AS	150672,299	150727,01
HAUGALAND KRAFT NETT AS	135178,253	135357,724
HELGELAND KRAFT AS	677559,552	701077,221
HEMSEDAL ENERGI KF	50366,5671	49608,5553
HJARTDAL ELVERK AS	40360,1991	39737,7684
HØLAND OG SETSKOG ELVERK SA	768374,375	764733,705
HURUM NETT AS	311221,719	313179,033
ISE NETT AS	27022,4375	26720,2191
ISTAD NETT AS	17214,5451	17075,6884
JÆREN EVERK KF	2814445,08	2783269,87
KLEPP ENERGI AS	94032,2877	96266,0354
KRAGERØ ENERGI AS	108156,265	105868,825
KRØDSHERAD EVERK KF	15563,8548	14721,495
KVAM KRAFTVERK AS	26373,8547	26175,635
KVINNHERAD ENERGI AS	66385,6522	66417,9119
LÆRDAL ENERGI AS	21977,0157	21801,8679
LOFOTKRAFT AS	102781,451	100591,064
LUOSTEJOK KRAFTLAG SA	42246,4622	45169,0743
LUSTER ENERGIVERK AS	7497,73042	7419,47388
LYSE ELNETT AS	527124,302	521576,237
MELØY ENERGI AS	58987,856	58436,4459
MIDTKRAFT AS	223878,54	224076,132
MIDT-TELEMARK ENERGI AS	41305,2339	41180,6548
MØRENETT AS	116556,887	115802,771
NEAS AS	380017,137	375550,555
NESSET KRAFT AS	75335,397	75115,035
NORDKRAFT NETT AS	55871,5561	55311,8735
NORDKYN KRAFTLAG SA	107158,901	107989,741
NORDLANDSNETT AS	606007,451	603540,404
NORD-ØSTERDAL KRAFTLAG SA	32650,8758	30678,6344
NORD-SALTEN KRAFT AS	149119,693	159203,516
NORDVEST NETT AS	349168,155	352673,317
NORE ENERGI AS	222815,749	234989,95
NORGESNETT AS	18312,0983	17398,8192
NOTODDEN ENERGI NETT AS	83593,827	82615,4099
NTE NETT AS	41369,4012	42885,5277
ODDA ENERGI AS	11095,6917	10906,5406
OPPDAL EVERK AS	23582,2506	23341,6086
ORKDAL ENERGINETT AS	29495,1056	28981,9466
ØVRE EIKER NETT AS	53345,8096	51907,047
RAKKESTAD ENERGI AS	25099,2009	25049,9515
RAULAND KRAFTFORSYNINGSLAG SA	22947,1756	22391,2886
RAUMA ENERGI AS	1300364,2	1297091,86
REPVAG KRAFTLAG SA	55295,5873	54048,3429
RINGERIKS-KRAFT NETT AS	23999,0331	24002,399

Table 48: Adjusted input after environmental variables. Source: Own contribution

ROLLAG ELEKTRISITETSVERK SA	13959,2956	14704,4824
RØROS ELEKTRISITETSVERK AS	24362,6304	24006,4342
SANDØY ENERGI AS	40027,7272	41711,729
SFE NETT AS	55492,0752	55646,2743
SKAGERAK NETT AS	53135,2869	55779,3131
SKJAK ENERGI KF	66845,0865	66391,1836
SODVIN SA	76814,2324	75835,2099
SOGNEKRAFT AS	1035548,34	1037725,9
SØR AURDAL ENERGI AS	88072,5013	87357,3084
STANGE ENERGI NETT AS	85341,1103	84647,7249
STRANDA ENERGI AS	89687,3531	87776,232
STRYN ENERGI AS	73378,6828	73313,7674
SUNNDAL ENERGI KF	51453,5625	50788,2981
SUNNFJORD ENERGI AS	66679,7578	65895,5381
SVORKA ENERGI AS	198944,011	195984,719
SYKKYLVEN ENERGI AS	20009,8828	20197,973
TINN ENERGI AS	493700,117	488369,939
TRØGSTAD ELVERK AS	123673,646	122415,671
TROLLFJORD NETT AS	32681,1395	32058,2868
TROMS KRAFT NETT AS	31125,5591	33147,032
TRØNDERENERGI NETT AS	12599,0369	13331,5369
UVDAL KRAFTFORSYNING SA	81750,3557	80319,1649
VALDRES ENERGIVERK AS	13722,6066	13089,8809
VANG ENERGIVERK KF	46303,8157	46889,7392
VARANGER KRAFTNETT AS	141029,697	141124,848
VESTERALSKRAFT NETT AS	12987,2882	12866,9553
VEST-TELEMARK KRAFTLAG AS	14111,0776	13854,4
VOKKS NETT AS	1072127,02	1071511,45
VOSS ENERGI NETT AS	31795,3399	31552,4098
YMBER AS	58219,3326	58566,6947

Table 49: Adjusted input after environmental variables. Source: Own contribution

Appendix K: Results from Second Stage DEA-Model

	VRS Model					CRS Model				
Company name	**VRS**	**SE**	**vrs - drs < 1e-4**	**Optimal Size**	**Optimal Size 1% CI**	**CRS**	**SE9**	**vrs - drs < 1e-4**	**Optimal Size2**	**mal Size 1%**
AGDER ENERGI NETT AS	0,8554	0,7065	TRUE	Above	Above	0,5489	0,6650	TRUE	Above	Above
ALTA KRAFTLAG SA	0,7314	0,9312	FALSE	Below	Below	0,6811	0,9511	TRUE	Above	Above
ANDØY ENERGI AS	0,3712	0,9943	TRUE	Above	At	0,3654	0,9976	FALSE	Below	At
ÅRDAL ENERGI KF	0,5382	0,9046	TRUE	Above	Above	0,4624	0,9102	FALSE	Below	Below
AS EIDEFOSS	0,9894	0,8923	FALSE	Below	Below	0,8860	0,9291	TRUE	Above	Above
AURLAND ENERGIVERK AS	0,5236	0,8024	TRUE	Above	Above	0,3878	0,8201	FALSE	Below	Below
AUSTEVOLL KRAFTLAG SA	0,4770	0,9922	TRUE	Above	At	0,4645	0,9994	TRUE	Above	At
BINDAL KRAFTLAG SA	1,0000	1,0000	TRUE	At	At	1,0000	1,0000	TRUE	At	At
BKK NETT AS	0,5792	0,8144	TRUE	Above	Above	0,4367	0,7994	TRUE	Above	Above
DALANE NETT AS	0,4162	0,9998	TRUE	Above	At	0,3954	0,9585	TRUE	Above	Above
DRANGEDAL EVERK KF	0,7933	0,9952	FALSE	Below	At	0,7861	0,9996	TRUE	Above	At
EIDSIVA NETT AS	1,0000	0,5872	TRUE	Above	Above	0,5006	0,5006	TRUE	Above	Above
FINNÅS KRAFTLAG SA	0,5336	0,9965	FALSE	Below	At	0,5179	0,9989	TRUE	Above	At
FITJAR KRAFTLAG SA	0,3817	0,8734	FALSE	Below	Below	0,3265	0,8617	FALSE	Below	Below
FJELBERG KRAFTLAG SA	0,5451	0,7327	TRUE	Above	Above	0,3657	0,7078	FALSE	Below	Below
FLESBERG ELEKTRISITETSVE	0,6572	0,9961	TRUE	Above	At	0,6366	0,9982	TRUE	Above	At
FOSEN NETT AS	0,9500	0,9712	TRUE	Above	Above	0,8851	0,9698	TRUE	Above	Above
FUSA KRAFTLAG SA	0,4631	0,9908	TRUE	Above	At	0,4517	0,9963	FALSE	Below	At
GLITRE ENERGI NETT AS	0,6393	0,9174	FALSE	Below	Below	0,5590	0,8993	TRUE	Above	Above
GUDBRANDSDAL ENERGI N	0,7906	0,9261	TRUE	Above	Above	0,7038	0,9160	TRUE	Above	Above
HAFSLUND NETT AS	1,0000	0,8445	FALSE	Below	Below	0,8451	0,8451	TRUE	Above	Above
HALLINGDAL KRAFTNETT A	1,0000	0,9503	FALSE	Below	Below	0,8573	0,8573	TRUE	Above	Above
HÅLOGALAND KRAFT NETT	0,8313	0,8229	FALSE	Below	Below	0,6519	0,8261	TRUE	Above	Above
HAMMERFEST ENERGI NET	0,4672	0,9237	TRUE	Above	Above	0,4269	0,9226	TRUE	Above	Above
HARDANGER ENERGI AS	0,5625	0,9779	TRUE	Above	Above	0,5372	0,9873	TRUE	Above	Above
HAUGALAND KRAFT NETT A	0,4226	0,8924	TRUE	Above	Above	0,3586	0,8727	TRUE	Above	Above
HELGELAND KRAFT AS	0,5111	0,6998	FALSE	Below	Below	0,3416	0,6770	TRUE	Above	Above
HEMSEDAL ENERGI KF	0,6163	0,9972	TRUE	Above	At	0,6051	0,9866	FALSE	Below	Below
HJARTDAL ELVERK AS	0,6082	0,9238	TRUE	Above	Above	0,5472	0,9311	FALSE	Below	Below
HØLAND OG SETSKOG ELVE	0,8236	0,9985	FALSE	Below	At	0,7905	0,9844	TRUE	Above	Above
HURUM NETT AS	0,7078	0,9766	FALSE	Below	Below	0,6535	0,9799	FALSE	Below	Below
ISE NETT AS	0,5196	0,9992	TRUE	Above	At	0,5019	0,9919	TRUE	Above	At
ISTAD NETT AS	0,7244	0,8944	TRUE	Above	Above	0,6227	0,8886	TRUE	Above	Above
JÆREN EVERK KF	0,5736	0,9973	FALSE	Below	At	0,5506	0,9978	TRUE	Above	At
KLEPP ENERGI AS	0,6747	0,9540	TRUE	Above	Above	0,5977	0,9562	FALSE	Below	Below
KRAGERØ ENERGI AS	0,5364	0,9985	TRUE	Above	At	0,5221	0,9964	TRUE	Above	At
KRØDSHERAD EVERK KF	1,0000	1,0000	TRUE	At	At	1,0000	1,0000	TRUE	At	At
KVAM KRAFTVERK AS	0,5678	0,9970	FALSE	Below	At	0,5433	0,9955	TRUE	Above	At
KVINNHERAD ENERGI AS	0,5721	0,9991	TRUE	Above	At	0,5467	0,9708	TRUE	Above	Above
LÆRDAL ENERGI AS	0,3919	0,8309	TRUE	Above	Above	0,3201	0,8366	FALSE	Below	Below
LOFOTKRAFT AS	0,2625	0,9162	TRUE	Above	Above	0,2356	0,9000	TRUE	Above	Above
LUOSTEJOK KRAFTLAG SA	0,6158	0,9148	TRUE	Above	Above	0,5035	0,9177	TRUE	Above	Above
LUSTER ENERGIVERK AS	1,0000	1,0000	FALSE	At	At	1,0000	1,0000	TRUE	At	At
LYSE ELNETT AS	0,5283	0,9311	FALSE	Below	Below	0,4723	0,9314	TRUE	Above	Above
MELØY ENERGI AS	0,4585	0,9986	FALSE	Below	At	0,4454	0,9952	TRUE	Above	At
MIDTKRAFT AS	0,6201	0,9997	FALSE	Below	At	0,5904	0,9687	TRUE	Above	Above
MIDT-TELEMARK ENERGI A	0,6287	0,9990	TRUE	Above	At	0,6005	0,9865	TRUE	Above	Above
MØRENETT AS	0,4457	0,9237	FALSE	Below	Below	0,3941	0,9095	TRUE	Above	Above
NEAS AS	0,3966	0,8786	FALSE	Below	Below	0,3369	0,8868	TRUE	Above	Above
NESSET KRAFT AS	0,5776	0,8897	TRUE	Above	Above	0,5019	0,9061	FALSE	Below	Below
NORDKRAFT NETT AS	0,5622	0,9608	FALSE	Below	Below	0,5221	0,9245	TRUE	Above	Above
NORDKYN KRAFTLAG SA	0,5508	0,9814	FALSE	Below	Below	0,5126	0,9657	TRUE	Above	Above
NORDLANDSNETT AS	0,5315	0,8486	TRUE	Above	Above	0,4327	0,8393	TRUE	Above	Above
NORD-ØSTERDAL KRAFTLA	1,0000	0,9634	FALSE	Below	Below	1,0000	1,0000	TRUE	At	At
NORD-SALTEN KRAFT AS	0,8195	0,8893	FALSE	Below	Below	0,6530	0,9025	TRUE	Above	Above
NORDVEST NETT AS	1,0000	1,0000	TRUE	At	At	0,9441	0,9441	TRUE	Above	Above
NORE ENERGI AS	0,6883	0,9287	FALSE	Below	Below	0,5968	0,9658	FALSE	Below	Below
NORGESNETT AS	1,0000	1,0000	TRUE	At	At	1,0000	1,0000	TRUE	At	At
NOTODDEN ENERGI NETT A	0,3561	0,9975	TRUE	Above	At	0,3426	0,9931	TRUE	Above	At
NTE NETT AS	1,0000	0,7398	TRUE	Above	Above	0,7063	0,7063	TRUE	Above	Above
ODDA ENERGI AS	0,3245	0,9692	FALSE	Below	Below	0,3047	0,9736	FALSE	Below	Below
OPPDAL EVERK AS	0,9409	0,9984	TRUE	Above	At	0,9036	0,9791	TRUE	Above	Above
ORKDAL ENERGINETT AS	0,8316	0,9975	TRUE	Above	At	0,8039	0,9905	TRUE	Above	At
ØVRE EIKER NETT AS	0,8594	0,9984	TRUE	Above	At	0,8402	0,9924	TRUE	Above	At
RAKKESTAD ENERGI AS	0,8678	0,9778	TRUE	Above	Above	0,8415	0,9940	TRUE	Above	At
RAULAND KRAFTFORSYNIN	1,0000	1,0000	TRUE	At	At	1,0000	1,0000	TRUE	At	At
RAUMA ENERGI AS	0,5484	0,9914	TRUE	Above	At	0,5338	0,9954	TRUE	Above	At
REPVÅG KRAFTLAG SA	0,4055	0,9401	TRUE	Above	Above	0,3759	0,9448	TRUE	Above	Above

Table 50: Second stage DEA-scores for the new VRS and CRS Model. 1/2. Source: Own contribution

RINGERIKS-KRAFT NETT AS	0,7278	0,9621	FALSE	Below	Below	0,6663	0,9162	TRUE	Above	Above
ROLLAG ELEKTRISITETSVER	0,9706	0,8392	TRUE	Above	Above	0,7396	0,8310	FALSE	Below	Below
RØROS ELEKTRISITETSVERK	0,9755	0,9642	FALSE	Below	Below	0,9239	0,9513	TRUE	Above	Above
SANDØY ENERGI AS	1,0000	0,4882	TRUE	Above	Above	0,4466	0,4466	FALSE	Below	Below
SFE NETT AS	0,3358	0,7958	TRUE	Above	Above	0,2602	0,7986	TRUE	Above	Above
SKAGERAK NETT AS	0,6458	0,7907	FALSE	Below	Below	0,4624	0,7734	TRUE	Above	Above
SKJÅK ENERGI KF	0,6449	0,9775	FALSE	Below	Below	0,6281	0,9929	FALSE	Below	At
SODVIN SA	0,8142	0,9821	FALSE	Below	Below	0,8012	0,9969	TRUE	Above	At
SOGNEKRAFT AS	0,4693	0,9896	FALSE	Below	Below	0,4448	0,9732	TRUE	Above	Above
SØR AURDAL ENERGI AS	0,5420	0,9938	TRUE	Above	At	0,5339	0,9907	FALSE	Below	At
STANGE ENERGI NETT AS	0,4991	0,9996	TRUE	Above	At	0,4792	0,9946	TRUE	Above	At
STRANDA ENERGI AS	0,4833	0,9999	TRUE	Above	At	0,4697	0,9996	TRUE	Above	At
STRYN ENERGI AS	0,6316	0,9954	TRUE	Above	At	0,6168	0,9969	TRUE	Above	At
SUNNDAL ENERGI KF	0,5516	0,9964	FALSE	Below	At	0,5304	0,9814	TRUE	Above	Above
SUNNFJORD ENERGI AS	0,5503	0,8609	FALSE	Below	Below	0,4744	0,8990	TRUE	Above	Above
SVORKA ENERGI AS	0,6150	0,9607	TRUE	Above	Above	0,5922	0,9943	TRUE	Above	At
SYKKYLVEN ENERGI AS	0,7766	0,9750	FALSE	Below	Below	0,7143	0,9802	FALSE	Below	Below
TINN ENERGI AS	0,4869	0,9985	FALSE	Below	At	0,4685	0,9702	TRUE	Above	Above
TRØGSTAD ELVERK AS	1,0000	1,0000	FALSE	At	At	1,0000	1,0000	TRUE	At	At
TROLLFJORD NETT AS	0,3683	0,9999	TRUE	Above	At	0,3617	0,9855	TRUE	Above	Above
TROMS KRAFT NETT AS	0,9640	0,6827	FALSE	Below	Below	0,5946	0,6407	TRUE	Above	Above
TRØNDERENERGI NETT AS	0,9044	0,7960	TRUE	Above	Above	0,6484	0,7730	TRUE	Above	Above
UVDAL KRAFTFORSYNING S	0,6841	0,8270	TRUE	Above	Above	0,5529	0,8186	FALSE	Below	Below
VALDRES ENERGIVERK AS	1,0000	1,0000	FALSE	At	At	1,0000	1,0000	TRUE	At	At
VANG ENERGIVERK KF	0,6703	0,9561	TRUE	Above	Above	0,6264	0,9803	FALSE	Below	Below
VARANGER KRAFTNETT AS	0,4854	0,8186	FALSE	Below	Below	0,3883	0,8247	TRUE	Above	Above
VESTERÅLSKRAFT NETT AS	0,4875	0,9204	TRUE	Above	Above	0,4383	0,9080	TRUE	Above	Above
VEST-TELEMARK KRAFTLAG	0,7123	0,8641	FALSE	Below	Below	0,6160	0,8965	TRUE	Above	Above
VOKKS NETT AS	0,8326	0,9049	TRUE	Above	Above	0,7435	0,9244	TRUE	Above	Above
VOSS ENERGI NETT AS	0,4313	0,9987	TRUE	Above	At	0,4136	0,9715	TRUE	Above	Above
YMBER AS	0,8616	0,8879	TRUE	Above	Above	0,7305	0,9067	TRUE	Above	Above

Table 51: Second stage DEA-scores for the new VRS and CRS Model. 2/2. Source: Own contribution

Appendix L: Merger Combinations with Efficiency Scores and Decomposed Gains

Merger ID	Firm 1	Firm 2	E_VRS	E_CRS	E*_VRS	E*_CRS	L_VRS	L_CRS	H_VRS	H_CRS	S_VRS	S_CRS
[1]	12	54	Inf	0,5258198	Inf	0,9944335	NaN	0,5287631	0,8481222	0,9944335	Inf	1
[2]	12	79	Inf	0,4986209	Inf	0,9988605	NaN	0,4991897	0,8576353	0,9988605	Inf	1
[3]	54	79	0,8304356	0,6973909	1,130856	0,9729503	0,7343425	0,7167796	0,9888611	0,9729503	1,1435944	1
[4]	5	20	1,0062399	0,7671943	1,1412219	0,9747149	0,8817216	0,7870961	1	0,9747149	1,1412219	1
[5]	5	75	0,9584302	0,8338705	1,0415954	1	0,920156	0,8338705	0,951847	1	1,0942886	1
[6]	5	78	0,9077587	0,7875534	1,0450168	0,9961813	0,8686546	0,7905724	0,9551936	0,9961813	1,0940366	1
[7]	5	92	1,1451414	0,9243523	1,1523699	0,9920602	0,9937273	0,9317502	0,9939376	0,9920602	1,1593987	1
[8]	5	93	0,9644791	0,8351263	1,0390995	1	0,9281875	0,8351263	0,9495357	1	1,0943238	1
[9]	5	97	1,0647397	0,8136275	1,168158	0,9986932	0,9114689	0,8146922	0,9962541	0,9986932	1,1725502	1
[10]	20	75	0,7964009	0,6639677	1,0409836	0,9615401	0,7650466	0,6905253	0,9060215	0,9615401	1,1489613	1
[11]	20	78	0,7635835	0,6372659	1,0440241	0,9607129	0,7313849	0,6633261	0,9123212	0,9607129	1,1443602	1
[12]	20	92	1,0021744	0,8003073	1,1545471	0,9871805	0,8680239	0,8107001	0,9919115	0,9871805	1,1639617	1
[13]	20	93	0,8002455	0,6668624	1,0386095	0,9655552	0,770497	0,6906518	0,9080271	0,9655552	1,143809	1
[14]	20	97	0,9301351	0,7075096	1,1486574	0,9799373	0,8097585	0,7219947	0,9961367	0,9799373	1,1531123	1
[15]	75	78	0,5910814	0,5654707	1,0127219	0,9884193	0,5836561	0,572096	0,9896846	0,9884193	1,0232775	1
[16]	75	92	0,9512595	0,8914353	1,0505853	0,9926552	0,9054568	0,8980312	0,9878653	0,9926552	1,0634904	1
[17]	75	93	0,653732	0,6272855	0,9946887	1	0,6572228	0,6272855	1	1	0,9946887	1
[18]	75	97	0,8253294	0,7185385	1,0387224	0,9976424	0,794562	0,7202365	0,9603343	0,9976424	1,0816259	1
[19]	78	92	0,8971215	0,833754	1,0670939	1	0,8407146	0,833754	0,9982581	1	1,0689559	1
[20]	78	93	0,5960052	0,5650279	1,0065012	0,9903445	0,5921555	0,5705367	0,9899781	0,9903445	1,0166903	1
[21]	78	97	0,7853247	0,6836436	1,0421778	0,9954121	0,753542	0,6867946	0,9620202	0,9954121	1,0833221	1
[22]	92	93	0,9616241	0,8990961	1,0499074	0,9985347	0,9159133	0,9004155	0,9902081	0,9985347	1,0602896	1
[23]	92	97	1,0478806	0,8431147	1,1622119	0,9961692	0,9016261	0,846357	0,9906689	0,9961692	1,1731588	1
[24]	93	97	0,8301156	0,7201907	1,036072	0,9994159	0,8012142	0,7206116	0,957379	0,9994159	1,0821963	1
[25]	11	29	0,7031581	0,6784439	0,9856494	0,9926274	0,7133958	0,6834829	0,9718328	0,9926274	1,0142171	1
[26]	11	36	0,585576	0,5628371	0,9652491	0,9457423	0,6066579	0,5951273	0,9554702	0,9457423	1,0102346	1
[27]	11	47	0,6559495	0,6134571	0,973338	0,9417519	0,6739175	0,6513999	0,9556331	0,9417519	1,0185269	1
[28]	11	59	0,4272631	0,4085995	0,9297753	0,9122074	0,4595337	0,4479239	0,9291929	0,9122074	1,0006268	1
[29]	11	66	0,952669	0,8781042	1,0739675	0,9954303	0,8870557	0,8821353	0,9953766	0,9954303	1,078956	1
[30]	11	74	0,6570004	0,4650543	1,0127289	0,9927624	0,6487426	0,4684447	0,8548337	0,9927624	1,1847087	1
[31]	11	86	0,5711798	0,5407772	0,9906431	0,9626515	0,5765747	0,561758	0,9663881	0,9626515	1,0250986	1
[32]	11	96	0,7835799	0,6445958	1,0786979	0,998009	0,7264128	0,6458818	0,9501462	0,998009	1,1352968	1
[33]	29	36	0,540422	0,5262727	0,9783449	0,9972181	0,5523839	0,5277408	0,9813469	0,9972181	0,9969409	1
[34]	29	47	0,6029623	0,5779432	0,9661512	0,9817558	0,6240869	0,5886832	0,9685333	0,9817558	0,9975404	1
[35]	29	59	0,386176	0,3722273	0,9554709	0,9758508	0,4041735	0,3814387	0,9586047	0,9758508	0,9967308	1
[36]	29	66	0,8433239	0,782568	1,037602	1	0,8127624	0,782568	0,9959523	1	1,041819	1
[37]	29	74	0,6498284	0,4629241	1,0070507	0,998526	0,6452787	0,4636075	0,847555	0,998526	1,1881833	1
[38]	29	86	0,5032806	0,4860606	0,9754501	0,9975017	0,515947	0,487278	0,9780148	0,9975017	0,9973777	1
[39]	29	96	0,7223672	0,6038016	1,0349682	0,9956037	0,6979608	0,6064678	0,9272551	0,9956037	1,1161634	1
[40]	36	47	0,5803224	0,5529891	0,996501	0,9847826	0,5823601	0,5615342	0,9861029	0,9847826	1,0105446	1
[41]	36	59	0,4266732	0,4127138	0,9752063	0,9751901	0,4375209	0,4232137	0,9768395	0,9751901	0,998328	1
[42]	36	66	0,6721756	0,6336107	1,0392855	0,9968212	0,646767	0,6356313	1	0,9968212	1,0392855	1
[43]	36	74	0,6515688	0,4633876	1,0175888	0,9960182	0,6403065	0,4652401	0,8626605	0,9960182	1,1795937	1
[44]	36	86	0,5130873	0,4964618	1,0004891	1	0,5128365	0,4964618	0,9997619	1	1,0007273	1
[45]	36	96	0,7047067	0,5498336	1,0855029	0,9441197	0,6491983	0,5823769	0,95015	0,9441197	1,1424542	1
[47]	47	66	0,7471927	0,6798474	1,0413157	0,9787988	0,7175467	0,6945732	0,9830283	0,9787988	1,0592937	1
[46]	47	59	0,481335	0,4591044	1,0055564	1	0,4786753	0,4591044	1	1	1,0055564	1
[48]	47	74	0,6683534	0,4690178	1,0362399	1	0,6449794	0,4690178	0,8823773	1	1,1743728	1
[49]	47	86	0,5718446	0,5311881	1,0195626	0,9880052	0,5608725	0,5376369	0,9884739	0,9880052	1,0314512	1
[50]	47	96	0,7452519	0,5900125	1,0920411	0,9666067	0,6824395	0,6103957	0,9507832	0,9666067	1,1485701	1
[54]	59	96	0,5934305	0,4825183	1,0444798	0,9556976	0,5681588	0,5048859	0,9207911	0,9556976	1,1343288	1
[55]	66	74	0,6564566	0,4667576	1,0073871	0,9918238	0,6516429	0,4706054	0,8496676	0,9918238	1,1856249	1
[51]	59	66	0,4802749	0,4586615	0,9844961	0,9642023	0,4878383	0,4756901	0,9701904	0,9642023	1,0147452	1
[52]	59	74	0,6436556	0,4555274	1,024558	1	0,6282276	0,4555274	0,8683491	1	1,1798917	1
[53]	59	86	0,4054664	0,3907392	0,9837841	0,9853704	0,4121498	0,3965404	0,9859548	0,9853704	0,9977984	1
[56]	66	86	0,663149	0,6027411	1,0729512	0,9995919	0,6180608	0,6029872	1	0,9995919	1,0729512	1
[57]	66	96	0,8546301	0,6728387	1,131755	1	0,7551371	0,6728387	0,9899219	1	1,1432771	1

[58]	74	86	0,6535558	0,4620885	1,0235904	0,9987213	0,6384935	0,4626802	0,867512	0,9987213	1,1799151	1
[59]	74	96	0,6661504	0,4627238	1,0222946	0,9742165	0,6516228	0,4749702	0,875885	0,9742165	1,1671562	1
[60]	86	96	0,6972289	0,5546184	1,0958118	0,9799254	0,636267	0,5659802	0,9601293	0,9799254	1,1413169	1
[61]	16	19	0,651826	0,5592361	1,0183311	0,9939869	0,6400924	0,5626192	0,919046	0,9939869	1,1080307	1
[62]	16	21	Inf	0,8416654	Inf	0,9983328	NaN	0,843071	0,9759755	0,9983328	Inf	1
[63]	16	22	0,9844315	0,7944557	1,0531427	0,9716387	0,934756	0,8176452	0,9321439	0,9716387	1,1298069	1
[64]	16	28	0,5953443	0,5785055	0,9388108	0,934765	0,6341472	0,6188781	0,9375863	0,934765	1,001306	1
[65]	16	30	0,7473313	0,7208206	0,9992517	1	0,747891	0,7208206	0,9997358	1	0,9995157	1
[66]	16	31	0,6610065	0,6296217	0,9624798	0,9738024	0,6867744	0,64656	0,9657694	0,9738024	0,9965938	1
[67]	16	37	0,764065	0,7498196	0,9959651	1	0,7671604	0,7498196	1	1	0,9959651	1
[68]	16	46	0,646226	0,5935278	1,0279858	0,9876727	0,6286332	0,6009357	0,9899508	0,9876727	1,0384211	1
[69]	16	57	0,6201931	0,5893942	0,9257871	0,951069	0,669909	0,6197176	0,9326077	0,951069	0,9926865	1
[70]	16	58	1,0065314	0,9706323	1,0340143	0,9998154	0,9734212	0,9708115	1	0,9998154	1,0340143	1
[71]	16	64	0,7562352	0,7359664	0,9646796	0,9639111	0,7839237	0,763521	0,9670378	0,9639111	0,9975614	1
[72]	16	65	0,7572776	0,7203353	0,985245	0,9661358	0,7686186	0,7455839	0,9529343	0,9661358	1,0339066	1
[73]	16	69	0,7222772	0,6482331	1,0092692	0,9803558	0,7156438	0,6612223	0,9482225	0,9803558	1,0643801	1
[74]	16	70	0,6802654	0,6443305	0,9022212	0,9618449	0,7539897	0,6698902	0,9099707	0,9618449	0,9914838	1
[75]	16	87	0,7834849	0,7584031	0,9794146	0,9622297	0,7999522	0,7881727	0,9640454	0,9622297	1,0159425	1
[76]	16	91	0,617644	0,6005407	0,9253971	0,9928722	0,6674367	0,604852	0,9427763	0,9928722	0,981566	1
[77]	19	21	Inf	0,7930567	Inf	0,9950582	NaN	0,7969952	0,9994025	0,9950582	Inf	1
[78]	19	22	0,8233503	0,608312	1,1737365	0,9922023	0,701478	0,6130927	1	0,9922023	1,1737365	1
[79]	19	28	0,662412	0,5572393	1,0384472	0,9919925	0,637887	0,5617375	0,9242134	0,9919925	1,1236011	1
[80]	19	30	0,6707019	0,5681285	1,0326854	0,9935162	0,6494736	0,5718362	0,9224573	0,9935162	1,1194941	1
[81]	19	31	0,6639984	0,565173	1,031574	1	0,643675	0,565173	0,9246235	1	1,1156692	1
[82]	19	37	0,6614324	0,5684961	1,0216561	1	0,647412	0,5684961	0,9232297	1	1,106611	1
[83]	19	46	0,6981716	0,5634461	1,0967917	1	0,6365581	0,5634461	0,9448438	1	1,160818	1
[84]	19	57	0,6516814	0,5570109	1,0168843	0,9940635	0,640861	0,5603373	0,9175581	0,9940635	1,1082505	1
[85]	19	58	0,9280104	0,7164585	1,2019227	1	0,7721049	0,7164585	1	1	1,2019227	1
[86]	19	64	0,6981413	0,5799143	1,0642614	1	0,6559867	0,5799143	0,9351471	1	1,1380685	1
[87]	19	65	0,6756909	0,5649109	1,0376428	0,984549	0,6511787	0,5737763	0,9198767	0,984549	1,1280238	1
[88]	19	69	0,7523922	0,579361	1,1467559	0,9998013	0,6561049	0,5794762	0,9703623	0,9998013	1,1817812	1
[89]	19	70	0,6538699	0,5625144	1,0116305	0,9989415	0,6463524	0,5631105	0,9169641	0,9989415	1,103239	1
[90]	19	87	0,6731001	0,5678	1,033249	0,9895183	0,6514404	0,5738146	0,9220285	0,9895183	1,1206258	1
[91]	19	91	0,645296	0,5577613	1,0073865	0,9980472	0,6405645	0,5588526	0,9154589	0,9980472	1,100417	1
[92]	21	22	Inf	0,8364888	Inf	0,9892051	NaN	0,8456171	0,9815946	0,9892051	Inf	1
[93]	21	28	Inf	0,8392616	Inf	0,9966274	NaN	0,8421016	0,9746417	0,9966274	Inf	1
[94]	21	30	Inf	0,8426074	Inf	0,9978105	NaN	0,8444563	0,9761725	0,9978105	Inf	1
[96]	21	37	Inf	0,8449732	Inf	0,9990479	NaN	0,8457784	0,9762276	0,9990479	Inf	1
[95]	21	31	Inf	0,8418623	Inf	0,9993178	NaN	0,842437	0,9774291	0,9993178	Inf	1
[97]	21	46	Inf	0,8338839	Inf	0,9963703	NaN	0,8369216	0,9783456	0,9963703	Inf	1
[98]	21	57	Inf	0,8415205	Inf	0,9978799	NaN	0,8433084	0,9748615	0,9978799	Inf	1
[99]	21	58	Inf	0,8607248	Inf	1	NaN	0,8607248	1	1	Inf	1
[262]	50	72	0,4946672	0,469409	0,7111504	0,9658729	0,6955873	0,4859946	0,9715917	0,9658729	0,7319437	1
[411]	40	6	0,3627195	0,3484632	0,8078764	0,9935151	0,448979	0,3507377	1	0,9935151	0,8078764	1
[376]	15	14	0,3605291	0,3420705	0,8085249	0,9986678	0,4459097	0,3425268	0,9971622	0,9986678	0,8108259	1
[195]	70	91	0,6628511	0,625093	0,8237825	0,984908	0,8046433	0,6346715	0,9918162	0,984908	0,8305799	1
[278]	72	80	0,4797944	0,4585146	0,801581	0,9875671	0,59856	0,4642871	0,9504312	0,9875671	0,8433868	1
[404]	6	4	0,4106591	0,3770857	0,7723568	0,8815289	0,5316961	0,4277633	0,8914173	0,8815289	0,8664368	1
[175]	57	91	0,6033246	0,5754057	0,8791135	0,9973572	0,6862875	0,5769303	0,9937328	0,9973572	0,8846578	1
[173]	57	70	0,7123313	0,6512955	0,891498	0,9976775	0,7990273	0,6528117	0,9979962	0,9976775	0,8932879	1
[281]	72	85	0,6858101	0,6385552	0,8180244	1	0,8383736	0,6385552	0,9137073	1	0,8952806	1
[405]	40	4	0,393892	0,3754187	0,8509864	0,963849	0,4628652	0,3894996	0,938038	0,963849	0,9071982	1
[158]	37	70	0,9052502	0,8611039	0,9183838	0,9938859	0,9856992	0,8664012	1	0,9938859	0,9183838	1
[160]	37	91	0,7546216	0,7429398	0,9188183	1	0,8212957	0,7429398	1	1	0,9188183	1
[387]	61	15	0,3320965	0,3166485	0,8932079	0,9945931	0,3718021	0,3183699	0,9580103	0,9945931	0,9323572	1
[352]	15	7	0,4456265	0,4248876	0,8890368	0,9933166	0,5012464	0,4277464	0,941833	0,9933166	0,9439431	1
[383]	18	15	0,4216847	0,3990447	0,8563638	0,9498497	0,492413	0,4201135	0,9015394	0,9498497	0,9498906	1
[263]	50	80	0,4876294	0,4753707	0,931642	0,9830712	0,5234086	0,4835567	0,9701399	0,9830712	0,9603171	1
[279]	72	82	0,533998	0,5083895	0,8345756	0,9906145	0,6398438	0,5132062	0,8681714	0,9906145	0,9613028	1
[153]	37	57	0,7848437	0,7490626	0,9633536	0,9989066	0,8146995	0,7498825	1	0,9989066	0,9633536	1
[381]	61	14	0,3207393	0,3111127	0,9392622	1	0,34148	0,3111127	0,9747423	1	0,9636006	1

[151]	31	91	0,6439107	0,6120801	0,9191255	0,9818386	0,7005689	0,6234019	0,9534268	0,9818386	0,9640232	1
[194]	70	87	0,9340412	0,8943255	0,944742	0,9982737	0,9886734	0,8958721	0,9729803	0,9982737	0,9709775	1
[369]	15	13	0,4966348	0,475086	0,9256449	0,995689	0,5365284	0,477143	0,9517705	0,995689	0,9725506	1
[130]	28	91	0,583525	0,5723063	0,9143966	0,9728459	0,6381531	0,5882805	0,9360756	0,9728459	0,9768405	1
[149]	31	70	0,7159087	0,6683827	0,9284256	0,9902531	0,7710997	0,6749615	0,9496244	0,9902531	0,9776767	1
[128]	28	70	0,6672557	0,6414301	0,9432949	1	0,7073671	0,6414301	0,9610956	1	0,9814787	1
[351]	14	7	0,4095591	0,4008691	0,9458114	1	0,4330241	0,4008691	0,9628578	1	0,982296	1
[377]	18	14	0,4004655	0,3925103	0,9413423	0,9947555	0,4254196	0,3945797	0,958015	0,9947555	0,9825966	1
[121]	28	37	0,7069229	0,6957324	0,9831571	0,9830511	0,7190335	0,7077276	1	0,9830511	0,9831571	1
[142]	31	37	0,7682275	0,7365447	0,9834152	1	0,7811832	0,7365447	1	1	0,9834152	1
[357]	61	7	0,3674772	0,357062	0,9804285	1	0,3748128	0,357062	0,9956484	1	0,9847135	1
[196]	87	91	0,8117716	0,7935798	0,9508214	0,9996342	0,8537582	0,7938702	0,9619162	0,9996342	0,9884659	1
[209]	34	35	0,6047122	0,5720673	0,9772881	1	0,6187655	0,5720673	0,9879885	1	0,9891695	1
[123]	28	57	0,6287765	0,5995733	0,9803178	0,9958467	0,6414007	0,6020739	0,9867659	0,9958467	0,9934654	1
[266]	50	85	0,626116	0,5954203	0,92375	0,9768681	0,6777982	0,6095196	0,9297633	0,9768681	0,9935324	1
[350]	13	7	0,5096173	0,4975102	0,9955359	1	0,5119025	0,4975102	1	1	0,9955359	1
[374]	61	13	0,4109139	0,3987718	0,985363	1	0,4170177	0,3987718	0,9896807	1	0,9956373	1
[406]	43	4	0,6818139	0,6548077	0,9320191	0,9549195	0,731545	0,6857203	0,936087	0,9549195	0,9956544	1
[368]	14	13	0,4634405	0,4517566	0,963683	1	0,4809055	0,4517566	0,9678608	1	0,9956835	1
[264]	50	82	0,5358124	0,519023	0,953985	0,999414	0,5616571	0,5193273	0,9579397	0,999414	0,9958717	1
[284]	80	85	0,5954713	0,5709112	0,9775902	0,9903616	0,6091216	0,5764674	0,9816092	0,9903616	0,9959058	1
[353]	18	7	0,4442923	0,4311103	0,9452532	0,9411565	0,4700246	0,4580644	0,9488064	0,9411565	0,9962552	1
[385]	38	15	0,5198393	0,49125	0,9260509	1	0,5613507	0,49125	0,9294503	1	0,9963425	1
[144]	31	57	0,6466548	0,6015259	0,9220216	0,9484668	0,7013445	0,6342087	0,9253845	0,9484668	0,996366	1
[286]	82	85	0,6277204	0,5995687	0,9815838	0,9939296	0,6394975	0,6032305	0,9850697	0,9939296	0,9964613	1
[399]	61	38	0,4114493	0,3961509	0,9709334	0,9839525	0,4237667	0,4026118	0,9743561	0,9839525	0,9964872	1
[379]	38	14	0,4781108	0,4618018	0,9616486	0,9993738	0,4971782	0,4620912	0,9649734	0,9993738	0,9965546	1
[392]	61	18	0,347693	0,3352392	0,939577	0,9483577	0,3700527	0,3534945	0,9426529	0,9483577	0,996737	1
[282]	80	82	0,5125901	0,4958794	0,9854658	0,9866538	0,5201501	0,502587	0,9886252	0,9866538	0,9968042	1
[409]	81	4	0,5325733	0,5075268	0,8979518	0,9178375	0,5930979	0,5529593	0,9007881	0,9178375	0,9968513	1
[139]	30	70	0,7989369	0,7537135	0,9252015	0,9711247	0,8635275	0,7761244	0,9281045	0,9711247	0,9968722	1
[390]	38	18	0,4967678	0,4757472	0,9475014	0,9417081	0,5242924	0,505196	0,9504719	0,9417081	0,9968746	1
[150]	31	87	0,7451993	0,7090836	0,9244756	0,9223643	0,8060779	0,7687674	0,9273719	0,9223643	0,9968769	1
[141]	30	91	0,7321452	0,706791	0,9431659	0,9946249	0,7762634	0,7106106	0,9460958	0,9946249	0,9969033	1
[273]	67	72	0,5251744	0,5059864	0,8485466	0,9736156	0,6189104	0,5196983	0,8511726	0,9736156	0,9969149	1
[120]	28	31	0,6217028	0,5943899	0,9362935	0,9426057	0,6640043	0,6305817	0,9390568	0,9426057	0,9970573	1
[386]	39	15	0,5240725	0,4944985	0,9277234	0,9944813	0,5649017	0,4972427	0,9303567	0,9944813	0,9971696	1
[132]	30	37	0,8710035	0,8476212	0,9971737	1	0,8734722	0,8476212	1	1	0,9971737	1
[147]	31	65	0,6961916	0,6615211	0,8939312	0,898129	0,7787977	0,7365547	0,8964433	0,898129	0,9971977	1
[186]	64	91	0,770895	0,7524124	0,9489151	0,9865939	0,8123962	0,7626364	0,9515727	0,9865939	0,9972072	1
[184]	64	70	0,8437518	0,8118101	0,9557958	0,9927842	0,8827741	0,8177106	0,9584349	0,9927842	0,9972464	1
[170]	57	64	0,7691955	0,7353627	0,9502737	0,961202	0,8094463	0,7650449	0,9528542	0,961202	0,9972918	1
[380]	39	14	0,4863114	0,4691661	0,9651905	0,9999025	0,5038501	0,4692119	0,9677699	0,9999025	0,9973347	1
[388]	98	15	0,4258976	0,4053393	0,9461108	1	0,4501562	0,4053393	0,9485881	1	0,9973885	1
[155]	37	64	0,8879659	0,8745207	0,997414	1	0,8902681	0,8745207	1	1	0,997414	1
[382]	98	14	0,4078528	0,3932756	0,9718846	0,9995462	0,4196515	0,3934542	0,9743219	0,9995462	0,9974984	1
[355]	38	7	0,5191335	0,5016075	0,9796139	0,9818718	0,5299369	0,5108687	0,9820548	0,9818718	0,9975145	1
[370]	18	13	0,4871589	0,4711097	0,9614771	0,9568619	0,5066775	0,4923487	0,963828	0,9568619	0,9975609	1
[223]	62	63	0,8752289	0,8454235	0,9893533	0,9917828	0,8846474	0,8524281	0,991667	0,9917828	0,9976668	1
[131]	30	31	0,7373788	0,7008536	0,9689309	0,978695	0,7610231	0,7161104	0,9710101	0,978695	0,9978587	1
[136]	30	64	0,815779	0,7909732	0,9660006	0,9654835	0,8444912	0,8192509	0,9680391	0,9654835	0,9978942	1
[146]	31	64	0,7823596	0,7534837	0,9900146	1	0,7902506	0,7534837	0,992045	1	0,9979533	1
[401]	61	39	0,4250538	0,4093041	0,9862627	0,9987615	0,4309742	0,4098117	0,9882835	0,9987615	0,9979552	1
[393]	98	18	0,4252651	0,4075927	0,9672969	0,962082	0,4396428	0,4236569	0,969163	0,962082	0,9980745	1
[372]	38	13	0,5410247	0,5224296	0,9846053	0,9860792	0,5494838	0,5298049	0,9864812	0,9860792	0,9980984	1
[398]	39	38	0,5617489	0,537005	0,9854814	0,9851424	0,5700249	0,545104	0,9873385	0,9851424	0,9981191	1
[400]	98	38	0,4760145	0,4569532	0,9981337	1	0,4769046	0,4569532	1	1	0,9981337	1
[358]	98	7	0,4408382	0,4252752	0,9943444	0,9963436	0,4433456	0,4268359	0,9961921	0,9963436	0,9981452	1
[185]	64	87	0,8607445	0,8377651	0,9549639	0,9429571	0,9013372	0,8884446	0,9565999	0,9429571	0,9982898	1
[403]	98	61	0,380947	0,3667358	0,9861245	0,9966699	0,3863073	0,3679611	0,9877912	0,9966699	0,9983126	1
[125]	28	64	0,7248183	0,7051783	0,9616754	0,956457	0,7537038	0,7372818	0,9632512	0,956457	0,998364	1

[182]	64	65	0,8003389	0,7751613	0,9276535	0,9220045	0,8627563	0,8407348	0,9291125	0,9220045	0,9984297	1
[204]	10	35	0,4694547	0,4436684	0,9777619	0,9941709	0,4801319	0,4462698	0,9792447	0,9941709	0,9984858	1
[375]	98	13	0,4667009	0,4501009	0,9956129	0,9970235	0,4687574	0,4514446	0,9971175	0,9970235	0,998491	1
[356]	39	7	0,5332633	0,5142244	0,9976664	0,9989112	0,5345106	0,5147849	0,9987757	0,9989112	0,9988893	1
[412]	43	6	0,7123755	0,6626225	0,9529502	0,9985793	0,7475474	0,6635652	0,9539575	0,9985793	0,9989441	1
[408]	77	4	0,463673	0,4409999	0,9546731	0,9822983	0,4856878	0,448947	0,955678	0,9822983	0,9989484	1
[168]	46	91	0,6068963	0,5788326	0,9632839	0,9900759	0,6300285	0,5846346	0,9637474	0,9900759	0,9995191	1
[134]	30	57	0,7185008	0,6741118	0,9282512	0,9402169	0,774037	0,7169748	0,9286368	0,9402169	0,9995847	1
[277]	67	85	0,5788576	0,5491693	0,9293839	0,9258373	0,6228401	0,5931596	0,9297244	0,9258373	0,9996338	1
[417]	43	40	0,614473	0,5944176	0,9637315	1	0,6375977	0,5944176	0,9638515	1	0,9998755	1
[373]	39	13	0,5519173	0,5315072	0,9992316	0,9989173	0,5523418	0,5320832	0,9993051	0,9989173	0,9999265	1
[396]	61	25	0,4090976	0,3934123	0,9468738	0,9578078	0,4320509	0,4107424	0,9467062	0,9578078	1,0001771	1
[119]	28	30	0,6694835	0,6432628	0,9349685	0,9258073	0,7160493	0,6948129	0,9339066	0,9258073	1,001137	1
[166]	46	70	0,6423823	0,605559	0,9711438	0,994647	0,6614698	0,608818	0,9688301	0,994647	1,0023881	1
[143]	31	46	0,6436986	0,6091714	0,9962917	1	0,6460945	0,6091714	0,9936693	1	1,0026391	1
[304]	8	3	0,4886066	0,4773408	1,003551	0,9968286	0,4868777	0,4788595	1	0,9968286	1,003551	1
[203]	10	34	0,461934	0,4373931	1,0005022	0,9943638	0,4617022	0,4398723	0,9940771	0,9943638	1,0064633	1
[152]	37	46	0,6719229	0,6387074	1,0071113	1	0,6671784	0,6387074	1	1	1,0071113	1
[268]	56	72	0,9424107	0,8771635	0,9424107	1	1	0,8771635	0,9347851	1	1,0081576	1
[174]	57	87	0,8546195	0,7950997	1,0095755	1	0,8465137	0,7950997	1	1	1,0095755	1
[161]	46	57	0,6170155	0,5744339	0,9766255	0,9710933	0,6317831	0,5915332	0,9664745	0,9710933	1,0105031	1
[159]	37	87	1,010827	1	1,010827	1	1	1	1	1	1,010827	1
[316]	45	8	0,5437739	0,5182546	0,9693141	0,9467888	0,5609883	0,5473814	0,9574691	0,9467888	1,0123712	1
[129]	28	87	0,7623565	0,7433877	1,0126226	0,9963796	0,7528535	0,7460889	1	0,9963796	1,0126226	1
[394]	38	25	0,5446503	0,5122712	0,9641303	0,9487078	0,5649136	0,5399673	0,9490391	0,9487078	1,0159015	1
[140]	30	87	0,8629866	0,8230393	0,9702508	0,9476993	0,889447	0,8684603	0,9550619	0,9476993	1,0159036	1
[275]	67	82	0,5494478	0,5229351	0,9994025	0,9822784	0,5497763	0,5323695	0,9826135	0,9822784	1,0170861	1
[384]	25	15	0,5104845	0,47878	0,9145574	0,9706408	0,5581766	0,4932618	0,8986277	0,9706408	1,0177266	1
[371]	25	13	0,5371619	0,5081312	0,9796454	0,9627156	0,5483228	0,5278103	0,961961	0,9627156	1,0183837	1
[391]	39	18	0,526778	0,4964976	0,9954735	0,9746573	0,5291733	0,5094074	0,9773493	0,9746573	1,0185442	1
[181]	58	91	0,9976939	0,9766421	1,0134299	0,999311	0,9844726	0,9773154	0,9946425	0,999311	1,0188886	1
[274]	67	80	0,5300832	0,5088288	1,0137632	0,9997082	0,5228866	0,5089773	0,994844	0,9997082	1,0190172	1
[193]	67	91	0,5603582	0,5384806	0,9610766	0,9997046	0,5830526	0,5386397	0,9419612	0,9997046	1,0202932	1
[420]	81	40	0,5112251	0,4905486	0,9660496	1	0,5291913	0,4905486	0,9449574	1	1,0223208	1
[419]	77	40	0,4404122	0,4137573	0,9785591	0,9994205	0,4500619	0,4139972	0,9554721	0,9994205	1,0241629	1
[179]	58	70	1,0171972	0,9885367	1,0182814	0,9989344	0,9989353	0,9895911	0,994158	0,9989344	1,0242651	1
[415]	81	6	0,568647	0,528029	0,9598795	0,9963978	0,592415	0,5299379	0,9365269	0,9963978	1,0249354	1
[414]	77	6	0,4648928	0,4313174	0,9679557	0,9969455	0,4802831	0,432639	0,9442281	0,9969455	1,0251291	1
[163]	46	64	0,7178261	0,6724498	1,025189	1	0,700189	0,6724498	1	1	1,025189	1
[378]	25	14	0,4890689	0,4657149	0,9755118	0,996778	0,501346	0,4672203	0,9505354	0,996778	1,0262761	1
[228]	63	76	0,8026949	0,7586405	0,9751286	0,9452741	0,8231683	0,8025614	0,9494104	0,9452741	1,0270886	1
[314]	32	8	0,5680195	0,5395506	0,9586251	0,9378476	0,5925356	0,5753074	0,9326346	0,9378476	1,0278679	1
[276]	67	84	0,6047854	0,5664319	1,0280856	0,9962001	0,5882637	0,5685925	1	0,9962001	1,0280856	1
[156]	37	65	0,9149392	0,8848447	1,0088705	0,9979682	0,9068946	0,8866462	0,9809715	0,9979682	1,0284401	1
[122]	28	46	0,6210618	0,5761766	1,0033105	0,9692847	0,6190125	0,5944348	0,975002	0,9692847	1,0290343	1
[154]	37	58	1,0294232	1	1,0294232	1	1	1	1	1	1,0294232	1
[329]	45	32	0,5078012	0,4771633	1,0297629	0,9995643	0,4931244	0,4773713	1	0,9995643	1,0297629	1
[190]	65	91	0,7707102	0,7385963	0,9600364	0,9974912	0,8027927	0,7404539	0,9318704	0,9974912	1,0302252	1
[188]	65	70	0,8556289	0,8030424	0,9538567	0,9897222	0,8970203	0,8113816	0,9249871	0,9897222	1,0312109	1
[137]	30	65	0,8254111	0,7767444	0,9768479	0,9527842	0,8449741	0,8152365	0,947014	0,9527842	1,0315032	1
[169]	57	58	1,0065124	0,9697162	1,0240616	0,9940243	0,9828631	0,9755458	0,9926878	0,9940243	1,0316049	1
[225]	62	76	0,8847837	0,8375574	1,0083085	0,9825751	0,877493	0,8524105	0,9774017	0,9825751	1,0316213	1
[354]	25	7	0,5214625	0,4880442	0,9829327	0,9560828	0,530517	0,5104623	0,9513728	0,9560828	1,033173	1
[283]	80	84	0,5809946	0,5501253	1,0099475	0,9904718	0,5752721	0,5554174	0,976816	0,9904718	1,0339179	1
[320]	88	8	0,4582761	0,4413336	1,0021075	0,9814771	0,4573123	0,4496627	0,9678197	0,9814771	1,0354279	1
[285]	82	84	0,5936007	0,5572039	0,9998687	0,9751469	0,5936786	0,5714051	0,9655303	0,9751469	1,0355642	1
[402]	98	39	0,498484	0,4592677	1,0358864	0,9961522	0,481215	0,4610417	0,997721	0,9961522	1,0382525	1
[429]	81	77	0,5372901	0,4972958	1,0348612	0,9995561	0,5191905	0,4975167	0,9959424	0,9995561	1,0390774	1
[280]	72	84	0,591222	0,5615439	0,8993454	0,9760832	0,6573915	0,5753033	0,8650737	0,9760832	1,039617	1
[145]	31	58	1,0077582	0,9614108	1,0399092	1	0,9690829	0,9614108	1	1	1,0399092	1
[287]	84	85	0,6182951	0,5793636	0,944653	0,9305437	0,6545208	0,6226076	0,9083565	0,9305437	1,0399585	1

[261]	50	67	0,5428602	0,5124228	0,9731752	0,9787939	0,5578237	0,5235248	0,935675	0,9787939	1,0400783	1
[306]	32	3	0,4678721	0,4358776	1,0306126	0,9873313	0,4539748	0,4414705	0,9900032	0,9873313	1,0410194	1
[389]	25	18	0,5392593	0,5054003	1,0262721	1	0,5254545	0,5054003	0,9845814	1	1,0423436	1
[319]	55	8	0,8627923	0,6907105	1,0258034	1	0,8410893	0,6907105	0,9835809	1	1,0429274	1
[295]	42	68	0,5223342	0,4356677	1,044616	0,9990212	0,5000251	0,4360946	1	0,9990212	1,044616	1
[424]	81	43	0,7891964	0,7447474	1,044737	1	0,7554019	0,7447474	1	1	1,044737	1
[333]	88	32	0,4588763	0,4272313	1,0412488	0,9957798	0,4406981	0,429042	0,9965377	0,9957798	1,0448665	1
[135]	30	58	1,0297957	0,9799123	1,046686	0,999895	0,9838631	0,9800152	1	0,999895	1,046686	1
[227]	63	71	0,9255833	0,8607315	1,0258291	0,9974753	0,9022783	0,8629101	0,9799462	0,9974753	1,0468218	1
[272]	56	85	0,9771064	0,8791361	1,0430083	1	0,9368155	0,8791361	0,9955079	1	1,0477148	1
[126]	28	65	0,7397961	0,6977377	1,0088615	0,9746803	0,733298	0,7158631	0,9628184	0,9746803	1,0478212	1
[189]	65	87	0,9633476	0,9027487	1,0481144	1	0,9191244	0,9027487	1	1	1,0481144	1
[171]	57	65	0,8047363	0,7430832	1,0067399	0,9973805	0,7993488	0,7450349	0,9601329	0,9973805	1,0485423	1
[148]	31	69	0,7305318	0,6628955	1,0100266	0,999297	0,7232798	0,6633619	0,9632411	0,999297	1,048571	1
[191]	69	70	0,7446812	0,6719163	0,9948652	0,9986285	0,7485248	0,6728391	0,9477438	0,9986285	1,0497195	1
[265]	50	84	0,6011162	0,5612565	0,9921039	0,9844608	0,6059004	0,5701157	0,9450348	0,9844608	1,0498067	1
[180]	58	87	1,0419237	0,9894507	1,0419237	0,9894507	1	1	0,9916912	0,9894507	1,0506534	1
[167]	46	87	0,7005351	0,6348294	1,0196837	0,959107	0,6870122	0,6618964	0,9701944	0,959107	1,0510097	1
[157]	37	69	0,7645367	0,6947177	1,0163568	1	0,7522326	0,6947177	0,9661902	1	1,051922	1
[172]	57	69	0,7214002	0,6484285	0,9980083	0,9867922	0,7228398	0,6571074	0,9487376	0,9867922	1,0519329	1
[423]	77	43	0,5977098	0,5454793	1,0549504	1	0,5665761	0,5454793	1	1	1,0549504	1
[124]	28	58	1,00818	0,9523223	1,0475363	0,9919411	0,9624297	0,9600594	0,992924	0,9919411	1,0550015	1
[311]	55	3	0,6660794	0,5380724	1,0235212	0,9785475	0,6507725	0,5498685	0,9688171	0,9785475	1,0564648	1
[192]	69	87	0,76927	0,6931529	1,0081018	0,9774768	0,7630876	0,7091247	0,9522008	0,9774768	1,0587071	1
[127]	28	69	0,7136747	0,643143	1,0135062	0,9842195	0,7041642	0,6534548	0,9557596	0,9842195	1,0604195	1
[177]	58	65	1,0345912	0,9711575	1,0465335	0,9852521	0,9885886	0,9856944	0,9865034	0,9852521	1,0608515	1
[303]	89	99	0,9969169	0,6068533	1,0509891	0,9882606	0,9485511	0,614062	0,9893231	0,9882606	1,0623315	1
[341]	55	45	0,684384	0,5529757	0,9968079	0,9530917	0,6865756	0,5801915	0,937104	0,9530917	1,0637111	1
[325]	53	27	0,5534419	0,35763	1,0677767	0,9590567	0,5183124	0,3728977	1	0,9590567	1,0677767	1
[299]	23	89	0,9946341	0,6080777	1,0679121	1	0,931382	0,6080777	1	1	1,0679121	1
[133]	30	46	0,7141972	0,6361702	1,0598923	0,9893154	0,6738395	0,6430408	0,9911762	0,9893154	1,0693278	1
[183]	64	69	0,7941001	0,7100251	1,0421921	0,9993658	0,7619517	0,7104757	0,9740868	0,9993658	1,0699171	1
[308]	45	3	0,4381767	0,3985603	1,0581425	0,9847085	0,4140999	0,4047495	0,9873986	0,9847085	1,0716467	1
[342]	88	45	0,4328016	0,3946363	1,0672378	0,995361	0,4055344	0,3964756	0,995764	0,995361	1,0717779	1
[301]	52	89	0,9542425	0,5842612	1,0161082	0,9904617	0,939115	0,5898877	0,9471923	0,9904617	1,072758	1
[233]	33	48	0,5465756	0,446367	1,0728979	1	0,5094386	0,446367	0,9995715	1	1,0733578	1
[224]	62	71	1,0005555	0,9046307	1,0439914	0,9899037	0,9583944	0,9138573	0,9726313	0,9899037	1,0733681	1
[260]	50	56	0,9279633	0,8201338	1,0524185	0,9983673	0,8817437	0,821475	0,9803414	0,9983673	1,0735224	1
[312]	88	3	0,3958823	0,3632878	1,0712862	1	0,3695393	0,3632878	0,9976288	1	1,0738324	1
[395]	39	25	0,5953149	0,5326855	1,0497962	0,9833233	0,5670767	0,5417196	0,9772261	0,9833233	1,0742613	1
[176]	58	64	1,0564407	0,9798244	1,0751334	1	0,9826137	0,9798244	1	1	1,0751334	1
[269]	56	80	0,8864968	0,7808309	1,0782901	0,9957599	0,822132	0,7841558	1	0,9957599	1,0782901	1
[206]	26	34	0,429976	0,3671018	0,9930467	0,9879132	0,4329867	0,3715931	0,9203361	0,9879132	1,0790045	1
[397]	98	25	0,5012459	0,4447797	1,0431451	0,9665379	0,480514	0,4601782	0,9663972	0,9665379	1,0794165	1
[211]	35	44	0,5385608	0,477343	1,0070555	0,9984606	0,5347876	0,478079	0,9326156	0,9984606	1,0798184	1
[210]	34	44	0,5339454	0,4738964	1,0060048	0,994359	0,5307583	0,4765848	0,9314386	0,994359	1,0800549	1
[245]	48	56	0,5367642	0,4463168	1,0787218	0,9997117	0,4975928	0,4464455	0,9985034	0,9997117	1,0803386	1
[207]	26	35	0,4341572	0,3700921	0,9939746	0,9941079	0,4367891	0,3722856	0,9186533	0,9941079	1,0819911	1
[243]	48	49	0,4638342	0,3738151	1,0831768	0,9998093	0,4282165	0,3738864	0,9997943	0,9998093	1,0833996	1
[216]	17	76	0,9778645	0,8543666	1,0836312	0,9979747	0,9023961	0,8561005	0,9997407	0,9979747	1,0839122	1
[348]	88	55	0,6277783	0,5105584	1,0209088	0,9687062	0,6149211	0,5270519	0,9411522	0,9687062	1,0847436	1
[202]	10	26	0,4472118	0,3642131	1,0606696	1	0,4216316	0,3642131	0,977431	1	1,0851606	1
[244]	48	50	0,4581751	0,3980866	1,016474	0,9994141	0,4507495	0,39832	0,9365863	0,9994141	1,0852967	1
[247]	48	72	0,4475086	0,3941283	0,9853597	0,9978332	0,4541576	0,3949842	0,9072756	0,9978332	1,0860643	1
[138]	30	69	0,7711918	0,6771941	1,0324226	0,9799879	0,7469729	0,6910229	0,9501503	0,9799879	1,0865888	1
[292]	24	42	0,5404483	0,4554569	1,0177539	0,9870977	0,5310206	0,4614102	0,9364464	0,9870977	1,0868256	1
[322]	41	27	0,4629068	0,30457	1,0693325	0,9840748	0,4328932	0,3094988	0,9834936	0,9840748	1,0872796	1
[164]	46	65	0,7145824	0,623683	1,0470417	0,9543526	0,6824775	0,6535142	0,962532	0,9543526	1,0877994	1
[324]	51	27	0,5530951	0,359542	1,0656434	0,9757536	0,5190245	0,3684762	0,9773295	0,9757536	1,0903625	1
[251]	48	85	0,4645688	0,4060002	1,0129776	0,9978523	0,4586171	0,406874	0,9290083	0,9978523	1,0903859	1
[250]	48	84	0,4902675	0,4042211	1,0553155	0,9714507	0,4645696	0,4161004	0,9668518	0,9714507	1,0914966	1

[249]	48	82	0,4648914	0,4022394	1,02855	1	0,4519872	0,4022394	0,9421231	1	1,0917363	1
[246]	48	67	0,4712177	0,4007147	1,038764	0,9893465	0,4536331	0,4050297	0,9511245	0,9893465	1,092143	1
[187]	65	69	0,7725287	0,6741504	1,0240321	0,9637712	0,7543989	0,6994922	0,9375733	0,9637712	1,0922155	1
[248]	48	80	0,4576967	0,397231	1,0225807	0,9981338	0,4475898	0,3979737	0,9356085	0,9981338	1,0929579	1
[118]	22	91	0,9805281	0,8146642	1,0212793	0,9919018	0,9600979	0,8213154	0,9330354	0,9919018	1,0945772	1
[270]	56	82	0,9076688	0,7879466	1,0946067	0,9989284	0,8292191	0,7887919	1	0,9989284	1,0946067	1
[230]	71	76	0,9687277	0,8580916	1,0815051	0,9941127	0,8957218	0,8631733	0,9864286	0,9941127	1,0963846	1
[116]	22	70	1,0305555	0,846169	1,033445	1	0,9972041	0,846169	0,9413089	1	1,0978807	1
[205]	10	44	0,5222167	0,455257	1,0151179	0,9838676	0,5144395	0,4627218	0,9243544	0,9838676	1,0981912	1
[321]	32	27	0,5311472	0,3495907	1,0376371	0,984274	0,5118815	0,3551762	0,9410646	0,984274	1,1026205	1
[111]	22	57	1,0038571	0,8200379	1,0496409	0,9988358	0,9563814	0,8209937	0,9512835	0,9988358	1,1033944	1
[367]	98	9	0,5831115	0,4352098	1,0224044	0,9997184	0,5703335	0,4353324	0,926283	0,9997184	1,1037711	1
[327]	88	27	0,5173658	0,3433987	1,0399507	0,9998889	0,4974907	0,3434368	0,9413747	0,9998889	1,104715	1
[363]	25	9	0,5911311	0,438915	1,0216532	0,9968769	0,5786025	0,4402901	0,9245742	0,9968769	1,1049987	1
[365]	39	9	0,5911029	0,4402708	1,0209433	0,9999123	0,5789772	0,4403094	0,9236228	0,9999123	1,1053683	1
[359]	13	9	0,5857364	0,4394311	1,0140961	1	0,5775946	0,4394311	0,9167133	1	1,1062304	1
[323]	45	27	0,5252418	0,347115	1,0349674	0,9960512	0,507496	0,3484911	0,9355089	0,9960512	1,1063148	1
[364]	38	9	0,5859555	0,4394044	1,0122496	0,9989247	0,5788647	0,4398774	0,914623	0,9989247	1,1067397	1
[293]	24	68	0,4671491	0,3955647	1,0675113	0,9827246	0,4376057	0,4025184	0,9644029	0,9827246	1,1069142	1
[214]	17	63	0,9516018	0,8207347	1,0492385	0,9587518	0,9069452	0,856045	0,9472423	0,9587518	1,1076769	1
[366]	61	9	0,5730395	0,4310501	1,0090653	1	0,5678915	0,4310501	0,9109289	1	1,1077321	1
[305]	27	3	0,5176757	0,3431955	1,0329783	0,9998861	0,5011487	0,3432346	0,9325071	0,9998861	1,107743	1
[349]	9	7	0,5824081	0,4372643	1,0094969	1	0,5769291	0,4372643	0,9106657	1	1,1085263	1
[362]	18	9	0,5823113	0,4358098	1,0098484	0,9972776	0,5766324	0,4369995	0,9109537	0,9972776	1,1085618	1
[416]	83	6	0,5490815	0,4639446	1,0031287	0,9995616	0,547369	0,4641481	0,9045233	0,9995616	1,1090137	1
[213]	17	62	1,0293271	0,882978	1,0871677	0,9904156	0,946797	0,8915228	0,9796233	0,9904156	1,1097814	1
[360]	14	9	0,5781644	0,4346664	1,0047681	1	0,5754207	0,4346664	0,9053569	1	1,1098033	1
[162]	46	58	1,0175083	0,9065942	1,1098531	1	0,9167955	0,9065942	1	1	1,1098531	1
[361]	15	9	0,5790815	0,4356757	1,0005004	0,9997763	0,5787919	0,4357732	0,9009934	0,9997763	1,1104414	1
[330]	51	32	0,593183	0,5149552	1,0834947	0,9997531	0,547472	0,5150824	0,9755686	0,9997531	1,110629	1
[317]	51	8	0,6188952	0,5419557	1,0313726	0,9641714	0,6000695	0,5620948	0,9285809	0,9641714	1,1106976	1
[109]	22	37	1,0568732	0,8659977	1,0568732	0,9952141	1	0,8701622	0,9510805	0,9952141	1,1112342	1
[231]	71	90	0,934254	0,6580508	1,0298397	0,9995099	0,9071839	0,6583734	0,9265211	0,9995099	1,1115124	1
[217]	17	90	0,9421009	0,6601517	1,0380897	0,9945036	0,9075332	0,6638002	0,9338358	0,9945036	1,1116406	1
[232]	76	90	0,9206238	0,6504895	1,0217643	0,994884	0,9010139	0,6538346	0,9190885	0,994884	1,1117149	1
[313]	27	8	0,5277349	0,3514332	1,0159489	0,998475	0,5194502	0,3519699	0,9133482	0,998475	1,1123347	1
[226]	62	90	0,9243141	0,6568571	1,0204244	0,9990642	0,9058133	0,6574724	0,9164035	0,9990642	1,11351	1
[229]	63	90	0,9172815	0,6542158	1,0174855	1	0,901518	0,6542158	0,9132321	1	1,1141587	1
[234]	33	49	0,5703292	0,4370734	1,1153474	0,9997009	0,5113467	0,4372042	1	0,9997009	1,1153474	1
[332]	55	32	0,6972227	0,5343612	1,010523	0,9048109	0,6899622	0,5905777	0,9045014	0,9048109	1,1172154	1
[339]	51	45	0,5783264	0,4999428	1,0865145	1	0,5322767	0,4999428	0,9722877	1	1,1174825	1
[108]	22	31	0,9797158	0,7925635	1,0564739	0,9802212	0,927345	0,8085558	0,9445952	0,9802212	1,1184408	1
[215]	17	71	1,0626641	0,8941915	1,108039	0,994942	0,9590494	0,8987373	0,9902738	0,994942	1,1189219	1
[421]	83	40	0,5383529	0,4522217	1,0192711	0,9987597	0,5281744	0,4527833	0,9108371	0,9987597	1,1190487	1
[338]	88	41	0,3062629	0,2586081	1,0849997	0,9977276	0,2822701	0,2591971	0,9679973	0,9977276	1,1208706	1
[307]	41	3	0,2983932	0,2525892	1,0731029	0,9930752	0,2780658	0,2543506	0,9572723	0,9930752	1,1210007	1
[315]	41	8	0,2971943	0,2541752	1,0273432	0,9674892	0,2892844	0,2627163	0,915994	0,9674892	1,1215611	1
[331]	53	32	0,5627411	0,4431188	1,0623079	1	0,5297344	0,4431188	0,9470719	1	1,1216761	1
[334]	45	41	0,3119421	0,2650621	1,0766033	1	0,2897465	0,2650621	0,9594167	1	1,1221436	1
[309]	51	3	0,5476555	0,472135	1,0829569	0,9924333	0,5057039	0,4757347	0,9649758	0,9924333	1,1222633	1
[267]	56	67	0,8935888	0,7543479	1,1208141	0,9910055	0,7972676	0,7611944	0,9985107	0,9910055	1,1224858	1
[208]	26	44	0,5227273	0,4157782	1,084413	0,9847998	0,4820371	0,4221956	0,9652687	0,9847998	1,1234312	1
[238]	33	72	0,7162416	0,6106913	0,9702789	0,9954636	0,7381811	0,6134742	0,8633296	0,9954636	1,1238801	1
[328]	41	32	0,3302564	0,282266	1,0748418	0,9997713	0,3072605	0,2823305	0,9561293	0,9997713	1,1241594	1
[340]	53	45	0,5536267	0,433941	1,0590447	0,999295	0,5227604	0,4342471	0,9414677	0,999295	1,1248869	1
[343]	53	51	0,5947439	0,4550489	1,1029035	0,9998457	0,5392528	0,4551191	0,9802513	0,9998457	1,1251233	1
[410]	83	4	0,5536622	0,4558557	1,00902	0,9641552	0,5487128	0,4728032	0,8967325	0,9641552	1,1252184	1
[345]	88	51	0,5381992	0,4625698	1,0956185	0,9975324	0,4912287	0,463714	0,973567	0,9975324	1,1253653	1
[165]	46	69	0,7593678	0,6347694	1,1108106	0,9994393	0,6836159	0,6351255	0,9870371	0,9994393	1,125399	1
[347]	88	53	0,5388356	0,4204369	1,0670499	0,9978999	0,504977	0,4213217	0,9475635	0,9978999	1,1260985	1
[310]	53	3	0,5403696	0,4224673	1,0560792	0,9953637	0,5116753	0,4244351	0,9374842	0,9953637	1,1265035	1

[318]	53	8	0,5610284	0,4418269	1,0275296	0,9828025	0,5459973	0,4495581	0,9119227	0,9828025	1,1267727	1
[336]	53	41	0,4520013	0,3430322	1,1069849	0,9992563	0,4083174	0,3432875	0,9811053	0,9992563	1,1283039	1
[117]	22	87	1,0878423	0,8747114	1,0878423	0,9978133	1	0,8766282	0,9633969	0,9978133	1,1291736	1
[289]	2	42	0,7390912	0,6005618	1,0801519	0,9920622	0,6842475	0,6053671	0,9548082	0,9920622	1,1312763	1
[290]	2	68	0,6428179	0,5352191	1,1038904	0,9867467	0,5823204	0,5424078	0,9742191	0,9867467	1,1331028	1
[259]	49	85	0,4329953	0,3617125	1,0242242	0,9952354	0,4227544	0,3634442	0,9038563	0,9952354	1,1331715	1
[252]	49	50	0,4253723	0,348234	1,0403587	1	0,4088708	0,348234	0,9176817	1	1,1336815	1
[255]	49	72	0,4010653	0,3384282	0,9707205	0,9951004	0,4131625	0,3400945	0,8562391	0,9951004	1,1337025	1
[335]	51	41	0,3943905	0,3178414	1,1337828	1	0,3478536	0,3178414	1	1	1,1337828	1
[253]	49	56	0,5577934	0,4343564	1,1338887	0,9993127	0,4919296	0,4346552	1	0,9993127	1,1338887	1
[257]	49	82	0,4347269	0,3568749	1,053605	0,9998555	0,412609	0,3569265	0,9290669	0,9998555	1,1340465	1
[106]	22	28	0,9963261	0,801789	1,0940871	1	0,9106461	0,801789	0,964755	1	1,134057	1
[236]	33	56	0,9029644	0,7065053	1,1348905	0,9994986	0,7956401	0,7068598	1	0,9994986	1,1348905	1
[302]	52	99	0,8804175	0,672607	1,1299324	0,9999242	0,7791771	0,672658	0,9951557	0,9999242	1,1354328	1
[242]	33	85	0,7482505	0,6312222	1,0239716	0,9957483	0,7307337	0,6339174	0,901519	0,9957483	1,1358293	1
[200]	1	35	0,8597739	0,5492899	1,0126692	0,9976101	0,8490175	0,5506058	0,8910568	0,9976101	1,1364811	1
[254]	49	67	0,4465085	0,3563071	1,0715395	0,9809054	0,4166981	0,3632431	0,9424849	0,9809054	1,1369301	1
[199]	1	34	0,8549217	0,5462872	1,0139208	0,9950703	0,843184	0,5489936	0,8910476	0,9950703	1,1378974	1
[256]	49	80	0,4217249	0,3474433	1,0429974	0,9963381	0,4043393	0,3487203	0,9160285	0,9963381	1,138608	1
[271]	56	84	0,8979862	0,7419124	1,1386389	0,9851331	0,7886487	0,7531087	0,9989545	0,9851331	1,1398306	1
[114]	22	65	1,0576343	0,8407162	1,0876872	0,9842744	0,9723699	0,8541482	0,9538158	0,9842744	1,1403534	1
[235]	33	50	0,7268486	0,6074871	1,0282074	0,998814	0,7069086	0,6082085	0,9010608	0,998814	1,1411076	1
[425]	83	43	0,6463404	0,5266351	1,0864032	1	0,594936	0,5266351	0,9518015	1	1,1414178	1
[428]	83	73	0,451766	0,3200466	1,1375837	0,9977658	0,3971277	0,3207632	0,9964812	0,9977658	1,1416008	1
[288]	2	24	0,6908069	0,5567438	1,141425	0,9940506	0,6052145	0,5600759	0,9997468	0,9940506	1,141714	1
[431]	83	81	0,6098655	0,4993492	1,0796808	0,9984761	0,5648572	0,5001113	0,9449234	0,9984761	1,1426121	1
[107]	22	30	1,029629	0,8180466	1,0711464	0,9700195	0,9612402	0,8433301	0,9366966	0,9700195	1,1435361	1
[346]	55	53	0,637941	0,4464015	1,0883012	0,9359543	0,5861806	0,4769479	0,9503907	0,9359543	1,1451093	1
[241]	33	84	0,7538968	0,5831846	1,0897088	0,9503733	0,6918332	0,6136374	0,9501935	0,9503733	1,1468283	1
[258]	49	84	0,4829245	0,3657566	1,1046702	0,951864	0,4371663	0,384253	0,9631943	0,951864	1,146882	1
[426]	77	73	0,3933509	0,2904549	1,0995386	1	0,3577418	0,2904549	0,9550657	1	1,1512701	1
[326]	55	27	0,6089935	0,3747026	1,1154802	0,9919013	0,5459474	0,377762	0,9683096	0,9919013	1,1519872	1
[240]	33	82	0,7312308	0,6064613	1,0537644	1	0,6939225	0,6064613	0,9133932	1	1,153681	1
[239]	33	80	0,7166969	0,5970515	1,0430096	0,9962664	0,6871431	0,599289	0,9032773	0,9962664	1,1546948	1
[407]	73	4	0,351341	0,2654965	1,0110489	0,9766983	0,3475015	0,2718306	0,8754973	0,9766983	1,1548281	1
[237]	33	67	0,7348197	0,5906576	1,0719308	0,9796161	0,6855104	0,602948	0,9276564	0,9796161	1,1555257	1
[298]	23	52	0,8265596	0,6086224	1,0526221	0,9675383	0,7852387	0,6290421	0,9106383	0,9675383	1,1559167	1
[344]	55	51	0,7348451	0,5176741	1,1004123	0,8952732	0,6677907	0,5782304	0,9486883	0,8952732	1,1599303	1
[113]	22	64	1,0779007	0,8412528	1,1225618	0,9865167	0,960215	0,8527506	0,96756	0,9865167	1,1601987	1
[430]	83	77	0,5899889	0,4638345	1,126696	0,9984357	0,5236451	0,4645612	0,9709052	0,9984357	1,1604594	1
[418]	73	40	0,344488	0,263603	1,0154424	0,9992932	0,3392491	0,2637894	0,8740661	0,9992932	1,1617455	1
[427]	81	73	0,3803821	0,2879782	1,0579877	0,9976619	0,3595336	0,2886532	0,9105581	0,9976619	1,1619113	1
[413]	73	6	0,3439519	0,2656496	0,9977767	0,9964362	0,3447183	0,2665997	0,8585451	0,9964362	1,1621715	1
[178]	58	69	1,0714694	0,9004166	1,1623422	0,9998002	0,9218192	0,9005966	1	0,9998002	1,1623422	1
[422]	73	43	0,3886348	0,2910077	1,0680674	1	0,3638673	0,2910077	0,9175233	1	1,1640765	1
[300]	23	99	0,9552431	0,6368497	1,1344981	0,9371567	0,8419962	0,6795552	0,9718366	0,9371567	1,1673754	1
[337]	55	41	0,4248123	0,3057781	1,1080396	0,9196016	0,3833909	0,3325115	0,9466983	0,9196016	1,1704253	1
[219]	60	63	1,1398448	0,704456	1,1494109	0,9910045	0,9916774	0,7108505	0,9738184	0,9910045	1,1803134	1
[294]	24	94	0,5433934	0,3971361	1,13061	0,997124	0,4806197	0,3982816	0,9540935	0,997124	1,1850096	1
[291]	2	94	0,642709	0,4683057	1,1600574	0,9977378	0,5540321	0,4693675	0,9753771	0,9977378	1,1893425	1
[110]	22	46	0,9787279	0,7358669	1,1749314	0,9894575	0,8330086	0,7437075	0,9875329	0,9894575	1,1897643	1
[112]	22	58	1,1905049	0,9518008	1,1905049	0,9921625	1	0,9593195	1	0,9921625	1,1905049	1
[197]	1	10	0,9136037	0,5341905	1,1259405	1	0,8114138	0,5341905	0,918387	1	1,2259978	1
[218]	60	62	1,1997649	0,7137789	1,2030882	0,9981688	0,9972377	0,7150884	0,9790617	0,9981688	1,2288175	1
[115]	22	69	1,0568063	0,7545415	1,2349003	0,9943481	0,8557827	0,7588303	1	0,9943481	1,2349003	1
[297]	68	94	0,5369411	0,3829492	1,1529355	0,9939125	0,4657165	0,3852947	0,9322748	0,9939125	1,2366905	1
[296]	42	94	0,6045196	0,4121174	1,1788351	0,9958182	0,512811	0,413848	0,9135765	0,9958182	1,2903518	1
[221]	60	76	1,284026	0,7105026	1,2952898	0,9999939	0,991304	0,710507	0,9780504	0,9999939	1,324359	1
[220]	60	71	1,3564522	0,7150363	1,3580419	0,9984103	0,9988294	0,7161748	0,9821979	0,9984103	1,382656	1
[212]	17	60	1,455242	0,7205983	1,4613393	0,9997255	0,9958277	0,7207962	0,993863	0,9997255	1,4703629	1
[222]	60	90	Inf	0,6249164	Inf	0,9273446	NaN	0,6738772	1	0,9273446	Inf	1

[201]	1	44	Inf	0,5113806	Inf	0,9905244	NaN	0,5162726	0,9655852	0,9905244	Inf	1
[102]	21	69	Inf	0,8313678	Inf	0,9933087	NaN	0,8369682	0,9777959	0,9933087	Inf	1
[101]	21	65	Inf	0,8410377	Inf	0,9952462	NaN	0,8450549	0,9736611	0,9952462	Inf	1
[104]	21	87	Inf	0,843113	Inf	0,9963836	NaN	0,8461732	0,9743888	0,9963836	Inf	1
[100]	21	64	Inf	0,8431734	Inf	0,9978188	NaN	0,8450166	0,9771311	0,9978188	Inf	1
[103]	21	70	Inf	0,8437262	Inf	0,9989607	NaN	0,8446039	0,9753127	0,9989607	Inf	1
[105]	21	91	Inf	0,8425489	Inf	0,9990474	NaN	0,8433523	0,9753519	0,9990474	Inf	1
[198]	1	26	Inf	0,4786168	Inf	1	NaN	0,4786168	0,9711005	1	Inf	1

Table 52: All merger combinations with efficiency scores and decomposed merger gains. Source: Own contribution.